Vol. 13, No. 2 (2024): 429 - 440 http://dx.doi.org/10.23960/jtep-l.v13i2.429-440

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Effectiveness of Bamboo Leaf Silica Applied with Nanosprayer and Growing Media on Yield of Red Beetroot (*Beta vurgaris* L.)

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Article History:

Received : 15 October 2023
Revised : 18 February 2024
Accepted : 07 March 2024

Keywords:

Chlorophyll,
Husk Charcoal,
Manure,
Soil.

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ABSTRACT

Silica protects plants from abiotic stress. Planting media provides a place to grow and nutrition for plant growth. The research aims to study the effect of bamboo leaf silica dosage and growing media on the yield of red beets cultivated in the lowlands. The research was designed using a completely randomized factorial design (CRD) with two treatment factors. The first factor is the dose of bamboo leaf silica fertilizer (0 ppm, 0.15 ppm, 0.30 ppm, 0.45 ppm, 0.60 ppm). The second factor is the growing media (soil growing media; soil growing media + goat manure, and soil growing media + goat manure + husk charcoal). Research results: bamboo leaf silica dosage (0.3 ppm, 0.45 ppm and 0.60 ppm) affects the chlorophyll b and total chlorophyll. Growing media soil + goat manure + husk charcoal affects the length of red beet plants, number of leaves, diameter and length of red beetroots, wet weight and dry weight of red beetroots. Combination of growing media treatment (soil + goat manure + husk charcoal) with all doses of bamboo leaf silica increased the chlorophyll a, chlorophyll b and total chlorophyll. The sugar content of red beetroots was not influenced by the dose of bamboo leaf silica or the growing medium.

1. INTRODUCTION

The origin of the beet plant comes from the Middle East and then spreads to the Mediterranean region, this plant spread and can grow throughout the world. The characteristic feature of beet plants is that they have roots that swell to form tubers so they are classified as tuber plants. The tubers and leaves can be consumed. The leaves are consumed as fresh vegetables or salad. The young leaves of beet plants are rich in secondary metabolites such as flavonoids and polyphenols so they are good for consumption as fresh vegetables (Takács-Hájos & Vargas-Rubóczki, 2022). More people consume beets for various reasons, especially for health. Red beets contain betalains, antioxidants, vitamins, minerals, and ascorbic acid (Akan *et al*., 2021). Red beetroot can be used as a therapeutic food to treat and prevent anemia (Putri & Tjiptaningrum, 2016).

Red beet plants have been widely developed in Indonesia, especially on the island of Java. Red beets are cultivated in cold mountainous areas. Red beet tubers have high economic value. Red beet cultivation is feasible for farmers to carry out (Sitepu *et al*., 2022). Efforts to cultivate red beet plants in the medium and lowlands have begun. During vegetative growth, beet plants require cold temperatures and are still tolerant of high temperatures of ±35^{0}C (Takács-Hájos & Vargas-Rubóczki, 2022). Plant breeding efforts are carried out to produce red beet plant varieties that are able to withstand abiotic and biotic stresses, thereby producing the best harvest. Red beet varieties have important role in determining tuber enlargement and wet weight of harvested tubers (Astuti *et al*., 2021; Dewi *et al*., 2022). Red beets planted in the lowlands can still grow well and produce tubers. Determining red beet varieties to be planted in medium and lowland areas needs to be considered in order to plant varieties that are tolerant of the local microclimate.

Lowlands are synonymous with hot air temperatures and low air humidity. A hot growing environment can inhibit the growth of plants that normally grow in cold areas such as red beets. Red beet plants have resistance to environmental stress (Yolcu *et al*., 2021). The availability of water and nutrients in the growing area can encourage plants to defend themselves from stress in the growing environment. Providing sufficient fertilizer and watering has an effect on the growth of red beets (Zulfati *et al*., 2018; Dewi *et al*., 2022). Sufficient macro and micro fertilizers available for plant absorption are expected to maintain the growth of red beet plants and increase resistance to environmental stress. Silica is a non-essential micro nutrient whose availability improves plant growth and whose absence does not interfere with plant growth. Silica is useful for increasing plant resistance to drought and increasing photosynthetic activity, as well as increasing the thickness of plant cell walls. Silica encourages photosynthetic activity by increasing the stomata conductivity of plant leaves experiencing drought stress (Santi *et al*., 2018). Silica plays a role in the formation of cell walls, thus stimulating plant growth and silica that accumulates in fruit skin can increase fruit shelf life (Triadiati *et al*., 2019). Silica is obtained from various sources in nature. Bamboo leaves have a fairly high silica content and are a source of silica for making silica fertilizer (Hasri *et al*., 2020; Wibowo *et al*., 2020). Silica spraying application using a nanosprayer so that silica is more effectively absorbed by red beet plants. Nanosprayer technology is designed to produce spray droplets with the sprayed particle size becoming smaller to nano-sized and the spray process is fast (Almansour *et al*., 2022).

Growing media that is not dense, loose, sandy loam, and contains organic fertilizer is good for growing red beets and forming tubers. The shaft growing medium prevents the plants from being waterlogged for a long time so that the beet tubers do not rot. Beetroot plants grow well in growing media that has lots of air space. The composition of the planting media influences yield of red beet in the lowlands (Wildasari *et al*., 2019). The presence of husk charcoal in the soil can break down the density of the soil so that soil porosity increases. The cavities in the charcoal husk function to hold air and water in the soil, as well as a place for soil microorganisms to live. Husk charcoal contains more carbon, so it will increase the amount of carbon in the soil. Husk charcoal can increase soil pH. Husk charcoal improves the physical properties of soil, increases the diversity of soil microorganisms, and stimulates plant growth (Mishra *et al*., 2017).

The research aims to study the response of red beet plants of the Ayumi variety to bamboo leaf silica spraying applied with a nano sprayer and planting media containing goat dung and husk charcoal. Cultivated beet plant varieties have high adaptation to lowland agroclimates. By spraying silica and providing planting media that is dense and contains organic fertilizer, it is possible to increase the resistance to growing red beet in the lowlands.

2. MATERIALS AND METHODS

The research was carried out in the greenhouse and laboratory of the Agrotechnology Department at Universitas Darussalam Gontor for 3 months from December 2022 to February 2023. The materials used in this research were polybags (30 x 35 cm), nano sprayer, ruler, caliper, analytical balance, Erlenmeyer, measuring flask, glass beaker, volumetric pipette, spectrophotometer, refractometer, Ayumi variety red beet seeds, bamboo leaf silica fertilizer, NPK fertilizer (15:15 :15), soil, goat manure and husk charcoal, ethanol, distilled water.

Silica is extracted from the leaf litter of ori bamboo (*Bambusa blumeana*), which has fallen to the ground. Bamboo leaf litter was collected from under ori bamboo plants (*B. blumeana*) located in Ponorogo, East Java, Indonesia. Silica from ori bamboo leaf litter (*B. blumeana*) is extracted with NaOH using the hydrothermal sol-gel method, according to Hamawi *et al*., (2023). The size of the extracted silica particles is 47 µm.

2.1. Research Design and Data Analysis

This research was designed using a completely randomized factorial design (CRD) with two treatment factors arranged factorially (Table 1). The first factor is the application dose of bamboo leaf silica fertilizer in ppm (parts per million) units. The second factor is the growing media. The dose of bamboo leaf silica used in this research was determined following the results of research by Triadiati *et al*. (2019), who found that a silica dose of 0.67 ppm can increase plant height and the number of leaves of melon plants. From these two factors get 15 treatment combinations. Each treatment will be repeated 3 times, resulting in 15 x 3 = 45. Three sample plants will be used in each treatment unit, resulting in 3 x 45 = 135 plants (Figure 1). The ANNOVA test was carried out to study the effect of the treatment being tested. If there is a significant influence on the observed parameters, then proceed with the Least Significant Difference (LSD) test at the α level of 5%.

Table 1. Research treatment factors

Factor I (Bamboo leaf silica fertilizer)		Factor II (Growing media)	
Control 0,00 ppm	(D_0)	soil	(M_0)
Bamboo leaf silica 0,15 ppm	(D_1)	soil + goat manure = 1:1 v/v	(M_1)
Bamboo leaf silica 0,30 ppm	(D_2)	soil+ goat manure + husk charcoal = 1:1:1 v/v	(M_2)
Bamboo leaf silica 0,45 ppm	(D_3)		
Bamboo leaf silica 0,60 ppm	(D_4)		

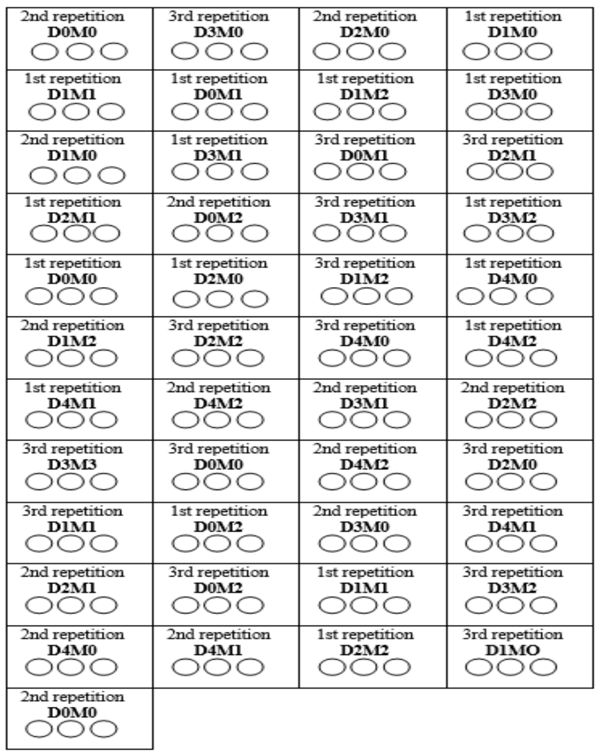

Figure 1. The lay out of the experimental design plan

2.2. Stages of Research

2.2.1. Preparation of Growing Media

Preparation of growing media was started by filling polybags (30 x 35 cm) with the composition of growing media according to the treatment. Growing media treatments were: 1) Soil, 2) Soil + Goat Manure (1:1 v/v), 3) Soil + Goat manure + Husk Charcoal (1:1:1 v/v). Each polybag contained 3.5 kg of growing media. The type of soil used in the research was Vertisol because the paddy soil around the research site is Vertisol.

2.2.2. Planting Red Beet Seeds

Planting was done by directly planting red beet seeds in the planting medium, without seeding. Planting was done by planting red beet seeds into the planting hole (one seed in each hole). Before planting, the seeds were soaked in warm water and left to soak for 12 h, then drained.

2.2.3. Fertilization

Fertilization was carried out using bamboo leaf silica fertilizer according to the treatment dose and sprayed on the plants at 3 weeks after planting. The treatment doses of bamboo leaf silica were 1) Control (0.00 ppm), 2) 0.15 ppm, 3) 0.30 ppm, 4) 0.45 ppm, and 5) 0.60 ppm. Fertilizer 0.30 N g per plant in NPK fertilizer (15:15:15) was given 2 times, namely at 2 and 4 weeks after planting (WAP) (Zulfati *et al*., 2018).

2.2.4. Plant Maintenance

Watering was done at intervals of 2 - 3 days or according to soil moisture. Maintain soil moisture at field capacity was carried out by watering. Ant attack was controlled by sprinkling Furadan '3GR pesticide around the plants.

2.2.5. Harvesting

Harvesting is carried out when the red beets are 60 days after planting. Harvesting is done by uprooting the red beet plants, before removing, water is sprinkled to make the soil loose and easy to remove.

2.2.6. Observed Parameters

In this study, various observations were made with the observed parameters including: plant height (cm), number of leaves, leaf chlorophyll (mg/l) which was analyzed using the Wintermans & De Mots method (Lu *et al*., 2019), the diameter and length of red beet tubers (cm), wet and dry weight of red beet tubers (g), sugar content of tubers (%) which was measured using a refractometer.

3. RESULTS AND DISCUSSION

3.1. Plant Height (cm)

The results of the interaction between the treatment dose of bamboo leaf silica fertilizer and the growing media had no effect on plant height. Separately, the growing media treatment had an effect on the height of the red beet plants (table 2). Observations at ages 6 and 8 WAP (week after planting) showed that the application of 0.6 ppm bamboo leaf silica tended to produce the highest height of red beet plants, namely 38.98 cm and 41.48 cm, although it was not significantly different from other bamboo leaf silica doses. At the age of 8 WAP, the height of red beet plants, the treatment with a mixture of soil, goat manure and husk charcoal, resulted in a plant height of 42.44 cm, which was significantly different from the soil growing media (34.62 cm).

Treatment with a dose of 0.60 ppm bamboo leaf silica tended to increase the height of red beet plants, although it was not significantly different from the other doses. All experimental samples of red beet plants were fertilized with 0.30 N g per plant twice. Providing 0.45 N g fertilizer per plant and 0.60 N g per plant increased the height of red beet plants (Zulfati *et al*., 2018). Sufficient nitrogen ensures that red beet plants do not experience problems with plant height growth. Bamboo leaf silica has the potential to increase the height of red beet plants, so the dose needs to be

Table 2. Average height of red beet plants due to treatment with bamboo leaf silica fertilizer and growing media.

Treatments	Plant height (cm)			
	2 WAP	4 WAP	6 WAP	8 WAP
D_0	25.07 a	27.15 a	37.18 a	38.74 A
D_1	24.63 a	26.41 a	37.30 a	39.26 A
D_2	25.26 a	27.41 a	34.93 a	37.08 A
D_3	24.33 a	26.22 a	37.04 a	39.37 A
D_4	23.78 a	25.74 a	38.94 a	41.48 A
LSD 5%	-	-	-	-
M_0	22.00 a	24.07 a	33.40 a	34.62 A
M_1	24.89 ab	26.71 ab	38.63 b	40.49 B
M_2	26.96 b	28.98 b	39.20 b	42.44 B
LSD 5%	4.14	4.37	4.31	4.26

Note: Numbers marked with the same letter in the same column are not significantly different in the 5% LSD test. Treatment codes refer to Table 1.

increased considering the importance of silica for plant growth. Silica fertilization can increase plant height growth, silica increases the efficiency of photosynthesis and nutrient absorption in the soil (Fitriani & Haryanti, 2016; Putri *et al*., 2017; Hoang *et al*., 2022). Providing 7.5 ml/L nano silica fertilizer increased the height of black rice plants by Putri *et al*., (2017). Applications 2.5 ml/L nano silica fertilizer increases the height of tomato plants (Fitriani & Haryanti, 2016). Meanwhile, research results from Hoang *et al*., (2022) reported that spraying 6.7 mg/L nano silica fertilizer twice spraying could increase the height of corn plants. Fertilizing via leaves and roots as one of the agricultural intensification efforts is an effort that aims to increase the supply of nutrients needed by plants to increase production and quality of crops. The Si nutrient is useful in supporting healthy plant growth.

Soil growing media produced the lowest height of red beet plants and was significantly different from growing media mixed with goat manure and husk charcoal (table 2). The land used for cultivation is Vertisol soil. Soil type influences the height growth of corn plants (Genesiska *et al*., 2020). Vertisol soil contains a lot of clay and has poor aeration. Goat manure and husk charcoal help the Vertisol soil become looser so that aeration is better. Soil mixed with organic materials increases the height of beet plants. The dose of N fertilizer affects the growth of the height of the beet plant, however the dose of N fertilizer in growing media that contains enough organic material does not have a significant effect on the height of the red beet (Nuryanti *et al*., 2023).

The height of red beet plants cultivated in the lowlands depends on the seed variety used. Variety influences the height of red beet plants cultivated in the lowlands (Astuti *et al*., 2021). The red beet variety used for research has the ability to adapt to lowland agroclimatic which tend to be hot (table 3). The application of 0.6 g N per plant in NPK fertilizer in this study was sufficient to help beet plants adapt to hot temperatures. Sufficient N fertilization (1.2 g per plant) in beet plants increases their adaptability to environmental temperature heat stress (Sitompul *et al*., 2020).

Table 3. Agro-climatic conditions in November-December 2022 and January 2023 recorded from Automatic Weather Station, Universitas Darussalam, Gontor)

Period	Maximum Temperature (°C)	Mean Temperature (°C)	Minimum Temperature (°C)	Relative Humidity (%)	Rainfall (mm)	Number of rainy days	Light Intensity (Lux)
November 2022	34	27	23	83	185	18	381
December 2022	35	27	23	81	199	19	434
January 2023	35	27	23	82	208	21	471

3.2. Number of Leaves

Treatment of bamboo leaf silica doses at all observation ages resulted in the number of red beetroots leaves not being significantly different (Table 4). The planting medium influenced the number of red beet leaves at the age of 2 - 6 WAP, but at the age of 8 WAP the number of leaves was not significantly different in all planting media (Table 4). At the age of 2 - 8 WAP the number of red beetroots leaves still increased, both in the bamboo leaf silica treatment and the planting medium. The average number of red beet leaves aged 8 weeks is 9 - 10 leaf blades.

Table 4. Average number of red beets leaves due to bamboo leaf silica fertilizer treatment and growing media.

Treatments	Number of leaves							
	2 WAP		4 WAP		6 WAP		8 WAP	
D_0	5.52	a	7.00	a	9.26	a	9.30	A
D_1	5.96	a	7.41	a	8.93	a	9.59	A
D_2	5.67	a	6.85	a	8.93	a	10.00	A
D_3	5.85	a	7.03	a	9.33	a	9.48	A
D_4	5.93	a	6.96	a	9.67	a	10.44	A
LSD 5%	-		-		-		-	
M_0	4.91	a	6.26	a	8.27	a	9.47	A
M_1	5.89	b	7.07	b	9.56	b	9.71	A
M_2	6.56	c	7.82	c	9.84	b	10.11	A
LSD 5%	0.51		0.63		1.02		1.28	

Note: Numbers marked with the same letter in the same column are not significantly different in the 5% LSD test. Treatment codes refer to Table 1.

The number of red beet leaves from the age of 2 - 8 WAP still saw growth in the number of leaves and there was no decrease or stagnation in the number (Table 4). At the age of 8 WAP, the number of leaves is 9-10. There is a possibility that the optimal point for the number of red beet leaves has not been found, because at the age of 60 DAP they have been harvested. The number of red beet leaves reaches optimal age 54 – 82 days after planting with 7 – 12 leaf blade in a rosette shape (Astuti *et al*., 2021).

Application of sufficient doses of silica fertilizer increases the accumulation of silica in plant leaf and root tissue. The silica content accumulated in the roots is more than in the leaves. As research results showed, the dose of bamboo leaf silica fertilizer had no effect on the number of red beet leaves (tab. 4). The dose of silica fertilizer did not affect the number of leaves. The amount of silica content in plant leaves and roots is not positively correlated with the number of leaves (Zainul *et al*., 2022).

At the beginning of red beet growth, the presence of goat manure and husk charcoal increased the number of leaves (Table 4). Goat manure contains high total N (> 2%) (Wildasari *et al*., 2019), so it is good for the growth of red beet plants. Growing media containing organic materials, whether from goat manure or other sources of organic materials, can increase the number of red beet leaves (Wildasari *et al*., 2019; Nuryanti *et al*., 2023). At the end of the observation at the age of 8 WAP, the growing media treatment had no effect on the number of leaves (Table 4). This can be caused by the age at which red beet plants reach their optimal number of leaves when cultivated in the lowlands. Research results Astuti *et al*., (2021), state that on average red beets in the lowlands have 8-9 leaf blade.

The number of leaves can influence plant growth because it is related to the photosynthesis process. The ideal number of leaves with absorption of solar radiation can stimulate plant growth. The number of red beet leaves affects the accumulation of plant biomass production (Sitompul *et al*., 2020). Protecting red beet leaves from pests and diseases is very necessary to keep the number of red beets leaves optimal.

People mostly harvest red beets by taking only the tubers and ignoring the leaves. When the red beet leaves studied were harvested at 60 DAP they still looked fresh and good. Red beet leaves at 60 days old contain high levels of polyphenols, flavonoids and vitamin C as well as minerals so they are good for fresh consumption (Takács-Hájos & Vargas-Rubóczki, 2022). When harvesting red beets at ± 60 DAP, the leaves should be consumed as leaf vegetables and not thrown away as waste.

Table 5. Average diameter and length of roots in red beetroots due to treatment with bamboo leaf silica fertilizer and growing media at the age of 8 WAP.

Treatments	Diameter of Red Beetroots (mm)		Length of Red Beetroots (mm)	
Control 0.00 ppm	58.48	a	69.30	a
Bamboo leaf silica dose 0.15 ppm	56.07	a	67.15	a
Bamboo leaf silica dose 0.30 ppm	61.37	a	71.55	a
Bamboo leaf silica dose 0.45 ppm	63.30	a	69.67	a
Bamboo leaf silica dose 0.60 ppm	65.59	a	74.00	a
LSD 5%	-		-	
Soil growing media (control)	47.49	a	55.60	a
Soil growing media + goat manure	65.18	b	74.42	b
Soil growing media + goat manure + husk charcoal	70.22	b	80.98	b
LSD 5%	9.38		7.26	

Note: Numbers marked with the same letter in the same column are not significantly different in the 5% LSD test.

3.3. Diameter and Length of Red Beetroots (mm)

In Table 5, bamboo leaf silica fertilizer treatment has no effect on the diameter and length of red beetroots, while the growing media treatment affects the diameter and length of red beetroots. Treatment with 0.60 ppm bamboo leaf silica fertilizer tended to increase the diameter and length of the roots, with an increase in root diameter of 10.84% and root length of 6.35% from the control (without bamboo leaf silica fertilizer). The dose of bamboo leaf silica fertilizer at 0.60 ppm still needs to be increased in order to increase the diameter and length of red beetroots. The diameter and length of beetroots correlate with the wet weight of beetroots. Beetroots weight can be increased by spraying 75 – 150 g of silica per ha (Artyszak *et al*., 2021). Growing media containing goat manure increased root diameter by 27.14% and root length by 25.29%, while planting media containing goat manure and husk charcoal increased root diameter by 32.37% and root length by 31.34 % compared to control only Vertisol soil.

The diameter of red beets cultivated in the lowlands is ready to be harvested when the root reach a diameter of 50 – 75 mm at the age of 86 days after planting for the Boro and Vikima varieties (Astuti *et al*., 2021). The red beets in this study were harvested at 60 days after planting, producing a root diameter of 47.49 – 70.22 mm and a root length of 55.6 – 80.96 mm (Table 5). The Ayumi 04 red beet variety used for research can be harvested at 60 days after planting, this supports the results of research (Suprihantono *et al*., 2022) with the same variety planted in the lowlands getting tuber diameters reaching 57.2 – 70.7 mm and Tuber length reaches 68.4 – 81.8 mm at 60 days after planting. The diameter and length of red beetroots were highest in growing media containing goat manure and husk charcoal. Soil density decreases when there is husk charcoal and goat manure, thus supporting plant growth and enlargement of red beetroots. Husk charcoal has high porosity and is porous to hold water and air in greater quantities. Husk charcoal has a surface area of 97.20 m^2/g (Mishra *et al*., 2017), helping to increase the space between soil particles.

Goat manure can reduce soil temperature and maintain soil moisture, thereby increasing the diameter and length of red beet tubers (Wildasari *et al*., 2019). The bamboo leaf silica dosage treatment did not have an effect on the diameter and length of the roots, it is suspected that goat manure provided sufficient amounts of organic material in the red beet growing medium.

3.4. Weight of Red Beet Tubers (g)

Bamboo leaf silica fertilizer treatment had no effect on the wet weight and dry weight of red beetroots, while the planting media treatment affected the wet weight and dry weight of red beetroots (Table 6). Bamboo leaf silica fertilizer treatment of 0.60 ppm tended to increase the wet weight of the roots, with an increase in the wet weight of the roots by 8.21% from control (without bamboo leaf silica fertilizer). The dose of bamboo leaf silica fertilizer at 0.60 ppm still needs to be increased in order to increase the wet weight of red beetroots. Artyszak *et al*., (2021) reported that spraying 75–150 g of silica per ha was able to increase the wet weight of red beetroots.

Growing media containing goat manure increased the wet weight of roots by 54.94% and dry weight of roots by 60.40%, while growing media containing goat manure and husk charcoal increased the wet weight of roots by 60.00% and the dry weight of roots. amounted to 60.92% compared to the control only Vertisol soil. Red beets require loose and fertile soil to support their growth. Growing media containing goat manure provide harvest results (wet weight and dry weight of roots) that are very real compared to soil planting media without goat manure. This difference reached > 50%. Organic materials can increase the dry weight accumulation of plants. The dry weight of plants fertilized by cows and N fertilized with small doses (50 kg N ha^{-1}) can increase dry matter accumulation (Nuryanti *et al*., 2023).

Table 6. Average wet weight and dry weight of red beetroots due to treatment with bamboo leaf silica fertilizer and growing media at the age of 8 WAP

Treatments	Wet Weight of Red Beetroots (g)		Dry Weight of Red Beetroots (g)	
Control 0.00 ppm	107.67	a	9.63	A
Bamboo leaf silica dose 0.15 ppm	109.15	a	8.59	A
Bamboo leaf silica dose 0.30 ppm	116.55	a	9.33	A
Bamboo leaf silica dose 0.45 ppm	108.22	a	9.37	A
Bamboo leaf silica dose 0.60 ppm	117.30	a	9.67	A
LSD 5%	-		-	
Soil growing media (control)	58.58	a	4.76	A
Soil growing media + goat manure	130.31	b	11.02	B
Soil growing media + goat manure + husk charcoal	146.45	b	12.18	B
LSD 5%	35.39		2.92	

Note: Numbers marked with the same letter in the same column are not significantly different in the 5% LSD test.

Soil water influences the increase in red beetroots yield. The growth of red beetroots is greatly influenced by the availability of soil water. Red beetroots of the Ayumi variety in medium plains (± 486 m above sea level) with sufficient fertilization and high irrigation water (1150 mm per season) when harvested at 60 HST are able to produce a beetroots weight of 193.78 g per plant (Dewi *et al*., 2022). Meanwhile, the Ayumi 04 variety planted in the highlands (±1300 m above sea level) is capable of producing a wet beetroots weight of 223.7-372.9 g at the age of 55 dap (Astuti & Murdono, 2019). Increasing soil porosity will reduce the specific gravity of the soil, thereby increasing the development of root to form tuber (Mishra *et al*., 2017). Loose planting media combined with adequate fertilizer and irrigation will increase the wet weight of the beetroots.

Silica fertilizer in sufficient quantities can increase plant production. Cow horn silica fertilizer increases pumpkin dry matter (Juknevičienė *et al*., 2021). The dose of bamboo leaf silica applied was not able to increase the wet weight and dry weight of red beetroots. There is a possibility that it is necessary to increase the frequency of spraying bamboo leaf silica fertilizer, because at the time of the research only one spray was carried out. Silica spraying has an effect on plant growth that increases significantly when spraying is carried out more than 3 times (Artyszak, 2018).

3.5. Leaf Chlorophyll (mg/L)

The combination of bamboo leaf silica treatment and growing media affected the amount of chlorophyll a, chlorophyll b and total chlorophyll in red beet leaves (Table 7). All doses of silica that interact with the planting medium (soil: goat manure: husk charcoal) increase the amount of chlorophyll a in red beet leaves by 53.63 - 68.35%, increase the amount of chlorophyll b in red beet leaves by 23.69 - 52.06 %, and increased the total chlorophyll amount of red beet leaves by 36.59 - 52.40 %. Independently, the dose of bamboo leaf silica did not affect the amount of chlorophyll a, but did affect the amount of chlorophyll b and total chlorophyll. The growing medium very significantly influences the amount of chlorophyll a, chlorophyll b and total chlorophyll, so that the interaction of all doses of bamboo leaf silica with the growing media (soil: goat manure: husk charcoal) produces a high amount of chlorophyll.

Table 7. Average amount of chlorophyll a, chlorophyll b and total chlorophyll in red beet leaves as a result of treatment with bamboo leaf silica fertilizer and growing media

Treatments	Chlorophyll a (mg/L)		Chlorophyll b (mg/L)		Chlorophyll total (mg/L)	
D_0M_0	1.70	b	4.18	a	5.88	A
D_0M_1	3.33	c	7.40	bc	10.73	C
D_0M_2	3.48	c	8.72	e	12.20	D
D_1M_0	1.79	b	4.15	a	5.94	A
D_1M_1	3.49	c	7.36	bc	10.84	C
D_1M_2	3.86	d	8.62	de	12.48	D
D_2M_0	1.25	a	6.78	bc	8.03	B
D_2M_1	3.53	c	7.38	bc	10.91	C
D_2M_2	3.91	d	9.02	e	12.93	D
D_3M_0	1.74	b	6.51	b	8.25	B
D_3M_1	3.40	c	7.54	c	10.94	C
D_3M_2	3.94	d	9.07	e	13.01	D
D_4M_0	1.25	a	6.83	bc	8.08	B
D_4M_1	3.34	c	7.69	cd	11.03	C
D_4M_2	3.95	d	8.95	e	12.90	D
BNT 5%	0.31		1.02		1.10	

Note: Numbers marked with the same letter in the same column are not significantly different in the 5% LSD test.

High light intensity increases carbon fixation during photosynthesis, but excess light will stress plants. Chlorophyll a is a molecule that allows photosynthesis to occur in leaves. Light absorption increases as the chlorophyll content increases, especially in the green parts of the leaves, so that older leaves are darker green than young leaves which are bright green. An increase in the amount of chlorophyll in red leaf plants is associated with a low value of the chlorophyll a/b ratio. Plants with a low chlorophyll a/b ratio are a sign that the plant is adapting to shade. The chlorophyll a/b ratio value in the red parts of the leaves is lower than the green parts of the leaves. Leaves that receive visible light illumination, the green and red parts of the leaves contain lower amounts of chlorophyll to avoid excessive energy absorption (Lin *et al*., 2019). The average chlorophyll a content (2.93 mg/L) in red beet leaves is smaller than the average chlorophyll b content (7.3 mg/L) (Table 7). It seems that red beets cultivated in the lowlands synthesize more chlorophyll b for efficient photosynthesis processes. Photosynthesis is the main process that determines the adaptability of plants to heat stress (Sitompul *et al*., 2020).

The dose of silica fertilizer increases the accumulation of silica in the leaves and roots of chili plants. The silica content in chili leaves and roots is positively correlated with the amount of leaf chlorophyll (Zainul *et al*., 2022). Treatment with doses of bamboo leaf silica fertilizer and planting media is expected to increase the amount of chlorophyll in red beet leaves cultivated in the lowlands. The results showed that bamboo leaf silica doses of 0.3 ppm, 0.45 ppm and 0.6 ppm significantly increased the chlorophyll b and total chlorophyll content of red beet leaves compared to those not sprayed with bamboo leaf silica. The chlorophyll content of oil palm seedling leaves increased 20% compared to controls with bio silica application (Santi *et al*., 2018).

Growing media provides nutrients and nutrition for plant growth and has an important role in the formation of chlorophyll in leaves. Humus soil which has a loose character and is rich in organic material and a source of plant nutrition is able to increase the amount of chlorophyll in wheat grass leaves (Khotimah & Yuniarti, 2021). The results of the research showed that the growing medium significantly influenced the amount of chlorophyll a, chlorophyll b, and total chlorophyll in red beet leaves. The growing medium (soil + goat manure + husk charcoal) produced the highest amounts of chlorophyll a, chlorophyll b and total chlorophyll and was significantly different from other growing media treatments. The dose of bamboo leaf silica combined with the growing media treatment (soil + goat manure + husk charcoal) produced high amounts of chlorophyll b and total chlorophyll and was significantly different from other treatment combinations (Table 7). Net photosynthetic productivity in plants fertilized with oxhorn silica increased but was still low. The addition of organic material from cow manure to the application of cow horn silica significantly increases net photosynthetic productivity (Juknevičienė *et al*., 2021).

3.6. Sugar Content of Red Beetroots (%)

The results of the analysis of the sugar content of the tubers showed that there was no significant difference in the dose of bamboo leaf silica and also the growing media on the sugar content of the red beet tubers. Data on average sugar levels can be seen in table 8.

Table 8. Average Sugar Content of Red Beetroots due to treatment with bamboo leaf silica fertilizer and growing media at the age of 8 WAP

Treatments	Sugar Content of Red Beetroots (%)
Control 0,00 ppm	6.07 A
bamboo leaf silica dose 0.15 ppm	5.78 A
bamboo leaf silica dose 0.30 ppm	5.78 A
bamboo leaf silica dose 0.45 ppm	6.04 A
bamboo leaf silica dose 0.60 ppm	6.04 A
BNT 5%	0.52
soil growing media (control)	5.73 A
soil growing media + goat manure	6.00 A
soil growing media + goat manure + husk charcoal	6.09 A
BNT 5%	0.67

Note: Numbers marked with the same letter in the same column are not significantly different in the 5% LSD test.

Sugar is produced as a result of photosynthesis and as a source or energy reserve. In an optimal environment with sufficient fertilization, red beet tubers at 35 DAP can produce sugar and this increases as the plant ages. The Ayumi variety of red beet grown in the highlands with adequate nutrition at 35 DAP in its tubers has a sugar content of 6.57% and at 55 DAP the sugar content reaches 8.53% (Astuti & Murdono, 2019). The average sugar content of red beet tubers from this study at the age of 56 DAP produced 5.94% sugar. The increase in sugar beet yield can be caused by an increase in yield due to swelling of the roots with greater fresh weight (Artyszak, 2018). In this study, the fresh weight and dry weight of red beet tubers in the growing media treatment had very significant differences, but produced the same sugar content (Table 8).

In the research, the sugar content in red beet tubers was not influenced by the dose of bamboo leaf silica or the growing media treatment. The humidity of the planting media during the research was always maintained, and the red beet plants did not experience drought stress, so that the bamboo leaf silica fertilizer treatment and the planting media treatment did not affect the sugar content of the red beet tubers. The sugar content in beet tubers can be influenced by plants experiencing stress due to weather during the growing season. Silica spraying increases the sugar content of beet tubers when they are under stress due to drought stress (Artyszak *et al*., 2021).

Plants that receive sufficient living needs will carry out vegetative and generative growth well. On the other hand, plants that experience environmental stress will experience growth inhibition but will produce a lot of secondary metabolites. Red beet plants that lack water will become stressed and produce higher levels of secondary metabolites than those with sufficient water (Dewi *et al*., 2022). The wavelength of light received for the photosynthesis process can influence the accumulation of sugar in red beet tubers (Oh *et al*., 2022).

The growth of beet plants and the accumulation of plant dry weight over time are greatly influenced by the altitude of the location. No real differences were found in growth patterns between plants at optimal heights and plants at low heights (Sitompul *et al*., 2020). So, cultivating red beets in the lowlands has great opportunities.

Red beet leaves at 60 days old contain high levels of polyphenols, flavonoids and vitamin C so they are good for fresh consumption. Young beet tubers (85 DAP) contain more vitamin C and flavonoids than older tubers (105 DAP), while the nitrate content is greater in older tubers than young tubers (Takács-Hájos & Vargas-Rubóczki, 2022). Planting red beets directly from seeds can be harvested at 8 days after planting. So that red beet harvesters at a young age can consume all plant organs, starting from the leaves and roots.

4. CONCLUSION

The conclusion of the research is: the dose of bamboo leaf silica (0.3 ppm, 0.45 ppm and 0.60 ppm) affects the amount of chlorophyll b and total chlorophyll of red beet leaves in the treatment. The growing media of soil + goat manure + husk charcoal affects the length of red beet plants, number of leaves, diameter and length of red beetroots, wet weight and dry weight of red beetroots. The interaction between soil growing media + goat manure + husk charcoal with all doses of bamboo leaf silica increased the amount of chlorophyll a, chlorophyll b and total chlorophyll. The sugar content of red beet tubers was not influenced by the dose of bamboo leaf silica or the growing medium. The Ayumi variety of red beet is suitable for planting in the lowlands using planting media (Vertisol soil, goat manure, and husk charcoal) in a greenhouse with sufficient irrigation and nitrogen fertilizer. Furthermore, further research is needed to increase the dosage of bamboo leaf silica and the particle size of bamboo leaf silica from micro to nano.

ACKNOWLEDGMENTS

This program was funded by Universitas Darussalam, Gontor.

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