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EVALUATING BIOPORE TECHNOLOGY FOR SUSTAINING COFFEE YIELD AND GROWTH DURING EL NIÑO EVENTS IN SOUTH SUMATRA, INDONESIA

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Abstract. In order to mitigate the impact of El Niño on declining crop yields, local water management is necessary. The present study aims to elucidate the impact of biopore application during the rainy season on the growth and yield of coffee plants in the dry season, which coincides with El Niñom. In the context of robusta coffee crops in Semendo, South Sumatra, the generative phase of the crop's development was characterised by the onset of flower production in April. The ripening of cherries occurs in July, while beans reach full maturity in August. A substantial discrepancy was observed in each of the variables, namely the leaf greenness index, the number of leaves, the number of flowers, and the number of seeds, following treatment. Biopore application has been shown to increase leaf water content by 1-2%, primary branch length by 3-18%, primary branch diameter by 1-8%, the number of plagiotropic branches by 53-62%, the number of flower clusters by 10-30%, the number of fruit clusters by 38-58%, and the number of fruits by 20-60%. The percentage of normal beans and the weight of the beans increased significantly along with the number of biopore holes.

Keywords: *climate change, homemade hole, production, perennial, robusta*

Introduction

El Niño is defined as a global climate phenomenon, characterised by elevated sea surface temperatures in the central and eastern Pacific Ocean. In Indonesia, El Niño has been observed to induce alterations in weather patterns, including a decrease in precipitation and the onset of drought conditions. Consequently, El Niño was considered a catalyst for climate change (CC). The repercussions of climate change, encompassing rising temperatures and shifting rainfall patterns, are poised to present substantial challenges to coffee plantations in tropical regions in the forthcoming years. It was hypothesised that climate change could result in the transformation of coffee production centres into areas that are suboptimal for coffee cultivation. Consequently, a range of CC adaptation technologies for coffee plants are being extensively researched in numerous countries, including Indonesia, a major coffee producer that has also suffered losses due to CC. The use of CC has been demonstrated to result in a substantial reduction in coffee bean production, a consequence of the method's capacity to disrupt the process of flower

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emergence, thereby causing a significant number of flowers to fall off (Imbach et al., 2017). Climate change has been demonstrated to affect temperature and rainfall patterns around coffee plantations (Jones et al., 2021). Prolonged dry and rainy seasons had been demonstrated to cause plants to grow and produce poorly (Patil et al., 2022). It has been demonstrated that drought has a detrimental effect on the amount of water present in soil, thereby reducing the growth of coffee plants (González-Robaina et al., 2017).

The availability of water in the rhizosphere was a prerequisite for the successful cultivation of coffee plants. The impact of low soil water content on plant water potential and cell turgor has been demonstrated to inhibit cell elongation and plant growth, consequently resulting in a significant reduction in bean yields (Malau et al., 2018). Moreover, a water deficit has been demonstrated to retard organ growth and induce plant shoots to wilt and eventually perish (Chemura et al., 2014; Prijono & Bana, 2015).

The two coffee genotypes cultivated were Robusta (Coffea canephora), which constituted 72.35% of the 2022 bean yield, and Arabica, which accounted for 27.65%. The majority of coffee plantations were situated at medium altitudes, ranging from 500 to 1,300 metres above sea level. The cultivation of the crops was undertaken under the canopy of *Leucaena glauca*, *Erythrina subumbrans*, and *Albizzia falcata*. The coffee production in Indonesia was found to be 0.62 tons per hectare. This yield was considered low due to several factors, including the inappropriate use of coffee clones and the poor maintenance of the plantations. Additionally, the country experiences a prolonged dry season, which further contributes to the low yield. In the highlands of West Lampung and South Sumatra, a significant number of coffee plants from diverse clones had been cultivated. Evizal et al. (2018) and Evizal and Prasmatiwi (2020) had reported that coffee cultivation currently implements intraspecific and interspecific grafting techniques for coffee clones. In the Semendo region, intraspecific coffee cultivation (Robusta/Robusta) has already become a pervasive practice.

One such method of water management involves the utilisation of biopores to regulate runoff and the water supply in the rhizosphere of plants during the rainy season. It has been demonstrated that biopores rapidly restore rhizosphere water levels during the rainy season, subsequently releasing it after the dry season (Permatasari, 2015). The capacity of biopores with a diameter of 10 cm and a length of 100 cm was estimated to be 7.85 cm^3 of water, equivalent to 0.78 Ω. The utilisation of biopores within coffee plantations has been demonstrated to enhance coffee bean yield whilst concomitantly supporting elevated groundwater capacity (Bermúdez-Florez et al., 2018). The water present within the biopores is connected by micropores in the walls, thereby facilitating the absorption of water into the soil. As reported by Defrenet et al. (2016), the coffee root biomass was found to be approximately 92% at a depth of 1.5 metres and around 8% at depths of up to 4 metres. It was evident from the observations made that the root reach width of coffee crops ranges from approximately 0.4 to 0.6 metres. Consequently, it was hypothesised that the coffee roots must be located at a depth between 0.1 and 2 metres. Horizontally, the coffee root system extends to a depth of 0.5 meters from the stem. It was estimated that the coffee rhizosphere encompasses an approximate volume of $0.5m^3$ for each individual coffee crop.

The results of the study by Tezara et al. (2024) showed significant differences in net photosynthesis rate and stomatal conductance among coffee genotypes when water efficiency decreased by 4-74%. Based on these findings, water deficits can occur during the dry season, impacting plant growth and yield. Robusta and Arabica coffee plantations in Indonesia are located in the highlands or mountains, making it very difficult to supply

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water. Thus, farmers need a suitable method. Biopore was a simple technique that coffee farmers can easily apply. However, the precise placement and number of biopores for each crop was still unknown.

The coffee farmers were accustomed to utilising a single biopore for each crop. However, no significant increase in plant growth or coffee crop yield was observed. Therefore, the recommendation was made that, during the rainy season, more than one biopore should be installed per plant, with a view to storing more water and releasing it during the long dry season. The present study evaluated the optimal number of biopores required to facilitate water supply to the rhizosphere for coffee plant growth during the protracted dry season. Furthermore, the study investigated the impact of biopores on the growth, flowering, and formation of coffee beans. It was imperative to comprehend the response of Robusta coffee crops to water supply from biopores, in order to formulate efficacious water management strategies to combat climate change (CC).

MATERIALS AND METHODS

Methods

The research was carried out in Rantau Dadap, Segamit Village, Semendo, South Sumatra, Indonesia, located at (-4.201212, 103.447751). The research period was from February through August 2019. The research area was located on a hilly slope with a 5% incline, at an elevation of 1,100 metres above sea level. El Niño conditions were observed in South Sumatra from July to October 2019, as reported by the Meteorology and Geophysics Agency in Palembang during the present study (Meteorology and Geophysics Agency, Palembang 2020)

The coffee crops grown were of the revitalized intraspecific Robusta variety, which was rejuvenated approximately five years ago using 20-year-old rootstocks and Garuda as the scion. The coffee crops were planted at a spacing of 3 × 3 meters. Additionally, *Erythrina subumbrans* were planted with a spacing of 10×15 and 10×20 meters. The study did not employ a design or non-design approach, as the area of land was extremely limited (28 m x 15 m) and comprised only 30 coffee trees. Accordingly, the quantity of water that had undergone treatment was then measured, and the samples were isolated from one another. The number of treatments was five, with three replications, thus resulting in a total sample of 15 trees. The placement of treatment samples was conducted in a randomised manner. The treatments utilised were B0-Control (no biopores); B1 (1 biopore); B2 (2 biopores); B3 (3 biopores); and B4 (4 biopores).

The installation of the biopores was conducted in February, coinciding with the onset of the rainy season. The biopores had a diameter of 10 centimetres, a depth of 1 metre, and were installed at a distance of approximately 0.5 metres from the coffee crop. Each coffee crop was fertilised with 500 g of NPK (16:16:16), which was broadcast at a distance of 40 cm from the crop and placed approximately 5 cm into the soil. Throughout the study, the biopore was maintained at a depth of one metre, and weekly soil samples were obtained from the hole. From early July until the conclusion of the study (i.e. the dry season), 2.4 kg of compost were administered to all biopore holes with the aim of controlling water evaporation.

Two secondary branches were selected from each sample crop for the purpose of collecting data on generative organs and leaf water content. The water content of the leaves was measured based on turgid leaf weight (see Equation 1). The leaves were then subjected to an oven-based drying process at a temperature of 80°C for a period of 24 hours. The leaf water content (LWC) was calculated according to the following formula:

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$$LWC (\%) = [(FW-DW) / (TW-DW)] \times 100 \quad \text{(Eq.1)}$$

where, FW – fresh weight, TW – turgid weight, and DW – dry weight (Ye et al., 2022).

Measurements were taken on a monthly basis. The measurement of the Leaf Green Index was conducted by means of a SPAD Chlorophyll Meter (model SPAD-502 Plus) on three fully mature leaves during the flowering period. The SPAD (Soil Plant Analysis Development) leaf greenness was assessed using the SPAD-502 Plus measuring instrument (Konica Minolta, Inc, Japan). The instrument was clamped in the middle of each leaf between 10am and 12pm. The results were expressed in non-metric SPAD units ranging from 0 to 200. The readings were recorded and averaged (Zarzecka et al., 2021). The length of the secondary branch was measured in centimetres from the branch union at the base to the terminal bud. The quantity of plagiotropic branches was determined for all branches bearing flower clusters. The production data comprised the number of flower clusters, fruit clusters, and beans produced. The Meteorology and Geophysics Agency of Palembang City was responsible for the procurement of local rainfall and weather data. The following text was intended to provide a concise summary of the key points.

The analysis of the data from each variable obtained was displayed in tabulation. The data was obtained by calculating the mean value and standard deviation. The data were then subjected to a comparison using the Least Significant Difference (LSD 0.05). Should the discrepancy between the two treatments exceed the LSD value, it is declared to be significantly different.

RESULTS

The availability of water in the soil was found to be a crucial factor in supporting the growth and development of coffee crops. From February to April, precipitation levels were elevated, thereby ensuring adequate hydration of the crops. However, there was a decrease in rainfall from May to August 2019. The impact of rainfall at an elevation of 1,100 metres on environmental temperature was also observed. The interaction between coffee crops, groundwater, and environmental temperature creates growth in the vegetative and generative organs and fruit of coffee crops (see Table 1).

Table 1. *Performance of vegetative and generative growth of coffee crops and weather in Semendo.*

Variables	2019						
	Feb	**March**	**April**	**May**	**June**	**July**	**August**
Precipitation (mm)	480	355	536	188	189	89	41
Rain Days (day)	21	19	20	13	13	3	3
Temp (ºC)	27,6	27,1	27,8	28	27,8	27,3	28
Humidity (%)	12	7	5	11	13	30	66
Phase of Crops	..……..Vegetative….……			…...Flowering….		…Cherry...	…Bean...

Note: Meteorology and Geophysics Agency, Palembang (2020)

The period of relatively normal rainfall from February to May was conducive to the flowering of coffee crops. In June, the optimal temperature for coffee flowers was approximately 28°C, and almost all robusta coffee crops were observed to be in flower at the research location. Consequently, the coffee crop transitions into the generative phase.

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The formation of coffee flowers marks the initiation of the processes that lead to the development of cherries and coffee beans.

The relative leaf water content of coffee crops was measured on a monthly basis, with the results indicating a correlation between this value and precipitation levels. As illustrated in Figure 1, there was an increase in leaf water content in April, followed by a drastic decrease in August. Following the implementation of biopores, there was a rapid increase in leaf water content after rainfall for all biopore treatment numbers. In April, the leaf water content reached its peak, after which it underwent a decrease during the dry season. The investigation revealed that the crops in the B4 category exhibited the highest levels of leaf water content, with B3, B2, and B1 crops exhibiting lower levels. The lowest values for leaf water content were recorded in coffee crops that had not been treated with biopores, and this was the case from the beginning to the end of the study. The application of biopores during the rainy season has been demonstrated to increase the amount of water entering the soil, whilst concomitantly increasing the relative water content of the leaves.

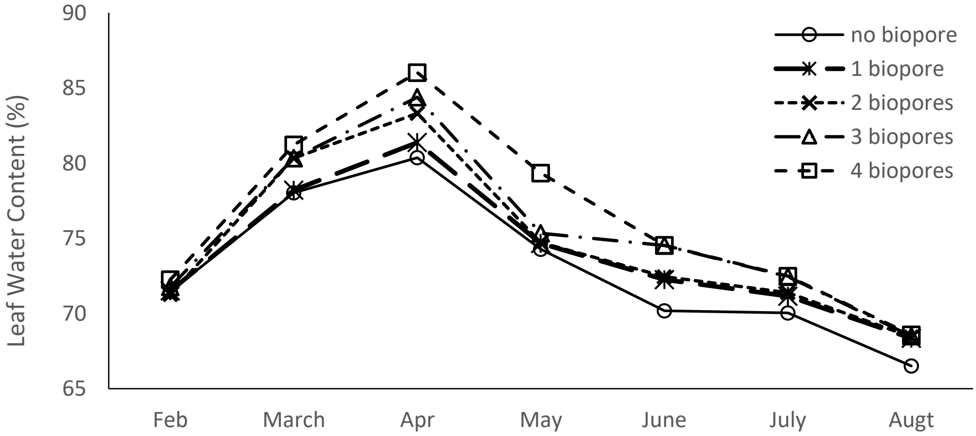

Figure 1: *Leaf Water Content (LWC) recorded along the course of the research as affected by different number of biopores imposed in each coffee crop.*

As indicated by the leaf green index, substantial disparities were evident by the study's conclusion between the treatments administered with and without biopores, in addition to between the biopore applications (see Figure 2). The leaf green index has been shown to reflect the chlorophyll content of the leaves. The results of the study indicate that there was no significant difference between the three biopore treatments, while the non-biopore application was significantly different from all biopore treatments. Consequently, the hypothesis was formulated that the implementation of biopores would contribute to the preservation of chlorophyll content in coffee leaves.

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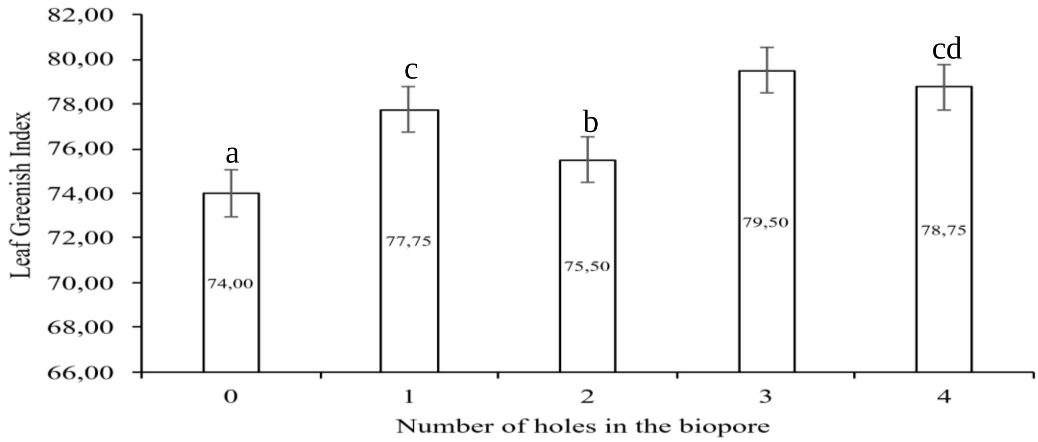

Figure 2. *Leaf greenish index showed improvement with the increase in biopore number built in per crop.*

It has been observed that a significant proportion of coffee crop leaves undergo defoliation as the seed formation phase commences. In conclusion, the utilisation of biopores resulted in a comparatively higher number of leaves compared to non-biopore applications. It was established that, in general, the sample branches boasted a total of more than 400 leaves at the commencement of the study. At the conclusion of the study, it was observed that the number of leaves had decreased by approximately 300. As demonstrated in Figure 3, the quantity of leaves in the three biopore treatments differed significantly from the other treatments. The non-biopore installation treatment comprised 112 leaves, a significant departure from the 112 leaves constituting all biopore treatments.

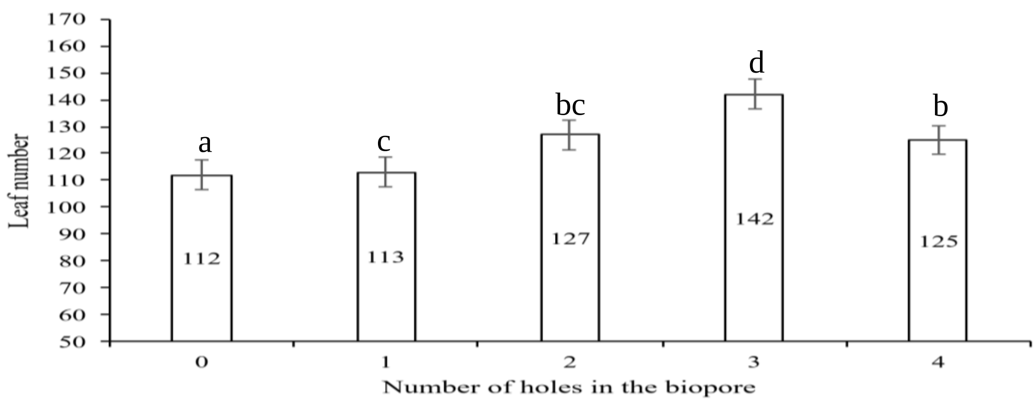

Figure 3. *Number of leaves in plagiotroph branch of coffee trees as affected by number of biopores furnished*

A significant variation in branch length, branch diameter, and the number of plagiotropics was observed in coffee crops treated with biopores in comparison to non-biopore applications (see Table 2). The maximum increase in branch length was observed in coffee crops treated with four biopores, reaching approximately 26 cm. This outcome was found to be statistically significant in comparison to all other treatment groups. The shortest recorded increase in branch length from non-biopore applications was 8 cm. The study reported that the diameter of coffee branches increased by approximately 0.26 cm over a period of six months for crops treated with three or four biopores, a result which differed significantly from that of the other treatments. Moreover, an increase of approximately three plagiotropics was observed in subjects who received treatment involving three or four biopores. The augmentation in branch length, branch diameter, and plagiotropes from four biopores appears to exceed that from alternative treatments and non-biopores.

Table 2. *Branch length (cm), branch diameter (cm), and plagiotroph branch number of robusta coffee trees recorded as treated by different number of biopores invested in each tree.*

Biopore numbers	Branch length (cm)		Branch diameter (cm)		Plagiotroph branch number	
	---------------------------------- Rate --					
0	98.00 ± 2.16	a	3.11 ± 0.17	a	4.00 ± 0.82	a
1	101.50 ± 5.74	b	3.15 ± 0.10	ab	6.50 ± 1.00	b
2	107.25 ± 5.85	c	3.21 ± 0.15	b	6.75 ± 1.50	b
3	112.50 ± 4.20	d	3.38 ± 0.05	c	7.00 ± 1.41	c
4	116.50 ± 4.73	e	3.38 ± 0.05	c	7.50 ± 0.96	d

Note: Numbers when followed by the same alphabets in the same columns indicated non-significant difference at LSD 5%.

The response of coffee crop growth to the application of biopores during the rainy season until the production of beans during the dry season was a subject of interest for study. Therefore, a comparison was made of the number of leaves, the leaf greenness index, and the leaf water content at the beginning and end of the study. The final data from the study were significant as they described the effect of biopores on coffee crops. Initially, the vast majority of measured variables exhibited equivalent values; however, by the conclusion of the study, a substantial discrepancy between the variables of each treatment was evident. Moreover, it was reported that the number of coffee leaves had decreased by the conclusion of the study. It appeared that the greater the abundance of fruit clusters, the fewer leaves there were on the branch. A comparison of the vegetative and generative phases of coffee crops indicates that biopore application increases the leaf green index and leaf water content, resulting in higher-quality coffee leaves.

Table 3. *Effects of different biopore numbers built in sround the coffee trees yield variables Including flower clusters, number of fruit clusters, average fruit and number of bean per branch*
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Biopore	Flower (cluster/branch)		Fruit/cherry (cluster/branch)		Average fruit (Fruit/cluster)		Bean (bean/branch)	
0	9 ± 0.92	a	5 ± 0.15	a	12,3 ± 0.16	a	70 ± 8.21	a
1	10 ± 0,31	ab	8 ± 0.82	ab	13,5 ± 1.21	a	87 ± 3.49	a
2	12 ± 0.49	bc	9 ± 0.31	bc	14,1 ± 0.07	ab	120 ± 9.03	b
3	12 ± 0.28	bc	10 ± 0.64	bc	14,6 ± 0.13	b	130 ± 8.62	b
4	13 ± 0.11	c	12 ± 0.99	c	16,7 ± 0.02	c	180 ± 9.11	c

Note: Numbers followed by the same alphabet in the same columns indicated non-significant difference at LSD Test 5%.

The percentage of flowers to cherries ranged from 7 to 56%, and the percentage of cherries to beans varied between 7 and 71%, contingent on the quantity of biopore administered to robusta coffee. The Biopore B4 treatment resulted in an increase in the percentage of cherry formation and a concomitant reduction in the incidence of abnormal

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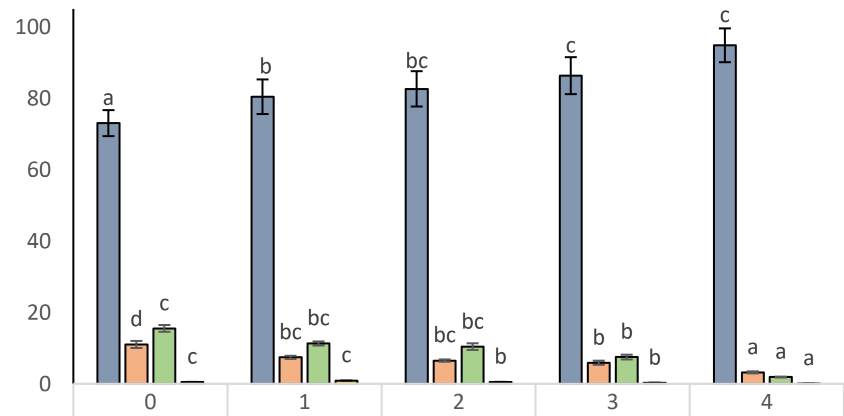
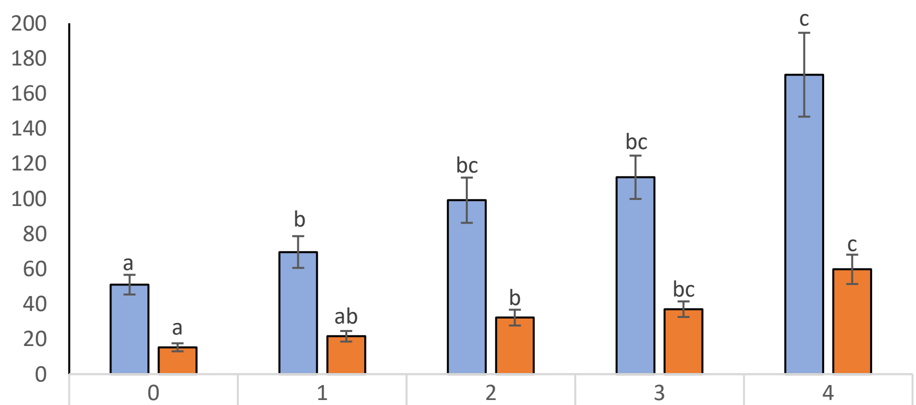
seeds (see Figure 4). This research indicates that in the absence of water management initiatives, there was a decline in the formation of cherries and an augmentation in the prevalence of abnormal seeds, characterised by defects, vacancies, and triage.



	0	1	2	3	4
percentage of normal seeds	73	80.4	82.6	86.3	94.8
Percentage defective	11.0	7.4	6.5	5.9	3.2
Percentage empty	15.5	11.3	10.4	7.5	1.9
Percentage triage	0.5	0.9	0.5	0.3	0.1

Figure 4. *Percentage of normal seed, defective, empty and tiage of coffee seed as affected by number of biopores furnished*

The number of beans formed by applying four biopores was found to be significantly different compared to the control group, which did not utilise biopores. The beans exhibited a comparatively greater mass, resulting in a greater weight compared to other treatments (Figure 5). The mean weight of the beans ranged from 0.3 g.bean-1 for the non-biopore sample to 0.34 g.bean-1 for the four-biopore sample.



	0	1	2	3	4
number Bean	51	70	99	112	171
weight (g)	15.3	21.6	32.2	37.0	59.7

Figure 5. *Number and weight of coffee bean as affected by number of biopores furnished*

DISCUSSIONS

The phenomenon observed in robusta coffee crops based on rainfall includes the vegetative phase and the generative phase, which includes flowering, fruit formation, and coffee bean formation. This phenomenon was analogous to that previously reported by

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Dinh et al. (2022) in Vietnam. Three months prior to the cessation of the rainy season, the prevailing vegetative phase was characterised by the emergence of new shoots and leaves. At the onset of the arid period, the generative phase commences. At the close of the rainy season, all coffee crops enter the generative phase of flowering. In addition to water, coffee flowering was found to be significantly influenced by temperature (Kath et al., 2020). During the dry season, which occurs from July to September, coffee berries begin to form. By the end of August, the coffee beans had formed. The growth and seed formation phenomena observed in Semendo exhibited certain parallels with the findings reported by Kath et al. (2023) in Vietnam, with the process from vegetative growth to seed formation taking approximately four months. It was evident from the data obtained that the percentage of flowers that developed into coffee berries ranged from 30 to 35%.

The relative leaf water content exhibited an approximate 86% increase from the B4 level in April, subsequently followed by the B3, B2, B1, and non-biopore levels. This increase was attributed to the accumulation of rainfall during the rainy season. The observed variation in the number of biopores appears to exert a significant influence on the process of water accumulation within the rhizosphere. The continuous decrease in the relative water content of coffee leaves from May to August was also related to rainfall. It has been demonstrated that coffee crops do not thrive in periods of heavy rainfall during the flowering phase (Molina & Rivera, 2022; Ronchi & Miranda, 2020). During this phase, the water content of coffee crop leaves ranges from 74% to 79.3%. During the process of fruit formation, the relative leaf water content undergoes a decline, reaching a range of 70%-72%. However, non-biopore treatments exhibited a decrease in leaf water content relative to biopore applications.

The findings of this study demonstrate that water availability from rainfall plays a significant role in controlling the growth, development, and production of coffee beans (Evizal et al., 2020). Moreover, the substantial impact on all variables signifies that biopores play a pivotal role in supplying water to the coffee rhizosphere. As reported by Syakir and Surmaini (2017), the utilisation of biopores confers numerous advantages, including the capacity for water storage and land conservation during periods of drought. Furthermore, these biopores had been demonstrated to regulate surface water flow, thereby mitigating the risk of erosion and safeguarding soil chemical fertility from leaching. Consequently, the implementation of biopores has been shown to enhance water levels in the rhizosphere, thereby ensuring sustained access to water for an extended period and promoting optimal crop growth and development. Consequently, the number of biopores had a substantial impact on all variables.

The decreasing trend in monthly rainfall was expected to impact temperature and humidity levels, with a concomitant rise in temperature and decrease in humidity. Consequently, the water deficit in the rhizosphere, in conjunction with rising temperatures and declining humidity, will exert an influence on the metabolism of coffee crops (Merga & Beksisa, 2023; Sarvina et al., 2020). It has been demonstrated by preceding studies that the quantity of water present within the rhizosphere, in conjunction with the relative water content of diverse leaves, exerts a substantial influence on the full spectrum of vegetative and generative variables exhibited by coffee crops.

The green leaf index revealed significant differences between treatments with (77.88) and without (74.00) biopores. As asserted by Tamirat (2019), the occurrence of water stress, precipitated by the dry season, has the potential to engender a decline in leaf chlorophyll levels. The combination of a water deficit and elevated temperatures has been demonstrated to induce a change in leaf colour, resulting in a greenish hue. Furthermore,

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it was hypothesised that the decline in green leaf index could be attributed to the redistribution of photosynthates from the leaves to the generative organs of the coffee crop (Mohammed et al., 2021). It can thus be concluded that the variation in the green leaf index of coffee crops during the dry season was attributable to relative leaf water content, the presence of water in the rhizosphere, metabolism, and weather.

It was a common phenomenon that many coffee crop leaves fall after entering the flower and fruit formation phase. This phenomenon was attributed to the dry season, as well as the breakdown of assimilates in the leaves, which was conducive to the growth of flowers and seeds. The utilisation of biopores has been demonstrated to enhance the accessibility of water and nutrients for coffee crops, thereby reducing leaf fall in comparison with non-biopore applications. The hypothesis that sufficient water availability in the leaves due to biopores maintains leaves on the tree was one that merits further investigation.

The present study reported an increase in the diameter of coffee branches and plagiotropic branches, as well as an increase in branch length, for a period of six months in coffee crops. The coffee crops were treated with biopores 3 and 4, which produced significantly different results than other treatments. The increase in all vegetative variables in B3 and B4 was hypothesised to be due to sufficient water availability, enabling the crops to carry out photosynthesis and organ growth. As posited by Izzah et al. (2019), an adequate supply of water has been demonstrated to enhance the growth of crop organs.

By the close of May, the flowering of all Robusta coffee crops had been observed. As posited by Da Matta and Ramalho (2006), the flowering of coffee crops was observed to coincide with rising temperatures and declining precipitation levels. Consequently, Boreux et al. (2016) proposed the irrigation of coffee plantations to promote flowering. Consequently, an adequate water supply in the rhizosphere, in conjunction with an elevated temperature, has been demonstrated to stimulate the emergence of coffee crop flowers. It was imperative to consider and maintain the number of flower and fruit clusters, as well as the average number of fruits. The three aforementioned variables are contingent upon the water supply from rain or irrigation, pollinating insects, and temperatures conducive to fruit and seed development (Evizal et al., 2020). It was hypothesised that B1 biopores, which are frequently employed by farmers, yielded suboptimal results in comparison to 3-4 biopores.

The presence of biopores has been demonstrated to increase the percentage of flowers that become fruit by increasing the leaf water content. In the absence of biopores, coffee crops exhibited a more than 50% reduction in both flowers and fruit, resulting in a significant decrease in the yield of fruits when compared to coffee crops where biopores were applied (see Table 4). In general, Arabica coffee experiences flower drop of up to 40% (Tarno et al., 2018).

The indicators of freshness and health of the crop under investigation were the leaves (color, quantity, and relative water content). The condition of the leaves was compared between the rainy and dry seasons at each level of biopore application in order to ascertain the relationship between the three variables. Crops that exhibited three or four biopores demonstrated consistently higher values in comparison to those with fewer applications. Furthermore, an increase in metabolic processes in coffee crops with biopore holes had a positive effect on the growth of vegetative organs, such as primary branch length, branch diameter, and the number of plagiotrophs. These results bear a certain resemblance to those obtained by Randriani et al. (2014), who determined that the yield of robusta coffee was contingent on the number of plagiotropes. The presence of a greater number of plagiotropes, both in terms of quantity and length, was observed in this experiment when compared to the B3 and B4 treatments. This phenomenon resulted in an increased number of seeds.

In tropical regions, the photoperiodic regulation of coffee flower emergence was a more significant factor than light intensity (Yuliasmara, 2020). The relatively low percentage of flowers that become cherries indicates a strong influence of temperature and water availability in the rhizosphere (Takeno, 2016; Kath et al., 2023). The findings of this study demonstrate that the biopore treatment results in a greater number of flowers and a higher yield of cherries in comparison to the non-biopore treatment, attributable to the optimal temperature and water availability. Furthermore, abnormal beans from the non-biopore treatment had been shown to had high levels of B0 due to suboptimal photosynthesis. Photosynthesis was imperative for the formation of normal coffee beans (Da Matta et al., 1997).

The number of biopores around a coffee tree affects the number of flower and fruit clusters, as well as the average number of fruits and seeds per branch. These generative organs appear to be more strongly influenced by the presence of optimal water in the rhizosphere. Izzah et al. (2019) and Kath et al. (2023) also stated that water was closely related to the growth of coffee generative organs.

Furthermore, the percentage of normal, defective, empty, and triaged coffee seeds was influenced by the number of biopores applied around the coffee tree. The quality of coffee beans was significantly influenced by the photosynthate and water present in the soil (Halupi, 2020). The quantity and mass of coffee beans were found to be contingent upon the number of biopores applied. The present study found that the number and weight of B4 beans were significantly different from those of B2, B1, and B0 beans. It was hypothesised that optimal water availability during the dry season was crucial for coffee crops.

CONCLUSIONS

The installation of biopores during the rainy season has been demonstrated to increase the water content of coffee crops' leaves, leaf chlorophyll, and generative organs during the dry season. Furthermore, an increase in the yield of beans of approximately 23.32% was observed in comparison with trees devoid of biopores**.**

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