JUATIKA
JURNAL AGRONOMI TANAMAN TROPIKA
VOL. 7 NO. 2 May 2025

DOI :https://doi.org/10.36378/juatika.v7i2.4267
eissn 2656-1727
pissn 2684-785X
pages : 408 – 416

RESEARCH ARTICLE
Open Access

Agronomic Appearance of Red Calliandra Plants (*Calliandra calothyrsus*) in Different Locations

Arifatul Aulia Fikra[1],Benni Satria[1,*], Dini Hervani[1], , Efderilla[1], Armansyah[1]

Abstract

Red calliandra (*Calliandra calothyrsus)* is a leguminous tree native to Indonesia. This species can serve as a renewable alternative energy source to replace coal. Calliandra wood is highly flammable and can be utilized as biomass energy, offering a quality comparable to coal's. PT Semen Padang employs red calliandra as an alternative to coal in cement production, which results in lower carbon emissions. The company has planted calliandra in various locations throughout West Sumatra. This descriptive exploratory study employs a survey method to investigate the places where the plants grow, utilizing direct observation techniques. The three locations observed were behind the PT Semen Padang Training Center (Indarung, Lubuk Kilangan District, Padang City, West Sumatra), PT Semen Padang Mine (Indarung, Lubuk Kilangan District, Padang City, West Sumatra), and Sialangan (V Koto Timur District, Padang Pariaman Regency, West Sumatra). A total of 10 plants were sampled from each location, resulting in 30 plant samples overall. Subsequently, observations and data analysis were conducted. The characteristics observed included the morphology of stems, leaves, and flowers and a chemical analysis of the soil, which assessed pH, organic carbon, total nitrogen, total phosphorus, and total potassium. The results indicated that plant age, soil nutrient availability, and environmental conditions significantly influenced* the vegetative and generative growth of *Calliandra calothyrsus*. Locations with neutral soil pH and high phosphorus content supported greater stem diameter growth, while areas with elevated organic carbon and nitrogen levels promoted enhanced leaf development. Variations in the color of stems, leaves, and flowers were closely related to plant age, light intensity, and the availability of micronutrients. In conclusion, the agronomic differences in red *Calliandra* are determined by the interaction among plant age, soil nutrient status, and growing environment, all of which are critical factors for optimizing biomass production in the future.

Keywords: Agronomic, Appearance Character, Location, Red Calliandra

1. Introduction

Red Calliandra (*Calliandra calothyrsus*) is a forest plant belonging to the tree legume group that grows naturally in Indonesia (Stewart et al., 2001). Red Calliandra has significant potential for development due to its resistance to pruning, rapid and dense growth, deep root system, and ability to form root nodules. Additionally, it thrives in light, acidic, and less fertile soil conditions thanks to its symbiotic relationship with rhizobia (Kementrian Kehutanan, 2014).

The Ministry of Forestry has stated that red calliandra plants serve as a source of biomass-based energy. The wood of red calliandra has a high density, with a specific gravity ranging from 0.5 to 0.8, which allows it to dry quickly and burn easily. This wood produces energy that meets commercial standards, yielding approximately 4,600 kcal per kilogram of dry wood and 7,200 kcal of heat per kilogram of charcoal, making it an ideal choice for firewood (Kementerian Kehutanan, 2014). Additionally, red calliandra plants provide green fodder, containing 20-25% protein, which makes them a suitable source of supplemental protein for livestock. The flowers of red calliandra also possess aesthetic appeal, contributing to landscape design and serving as a food source for honey bees. Furthermore, red calliandra is a nitrogen-fixing plant that enhances soil structure and fertility. It forms a symbiotic relationship with rhizobium bacteria, which enables the plant to capture nitrogen from the atmosphere

*Correspondence: bennisatria@agr.unand.ac.id
1) Universtias Andalas - Jl. Dr. Mohammad Hatta, Limau Manis, Pauh, Kota Padang, Sumatera Barat 25163, Indonesia

and store it in root nodules. Reason: The revised text improves clarity and readability by restructuring sentences, enhancing vocabulary, and correcting grammatical errors while maintaining the original meaning. (Orwa et al., 2009).

Currently, using alternative energy is one of the solutions to overcome the problem of decreasing fossil energy, which has become the main source of world energy. On the other hand, energy consumption is increasing due to the increasing human population. This condition is the basis for finding alternative renewable energy sources that can be used to meet world energy needs (Ibrahim et al., 2020). Biomass is one of the renewable energy sources that can be an option to overcome this problem. One form of biomass utilization as renewable energy is charcoal briquettes (Kongprasert et al., 2019).

Red calliandra (*Calliandra calothyrsus*) is an energy-producing plant used as a raw material for wood pellets. This wood has characteristics, namely a density of 0.5-0.8, flammable, and can produce heat up to 7,200 cal/g (through the pyrolysis process) (Pradana et al., 2021). Thus, this wood can potentially be used as a raw material for charcoal briquettes. Red calliandra can produce 15-40 tons of wood/ha/year with annual logging and remains productive for 10-20 years (Orwa et al., 2009). Therefore, PT Semen Padang utilizes this red calliandra plant as an alternative substitute for coal in cement production.

In addition to the social forestry area in West Sumatra, PT Semen Padang also planted red calliandra in the company's yard. PT Semen Padang has prepared around 19 hectares of land in the company's yard to plant red calliandra. In addition to the company's yard area, PT Semen Padang had planted around 4,000 red calliandra in the former reclamation of PT Semen Padang's limestone mine. Since its inception, the company has used red calliandra as biomass energy to produce cement. A total of 200 tons of red calliandra have been utilized and have succeeded in helping reduce coal use in November 2023.(PT Semen Padang, 2023)

Planting that has been done in various locations shows different growth of red calliandra plants. So, this problem will affect the target of PT Semen Padang in producing this red calliandra plant. With the hope that this research will answer the issues that occur and maximize the production of red calliandra plants in various planting locations, it is necessary to research the agronomic performance of red calliandra plants (*Calliandra calothyrsus*) in several different places.

2. Material and Methods

This research was conducted in October - November 2024 at PT Semen Padang Indarung, Lubuk Kilangan District, Padang City, West Sumatra; Sialang, V Koto Timur District, Padang Pariaman Regency, West Sumatra. With an altitude of ± 200 meters above sea level.

2.1. Materials and tools

The materials used in this study were red calliandra plants planted by PT Semen Padang in different locations. The tools used in this study were rulers, calipers, meters, label paper, ribbons, stationery, abo boards, branch scissors, black and white photo backgrounds, plastic bags, hoes, hoe, digital scales, munsell color charts, and digital cameras.

2.2. Research Procedures

This study was conducted using a survey method consisting of two stages. The first stage is a survey at the location where the plants grow to determine sample plants using purposive sampling techniques, namely sampling techniques using specific considerations after knowing the characteristics of the population. The second stage is characterization activities, which are done by observing certain characters in the sample plants. The sample used was 10 plants at each location, so the total number of samples was 30. The criteria for plants used as samples are red calliandra plants that have flowered. Sample data collection is carried out directly at the observation location. Furthermore, statistical analysis is done by comparing and displaying it in table form.

The sample locations consist of 3 (three) locations, namely:

1. Behind the Training Center of PT. Semen Padang (Indarung, Lubuk Kilangan District, Padang City, West Sumatra) (-0.950057,100.478524)
2. PT. Semen Padang Mine (Batu Gadang, Lubuk Kilangan District, Padang City, West Sumatra) (-0.966760,100.471506)
3. Sialangan (V Koto Timur District, Padang Pariaman Regency, West Sumatra) (-0.481063,100.207096)

The implementation of this research is as follows:

2.2.1. Plant Survey

The survey was conducted to obtain data on the existence and condition of red calliandra plants per location. Data was obtained by asking PT Semen Padang's CSR directly. The survey data obtained were used for further activities, namely determining and installing labels on sample plants.

2.2.2. Sample Determination and Labeling

Determination and labeling of samples are carried out as markers of plants to be observed. Labeling is done by marking plants using label paper tied with ribbon on the sample plant containing the number or code of the plant sample.

2.2.3. Soil Analysis

The soil analyzed in this study was the soil at the five sample plant locations. Each location was taken 3 soil sample points diagonally or vertically representing the location and then composited. The soil was taken at a depth of about 0-20 cm using a Belgian drill/hoe and then cleaned from plant roots and weeds. The soil was then air-dried for 1 week. The dried soil was sieved using a 5 mesh sieve until the soil size obtained was relatively homogeneous. Furthermore, the soil samples were analyzed at the Star Laboratory, PT. Wiwiadi Bintang Sains. The soil analysis carried out was pH, C-Organic, total N, total P, and total K.

2.2.4. Characterization of Red Calliandra Plants

Characterization of red calliandra plants based on plant morphological characteristics by observing, measuring, and documenting.

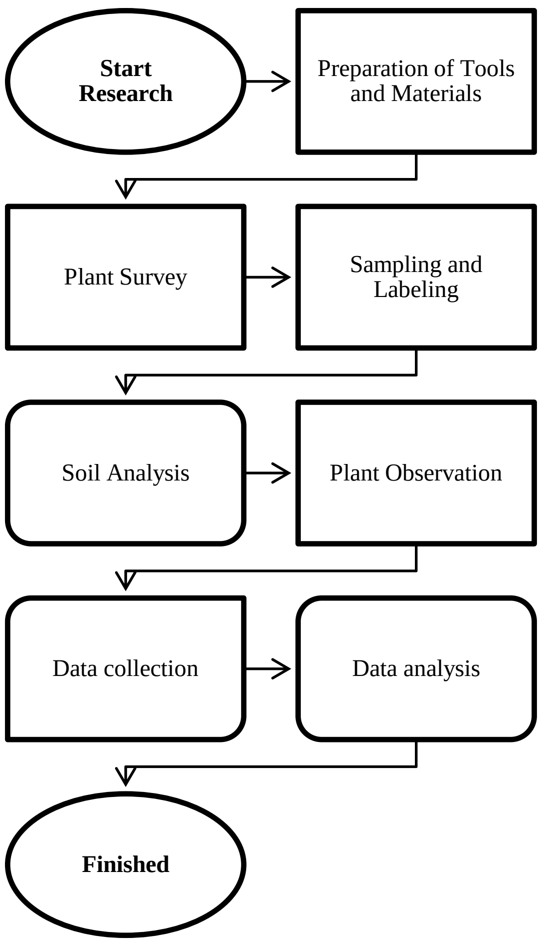


Figure 1. Research Flow Diagram

3. Results and Discussion

Based on the research that has been conducted, the following results were obtained:

3.1. Plant Sampling Determination

Red calliandra plants (*Calliandra calothyrsus*) were intentionally planted by PT Semen Padang. The seeds were sourced from nurseries, including those at PT Semen Padang and in Payakumbuh City and Padang Pariaman Regency.

Planting has been conducted in several locations, including three sites in this study. At each site, a survey was performed to collect sample plants that met the specified criteria: plants already flowering. A total of ten plants were selected as samples from each location to observe their agronomic characteristics.

3.2. Soil analysis

Soil analysis was conducted to determine each location's soil condition and nutrient content. The results of the soil analysis can be seen in Table 1.

The soil at Location L1 is brown, sandy, and rocky because the location was filled with soil from a former limestone mine. At L2, it is located in a limestone mine with yellow, sandy, clayey, and rocky soil. At the same time, L3 is an empty land or former farmer's farm with black and crumbly soil conditions.

Former limestone mining land is categorized as critical or marginal land due to low soil fertility due to continuous mining (Andriani et al., 2019). This can be seen in Table 2; the content of C-Organic (1.98% and 0.001%) and N (0.03% and 0.01%) in L1 L2 is classified as very low.

Soil chemical analysis from locations L1, L2, and L3 showed that macro and micro soil nutrient condition plays a major role in the vegetative and generative growth of red calliandra plants. Location L2 has the highest pH (7.22), which is in the neutral category, while L1 and L3 have slightly acidic pH (6.82 and 6.21).

Table 1. Results of Soil Analysis at Five Sample Locations

Types of Analysis	Sample Location		
	L1	L3	L5
pH (H2O) (1:5)	6.82 n	7.22 n	6.21 am
C-Organic (%)	1.98 r	0.001 sr	4.77 t
N-Total (%)	0.03 sr	0.01 sr	0.31 s
P-Total (mg P205/100g)	42.87 t	59.92 t	38.16 s
K-Total (mg P205/100g)	44.56 t	35.89 s	31.01 s

Description: n: neutral, am: slightly sour, sr: very low, r: low, s: medium, t: high

Neutral soil pH can increase the availability of phosphorus (P) and calcium (Ca), which are essential in the formation of stem and root tissue, so that L2 tends to support the enlargement of stem diameter (Zhao et al., 2021). However, the very low C-organic and N-total content in L2 inhibits the growth of the number and size of leaves because the elements C and N play an essential role in forming chlorophyll and complex organic compounds in leaves. (Sun et al., 2020).

Higher K in L1 (44.56 mg P_2O_5 /100g) also increased plant resistance to environmental stress, improved stomatal function, and increased photosynthetic efficiency, which ultimately increased the number of leaves and maintained stem growth. (Chen et al., 2020).

In contrast, in L1 and L3, which have a slightly acidic pH (6.82 and 6.21), plants benefit from relatively higher C-Organic and N-Total content, especially in L3 (C-Organic 4.77%, N-Total 0.31%). The availability of C and N encourages vegetative growth in the form of better leaf number, leaf length, and width because N supports the formation of chlorophyll and other essential compounds for photosynthesis. (Sun et al., 2020)

The relationship between soil variables and vegetative growth greatly determines the reproductive phase of plants. Plants with sufficient C and N elements will be more optimal in multiplying leaves and enlarging leaf size. At the same time, soil with P and K support supports stem diameter growth and complex tissue formation. Therefore, balanced soil nutrient management is essential to optimize both vegetative growth and generative development of red calliandra.

3.3. Observation of the morphology of red calliandra plants

3.3.1. Stem

Observations of the red calliandra stems observed were stem diameter and stem color. The results of observations of the red calliandra stem diameter can be seen in Table 2.

Table 2. Results of quantitative observations of the characteristics of red calliandra stems

Sample Code	Stem Diameter (cm)		
	L1	L2	L3
01	3.2	4.7	4.4
02	4.3	3.8	3.8
03	2.5	8.9	2.8
04	2.5	5.7	3.1
05	2.2	5.4	4.7
06	1.9	6	4.1
07	3.5	6.6	4.7
08	2.9	5.4	3.5
09	3.2	4.7	2.5
10	3.5	5.7	2.2

Based on the results of observations of the stem diameter of red calliandra, there is quite an apparent variation between locations. Location L2 generally shows a larger stem diameter, such as in samples 03 (8.9 cm) and 07 (6.6 cm), compared to L1 and L3. This variation can be closely related to soil nutrient conditions. Location L2 has a neutral soil pH (7.22) and a high P-Total of 59.92 mg P_2O_5 /100g. P plays an essential role in stimulating strong root growth and nutrient transport systems in plants, which has an impact on increasing stem diameter(Zhao et al., 2021b)

In addition, although the C-organic content in L2 is very low (0.001%), the presence of high phosphorus can still compensate for the metabolic energy needs of plants for structural growth. P increases the synthesis of ATP needed in cell division and elongation (Vance et al., 2020).

The role of K in L1, which is relatively high (44.56 mg P_2O_5 /100g), also needs to be considered. Potassium is crucial in regulating osmotic pressure and strengthening cell walls, thus supporting stem rigidity (Hasanuzzaman et al., 2018). However, because the N content in L1 is very low (0.03%), stem tissue growth may be less than optimal overall, as seen in sample 06 (1.9 cm) with the most minor diameter. In contrast, L3, although it has a higher C-organic content (4.77%) and N-Total (0.31%), shows a relatively smaller stem diameter, such as sample 10 (2.2 cm). This indicates that N and C-organic promote more vegetative growth, such as leaves, than stem thickening (Zhang et al., 2023). In addition, high total K in L1 (44.56 mg P_2O_5 /100g) helped strengthen the stem structure, although diameter growth remained suboptimal due to low nitrogen content (Xu et al., 2024).

Table 3. Results of qualitative observations of the characteristics of red calliandra stems

Character	Type	Percentage	Sample Code
Bar Color	Reddish brown 	65%	L101-L110, L201-L210,
	Dark reddish green 	25%	L502, L504-L510
	Yellowish green 	10%	L501, L503

Based on the observation results shown in Table 3, the color of the stem of the red calliandra plant (*Calliandra calothyrsus*) is dominated by reddish brown with a percentage of 65%. This stem color reflects the typical morphological characteristics of red calliandra, which generally show adaptation to tropical environmental conditions with high light intensity. The dominance of this reddish brown color is thought to be related to the content of secondary metabolite compounds, such as phenolics and tannins, which function as a plant defense system against pathogen attacks and environmental stress.(Rahman et al., 2021).

The presence of dark green-reddish color variations on the stem also reflects differences in the level of lignification and development of plant tissue. In addition, the expression of stem color is influenced by external factors such as light intensity, water availability, and soil nutrients, which also affect the accumulation of pigments and the level of plant metabolism (Widodo et al., 2017). In addition, the stem also appears dark green-reddish, which is likely related to the development stage of the young stem towards the old stem. This color variation is essential to support the identification of morphology and the potential for plant adaptation to the environment. (Siregar & Ginting, 2018). Therefore, observing stem color is essential in the selection and development program for red calliandra for various agroforestry and land rehabilitation purposes.

3.3.2. Leaf

Observations of red calliandra leaves can be seen in Table 4 and Table 5.

Table 4. Results of qualitative observations of the characteristics of red calliandra leaves

Character	Type	Percentage	Sample Code
Leaf Type	Compound Paired/dual	100%	L1, L2, L3
Leaf Shape	Lancet	100%	L1, L2, L3
Leaf Bone Shape	Fins	100%	L1, L2, L3
Leaf Tip Shape	Tapered	100%	L1, L2, L3
Leaf Base Shape	Blunt	100%	L1, L2, L3
Leaf Edge Shape	Flat	100%	L1, L2, L3

Based on the observation results in Table 6, the morphological characteristics of red calliandra leaves (*Calliandra calothyrsus*) show high uniformity with a percentage of 100% in all samples (L1, L2, L3). Red calliandra leaves are compound in pairs/double, with a lanceolate shape, pinnate leaf veins, pointed leaf tips, blunt leaf bases, even leaf edges, and green leaf color. The compound leaf type increases the total surface area of light absorption, which is very important for photosynthesis efficiency in environments with high light intensity. (Siregar & Ginting, 2018)

The lanceolate shape and tapered leaf tips are morphological adaptations that support the efficiency of rainwater flow from the leaf surface, thereby reducing the risk of fungal infections and leaf diseases in humid environments (Rahman et al., 2021). The pinnate leaf veins provide additional mechanical strength to the leaves, allowing the plant to withstand wind stress or heavy rain while facilitating the distribution of nutrients throughout the leaf surface. The uniform green color of the leaves indicates optimal chlorophyll levels, reflecting good photosynthetic capacity and physiological adaptability of the plant to tropical environmental conditions (Widodo et al., 2017).

Overall, the uniformity of leaf morphological characters strengthens the potential of red calliandra to be used in agroforestry programs, soil conservation, and critical land rehabilitation, considering its ability to adapt to various environmental conditions.

Table 5. Results of observations of the characteristics of red calliandra leaves

Code Sample	Observation Character				
	PHD (cm)	LHD (cm)	PAD (cm)	LAD (cm)	JAD (psg)
L101	35	17.5	8.3	1.1	18
L102	23.6	11.3	7.2	1.1	14
L103	28	15.3	8.1	1.4	17
L104	24.4	11.2	6.7	1.1	17
L105	24.8	16.6	8.9	1.3	13
L106	20.5	13.4	7.2	1.1	13
L107	24.6	10.6	7.5	1.0	15
L108	26.2	14	8.3	1.3	18
L109	26	16.3	8	1.0	12
L110	27.2	14.6	8.2	1.3	14
L201	28	15.3	8.7	1.1	15
L202	29.2	15.2	8.3	1.1	16
L203	23.2	15.4	7.2	1.1	16
L204	19.6	14	6	0.8	17
L205	31	18.2	8.6	1.1	2 0
L206	17 ,5	1 7	9 , 4	1.5	11
L207	24	13	7.1	1.4	13
L208	33.1	14.8	8.1	1.4	20
L209	21.7	9.2	5.9	0.7	16
L210	19.4	12.5	5.5	1.0	18
L301	26.5	19.6	8.6	1.6	13
L302	28.3	13.8	7.7	1.6	18
L303	29.4	16.5	7.2	1.1	18
L304	29.4	18	8.5	1.2	16
L305	30.3	16	8	1	20
L306	37.7	20.5	10.4	1.1	17
L307	28.5	17.5	8.25	1	13
L308	36.7	19.1	9.5	1.2	20
L309	29.5	16	7.65	0.9	17
L310	27.5	18	7.95	1	15

Description: PHD (Leaf Blade Length); LHD (Leaf Blade Width); PAD (Leaflet Length); LAD (Leaflet Width); JAD (Number of Leaflets)

Variations in the size and number of leaf parts were observed based on the characteristics of red calliandra leaves. The length of the leaf blade varies from 17.5 cm to 37.7 cm. L308 (3.7 cm) has the most extended leaf blade length, indicating the plant's ability to adapt to lighting conditions and high photosynthesis needs. Longer leaves can increase the surface area of photosynthesis, thereby supporting plant growth in competitive environments.(Poorter et al., 2009).

Figure 2. Red Calliandra leaves Red

Leaf blade width showed variation from 9.2 cm to 20.5 cm. The widest leaf width was in L306 (20.5 cm), which increases the total photosynthetic area, which is essential to capture more light, especially in partial shade conditions. Conversely, narrower leaves function to reduce water loss through transpiration in environments with high light intensity and high temperatures. (Taiz et al., 2015)

The length of the leaflets shows a variation from 5.5 cm to 10.4 cm. The longest leaflets are found in L306 (10.4 cm). The width of the leaflets shows a variation from 0.7 cm to 1.6 cm. The widest leaflets are found in L301 and L302 (1.6 cm). The length and width of these leaflets are closely related to the number of leaflets because the more and longer the leaflets, the greater the plant's photosynthetic capacity(Valladares & Niinemets, 2008). The number of leaflets varies between 11 and 20 pairs of leaflets per leaf blade. The largest number of leaflets, namely 20, is found in several samples at two locations. The large number of leaves indicates an adaptive strategy to increase the total photosynthetic area. However, the increase in the number of leaflets must be balanced with the supply of macronutrients such as nitrogen (N) to support leaf tissue growth and prevent deficiency. (Marschner, 2012)

The relationship between variables shows that the length and width of the leaf blade are positively related to the length and number of leaflets. Large parent leaves provide space and support for forming more and larger leaflets. Environmental conditions such as water availability, micronutrients (such as Zn and Fe), and macronutrients (such as N and K) greatly influence the synergistic development of these structures.(Mengel & Kirikby, 2001).

Observation results show variations in red calliandra leaves from 5GY 5/6 to 7.5 GY 3/4, with the dominant color in the 7.5 GY ¾ group (43.3%). This color difference is closely related to the chlorophyll content, which is directly influenced by the availability of microelements, especially iron (Fe), magnesium (Mg), and zinc (Zn). Iron (Fe) is essential for forming chlorophyll because it is a cofactor in the chlorophyll biosynthesis enzyme. At the same time, magnesium (Mg) is the atomic nucleus in the structure of the chlorophyll molecule itself (Marschner, 2012). Deficiency of the element Fe usually causes chlorosis symptoms (yellowing of the leaves) due to disruption of chlorophyll formation, while Mg deficiency can cause chlorosis between leaf veins(Mengel & Kirikby, 2001)

Table 6. Observation Results of the Color Character of Red Kaliandra Leaves Red

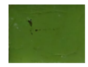
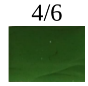
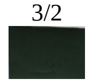
Character	Type	Percentage	Sample Code
Flower Color	5GY 5/6 	3.3%	L105
	5GY 4/6 	3.3%	L104
	5GY 4/8 	6.7%	L306, L308
	5GY 3/4 	16.7%	L101, L202, L210, L302, L307
	7.5GY 4/2 	3.3%	L204
	7.5GY 4/6 	3.3%	L102
	7.5GY 3/2 	20%	L109, L203, L205, L206, L207, L310
	7.5GY 3/4 	43.3%	L103, L106, L107, L108, L110, L201, L208, L209, L301, L303, L304, L305, L309

Figure 3. Comparison of Red Calliandra Leaf Colors

In addition to nutritional factors, differences in leaf color are also influenced by environmental conditions. High light intensity can increase reactive oxygen species (ROS) production, which accelerates chlorophyll degradation and results inaler or yellowish leaf colors (Taiz et al., 2015). Conversely, plants grown in shaded areas tend to retain more chlorophyll, resulting in darker green leaves. Extreme temperatures also contribute to physiological stress that accelerates chlorophyll degradation. For example, photosynthetic enzymes become unstable at high temperatures, which ultimately accelerates leaf discoloration (Yamori et al., 2014). In addition, low water availability will cause stomata to close, reducing photosynthesis and chlorophyll production, resulting in duller leaf colors.

Thus, leaf color variations in red calliandra reflect not only the micronutrient status of the soil but also the adaptation to environmental conditions such as light intensity, water availability, and temperature. Therefore, leaf color observations can be used as physiological indicators to assess plant health and the quality of the growing environment.

3.3.3. Flowers

Table 7. Results of observations of the characteristics of red calliandra flowers

Sample Code	Observation Variables								
	Stamen Length (cm)			Length of Pistil (cm)			Number of Stamens		
	L1	L2	L3	L1	L2	L3	L1	L2	L3
01	5.6	5.7	6.7	6.5	7.5	5.8	33	32	34
02	4.4	6.4	5.8	6	4.8	7.4	31	30	36
03	4.4	5.3	5.8	5.8	4.9	7.4	31	34	32
04	6.8	5.1	6	5.2	6.7	6.9	29	35	35
05	4.9	5.4	5.8	7	6.3	7.2	30	29	32
06	5.6	6.3	5.4	6.5	4.8	5.9	24	29	39
07	5.4	4.3	5.5	7	5.5	5.8	32	31	35
08	5.5	4.6	5.4	6.7	5.6	6.4	31	30	32
09	6.2	4.8	5.4	7.8	7.3	6.9	36	30	33
10	5.4	5.3	5.7	7	4.8	6.8	30	33	30

The results of observations of the characteristics of red calliandra flowers show that the length of the stamens varies between 4.1–6.7 cm, the length of the pistil between 4.8–8.0 cm, and the number of stamens between 29–34 strands. The length of the pistil is generally longer than the stamens, which indicates the presence of a herkogamy mechanism, namely the separation of the positions of the male and female reproductive organs to reduce the possibility of self-pollination and increase the opportunity for cross-pollination (Barret, 2002).

These length differences are evolutionary adaptations to increase genetic diversity within a population. In addition to genetic factors, the availability of soil nutrients, such as nitrogen (N) and zinc (Zn), also contribute to optimal flower organ development (Taiz et al., 2015). These length variations may also be influenced by microenvironmental factors such as light intensity and humidity, which have been shown to impact reproductive organ differentiation in tropical plants (Sarkar et al., 2017).

The relatively stable number of stamens suggests that the quantity of these reproductive structures is maintained as part of the plant's reproductive strategy and is more controlled by genetic factors than environmental factors. (Barret, 2002). This variation in the morphology of the reproductive organs also serves as an adaptation to increase the chances of successful pollination, especially in dynamic tropical ecosystems, where changes in light and humidity can affect flower formation.(Sarkar et al., 2017).

Table 8. Results of observations of the color of red Kaliandra flowers

Character	Type	Percentage	Sample Code
Flower Color	5R 5/10	3.33%	L205ab
	5R 4/6	8.33%	L207ab, L207d, L209b, L210a, L304a
	5R 4/8	3.33%	L201a, L203a
	5R 3/4	33.33%	L102aB, L104aB, L105aB, L106a, L107aB, L110aB, L210b, L302ab, L305ab, L306a, L308ab, L309b
	5R 3/6	38.33%	L103ab, L106b, L108b, L109ab, L202a, L203b, L204ab, L206ab, L208ab, L209a, L301ab, L303ab, L306b, L307ab, L310b
	5R 3/8	13.33%	L101ab, L108a, L201b, L202b, L304b, L309a, L310a
Flower shape	Sign	100%	L1, L3, L5

Figure 4. Red Calliandra leaves Red

Figure 5. Comparison of the Colors of Red Calliandra Flowers

Based on the observation results of the red calliandra flower characters (L1, L3, and L5), the flower color is known to be dominated by the 5R 3/6 and 5R 3/8 types with a percentage of 38.33% each. The color of this type shows a dark red hue with moderate to vigorous color intensity. The dominance of this color indicates that most of the red calliandra population has genetic stability in expressing red pigments, which is closely related to the anthocyanin content in flower tissue. (Siregar & Ginting, 2018).

In addition to the dominant color type, there are other color types, such as 5R 5/10, 5R 4/6, 5R 4/8, and 5R 3/4, although with a much smaller percentage (3.33% to 8.33%). These flower color variations occur due to a combination of several factors, namely genetic variation between individuals, the influence of environmental conditions (such as light intensity, temperature, and humidity), and the availability of certain microelements in the soil. Anthocyanin, as the primary pigment that causes red color in flowers, its synthesis is greatly influenced by genetic factors and environmental factors; for example, low temperatures can increase anthocyanin production so that the flower color becomes more intense (Widodo et al., 2017).

The shape of the flower cluster supports pollination efficiency, especially in attracting pollinators such as bees, which are essential for the continuity of generative reproduction of red calliandra plants. The stability of the shape of the flower cluster also indicates that environmental factors have a more negligible effect on flower morphology than flower color (Rahman et al., 2021).

4. Conclusion

Based on the research findings, it was concluded that the age of the plants is the primary factor influencing the agronomic performance of red calliandra. Additionally, the nutrient content of the soil—particularly phosphorus (P), organic carbon (C), nitrogen (N), and potassium (K)—significantly affects the growth of stem diameter, leaf quantity, leaf length and width, and flower development. A neutral soil pH at location L2 enhances stem diameter growth, while elevated levels of organic carbon and nitrogen at location L3 promote increased number and size of leaves.

Acknowledgment

Andalas University funds this Research following the Research Contract for Undergraduate Thesis Research (Pss) Batch I Number: 118/Un16.19/Pt.01.03/Pss/2024 Fiscal Year 2024.

References

Andriani, R., Hesti, K., & Sriwulan. (2019). Inventarisasi tumbuhan pionir lahan bekas tambang kapur di Kecamatan Rengel Kabupaten Tuban Jawa Timur. *BIOTROPIC: The Journal of Tropical Biology*, *3*(1), 56–61.

Barrett, S. C. H. (2002). The evolution of plant sexual diversity. *Nature Reviews Genetics*, *3*(2), 274–284.

Chen, Q., Zhang, X., & Zhou, W. (2020). Influence of potassium nutrition on plant physiology and resistance to environmental stress. *Frontiers in Plant Science*, *11*, 1240.

Kementerian Kehutanan. (2014). *Budidaya kaliandra merah (Calliandra calothyrsus) untuk bahan baku sumber energi*. IPB Press.

Marschner, H. (2012). *Marschner's mineral nutrition of higher plants* (3rd ed.). Academic Press.

Mengel, K., & Kirkby, E. A. (2001). *Principles of plant nutrition* (5th ed.). Kluwer Academic Publishers.

Orwa, C., Kindt, A., Jamnadass, R., & Anthony, S. (2009). *Agroforestree database: A tree reference and selection guide version 4.0*. World Agroforestry Centre.

Poorter, H., Niinemets, Ü., Poorter, L., Wright, I. J., & Villar, R. (2009). Causes and consequences of variation in leaf mass per area (LMA): A meta-analysis. *New Phytologist*, *182*(3), 565–588.

PT Semen Padang. (2023, December 6). Semen Padang tanam 2.000 *kaliandra merah* untuk substitusi batubara. *Semenpadang.co.id*.

Rahman, M., Fitriani, N., & Sukmawati, D. (2021). Adaptasi morfologi daun tanaman tropis terhadap faktor lingkungan. *Jurnal Ilmu Pertanian Tropis*, *6*(1), 33–41.

Sarkar, R. K., Das, B. S., & Bhattacharya, A. (2017). Environmental regulation of flower morphology in tropical plants. *Tropical Plant Biology*, *10*(2), 120–130.

Siregar, I. Z., & Ginting, A. N. (2018). Kajian morfologi dan adaptasi tanaman *kaliandra merah* (*Calliandra calothyrsus*). *Jurnal Agroforestri Indonesia*, *2*(1), 12–20.

Stewart, J., Mulawarman, Roshetko, M. J., & Powell, M. H. (2001). *Produksi dan pemanfaatan kaliandra merah (Calliandra calothyrsus)*. International Centre for Research in Agroforestry (ICRAF).

Sun, X., Zheng, S., & Zhang, S. (2020a). Effects of soil organic carbon on plant nutrient uptake and biomass production. *Soil Science and Plant Nutrition*, *66*(1), 89–98.

Sun, X., Zheng, S., & Zhang, S. (2020b). Effects of soil organic carbon on plant nutrient uptake and biomass production. *Soil Science and Plant Nutrition*, *66*(1), 89–98.

Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). *Plant physiology and development* (6th ed.). Sinauer Associates.

Valladares, F., & Niinemets, Ü. (2008). Shade tolerance, a key plant feature of complex nature and consequences. *Annual Review of Ecology, Evolution, and Systematics*, *39*, 237–257.

Vance, C. P., Uhde-Stone, C., & Allan, D. L. (2020). Phosphorus acquisition and use: Critical plant adaptations for securing a nonrenewable resource. *New Phytologist*, *157*(3), 423–447.

Widodo, W., Sutrisno, & Nugroho, J. T. (2017). Pengaruh faktor lingkungan terhadap pertumbuhan dan karakter morfologi tanaman. *Jurnal Agroteknologi Tropika*, *5*(2), 85–92.

Yamori, W., Hikosaka, K., & Way, D. A. (2014). Temperature response of photosynthesis in C_3, C_4, and CAM plants: Temperature acclimation and adaptation. *Photosynthesis Research*, *119*(1–2), 101–117.

Zhao, Y., Wang, P., Li, J., & Li, Y. (2021a). Soil pH regulates the availability of phosphorus and growth of crops in acid soils. *Environmental Research and Public Health*, *18*(15), 78–96.

Zhao, Y., Wang, P., Li, J., & Li, Y. (2021b). Soil pH regulates the availability of phosphorus and growth of crops in acid soils. *Environmental Research and Public Health*, *18*(15), 78–96.