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The Effect of Biosaka Elicitor Types and Concentrations on the Growth and Yield of Chili Pepper (*Capsicum frutescens* L.)

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ABSTRACT

Chili pepper (Capsicum frutescens L.) is an important horticultural crop that requires sufficient production to meet increasing market demand. This study aimed to evaluate the effects of Biosaka elicitor composition and concentration on the growth and yield of chili pepper. The experiment was arranged in a two-factor factorial Randomized Complete Block Design (RCBD) with three replications. The first factor was Biosaka composition (J), consisting of five formulations: J1 = babandotan, J2 = J1 + pukul empat, J3 = J2 + patikan kebo, J4 = J3 + meniran, and J5 = all biosaka materials. The second factor was Biosaka concentration (K), consisting of three concentration levels: K1 = 1.5 mL/L, K2 = 2.5 mL/L, and K3 = 3.5 mL/L. The results showed that Biosaka composition significantly affected plant height at 21–63 DAT, stem diameter at 28–63 DAT, leaf number at 21–63 DAT, fruit number per plant at the fifth harvest, and fruit weight per plant at the first and fifth harvests. Biosaka concentration significantly affected plant height at 21 DAT and 42–56 DAT, leaf number at 49 and 56 DAT, and fruit number (total fruit number and fruit number per plant) at the first, fourth, and fifth harvests. Overall, the J5 formulation and the concentration of 2.5 mL/L tended to produce the most favorable growth responses in chili pepper plants.

1. INTRODUCTION

Chili pepper (*Capsicum frutescens* L.) is an important horticultural crop with consistently high market demand. In addition to its economic value, chili pepper is a rich source of nutrients, including vitamins A and C, iron, and calcium (Candrianto *et al*., 2021). According to the Central Statistics Agency (BPS, 2022), chili production in Indonesia decreased by 8.09% in 2021, whereas consumption increased by 10.25% during the same period. This imbalance highlights the need to improve chili productivity to meet increasing consumer demand. However, chili cultivation remains highly dependent on synthetic chemical fertilizers, which may negatively affect environmental sustainability and increase production costs. Therefore, alternative cultivation strategies that support sustainable agricultural production are required.

One potential alternative is the use of Biosaka as a plant elicitor. Biosaka is a liquid-based formulation prepared from various plant materials and is reported to enhance plant growth, improve resistance to pests and diseases, and reduce the dependence on chemical fertilizers by 50–90% (Reflis *et al*., 2023). As part of sustainable agricultural practices, Biosaka is considered compatible with the principles of organic farming, which emphasize ecological balance and environmentally friendly production systems (Husain *et al*., 2023). Previous studies have suggested that Biosaka may stimulate physiological processes in plants, resulting in improved growth and healthier crop production (Jannah *et al*., 2023). In addition, elicitor-containing plant materials may induce phytoalexin production and activate plant defense mechanisms, thereby enhancing plant growth and productivity while reducing pest and disease incidence (Azhimah *et al*., 2023).

Several studies have reported the positive effects of Biosaka application on crop performance. Adiwijaya *et al*. (2023) found that Biosaka formulations derived from broadleaf weeds at a concentration of 2.5 mL/L increased plant height, leaf number, and bulb weight in shallot plants. Similarly, Nugroho (2023) reported that the application of 40 mL Biosaka per 15 L of water significantly improved plant height, leaf number, plant biomass, and yield components in water spinach. Azhimah *et al*. (2023) also recommended a dosage of 40 mL per 15 L of water for rice and corn cultivation due to its effectiveness in promoting plant growth.

Despite these promising results, information regarding the effectiveness of different Biosaka formulations and concentrations remains limited, particularly in chili pepper cultivation. In addition, the potential synergistic effects of combining different plant species as Biosaka raw materials have not been thoroughly investigated. Different plant species may contain distinct bioactive compounds, secondary metabolites, and growth-promoting substances that could influence the effectiveness of Biosaka formulations. Therefore, evaluating various combinations of plant materials is necessary to identify the most effective formulation for improving chili growth and yield.

In this study, Biosaka was prepared using five types of leaves. These plant species were selected because they are commonly available in agricultural environments and are reported to contain various bioactive compounds with potential growth-promoting properties. Therefore, this study aimed to evaluate the effects of Biosaka composition and concentration on the growth and yield of chili pepper and to determine the most effective Biosaka formulation and concentration for improving plant performance.

2. MATERIALS AND METHODS

2.1. Time and Location of the Study

The experiment was conducted from October 2024 to January 2025 at the experimental field of the Surabaya City Food Security Service, located on Jambangan Sawah Street, Jambangan District, Surabaya, Indonesia.

2.2. Plant Materials and Experimental Inputs

The plant material used in this study was chili pepper (*Capsicum frutescens* L.) cv. Ori 212. This variety is characterized by plant height of 150–165 cm, harvest age of 91–96 DAT (days after transplanting), and productivity potential of 23.5–28.8 t/ha (Ministry of Agriculture, 2019). The variety was selected because of its high yield potential and adaptability to lowland conditions during the rainy season.

The plant materials used for Biosaka preparation consisted of babandotan (*Ageratum conyzoides* L.) leaves, bunga pukul empat (*Mirabilis jalapa* L.) leaves, patikan kebo (*Euphorbia hirta* L.) leaves, meniran (*Phyllanthus niruri* L.) leaves, and anting-anting (*Acalypha indica* L.) leaves. Additional materials included soil, compost, manure, NPK fertilizer, fungicides, insecticides, water, bamboo stakes, and polybags (35 × 35 cm). GAMBAR 1

The equipment used in this study included measuring instruments (rulers, measuring tape, digital calipers, and a Total Dissolved Solids [TDS] meter), a digital balance, watering cans, sprayers, seed trays, shovels, tweezers, labels, stationery, cameras, and a computer for data processing and statistical analysis.

2.3. Experimental Design and Treatments

The experiment was arranged in a two-factor factorial Randomized Complete Block Design (RCBD) with three replications. The first factor was Biosaka composition (J), consisting of five formulations leaves, namely: J1 = Babandotan leaves (BL), J2 = BL + Bunga pukul empat (P4), J3 = BL + P4 + Patikan kebo (PK), J4 = BL + P4 + PK + Meniran (ML), J5 = BL + P4 + PK + ML + Anting-anting (AA). The second factor was Biosaka concentration (K), consisting of three concentration levels, nemely: K1 = 1.5 mL/L, K2 = 2.5 mL/L, and K3 = 3.5 mL/L.

The combination of the two factors resulted in 15 treatment combinations replicated three times. Each experimental unit consisted of two sample plants. In addition, a control treatment without Biosaka application (J0K0) was included for comparison, resulting in a total of 96 plants. Plants were grown in 35 × 35 cm polybags containing a growing medium composed of soil, compost, and manure at a volume ratio of 3:1:1. The spacing between polybags was maintained at 50 × 50 cm. The experimental layout is presented in Figure 3.

Figure 2. Biosaka materials used in this research: (a) babandotan (*Ageratum conyzoides* L.), (b) bunga pukul empat (*Mirabilis jalapa* L.), (c) patikan kebo (*Euphorbia hirta* L.), (d) meniran (*Phyllanthus niruri* L.), and 9e) anting-anting (*Acalypha indica* L.) leaves.

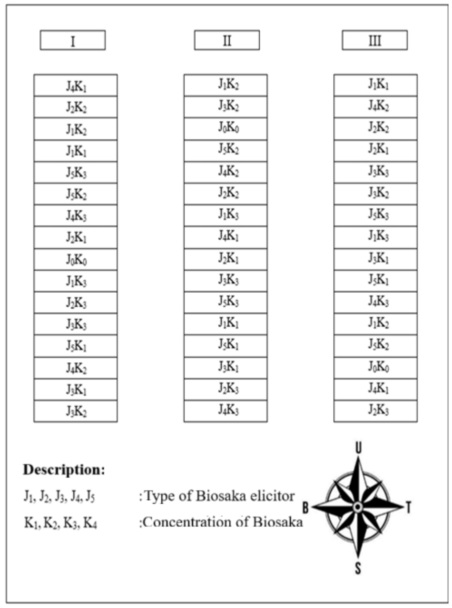

Figure 3. Research experiment layout

2.4. Observation Variables and Statistical Analysis

Vegetative growth parameters were observed weekly from 7 to 63 DAT and included plant height (cm), stem diameter (cm), and leaf number. The generative parameters observed were the number of productive branches, flowering age (DAT), number of flowers, total fruit number, harvest age (DAT), fruit number per plant, fruit diameter (cm), fruit length (cm), fruit weight per fruit (g), and fruit weight per plant (g). Data were subjected to analysis of variance (ANOVA). When significant treatment effects were detected, mean comparisons were performed using the Honestly Significant Difference (HSD) test at the 5% significance level ($\alpha = 0.05$). In addition, regression analysis was conducted to evaluate the relationships among selected variables.

3. RESULTS AND DISCUSSION

Figure 4 shows visual appearance of chili pepper plants under different Biosaka composition and concentration treatments at the end of the experimental period. The vegetative and generative growth parameters are discussed in the following sections.

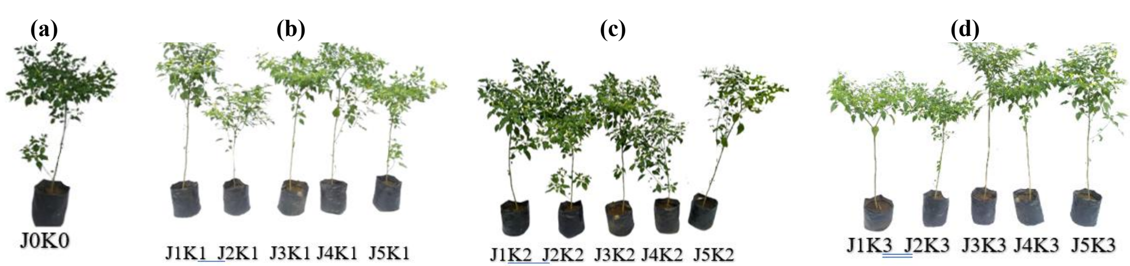

Figure 4. Visual appearance of chili pepper plants under different treatments: (a) Control, (b) – (d) Biosaka concentration at K1 = 1.5 mL/L, K2 = 2.5 mL/L, and K3 = 3.5 mL/L, respectively

3.1. Plant Height

Figures 5 and 6 illustrate the growth of chili pepper plants in terms of plant height as affected by Biosaka composition and Biosaka concentration, respectively. In general, plant height increased progressively throughout the observation

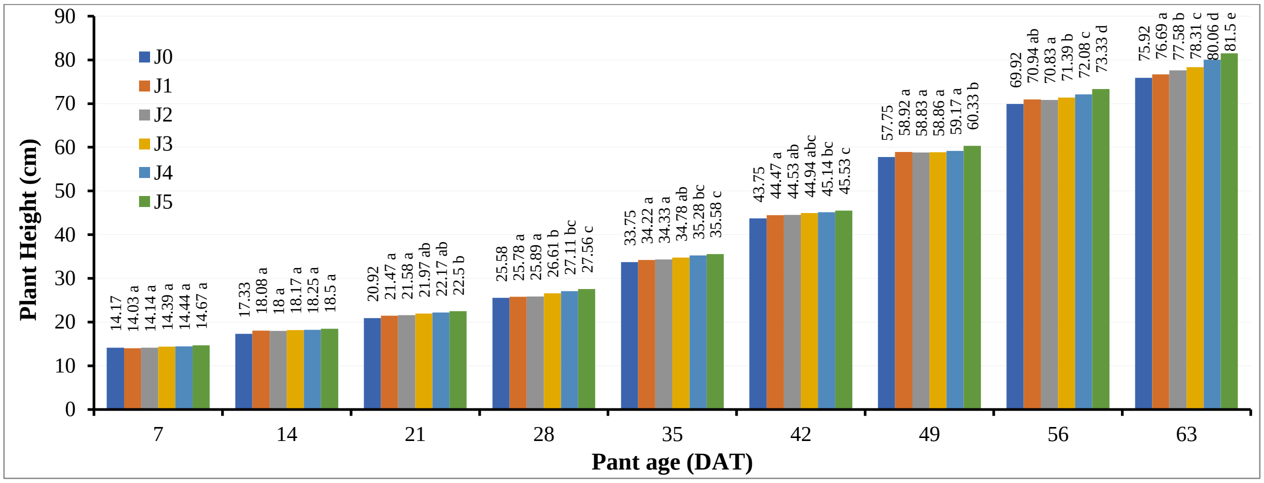

Figure 5. Effect of Biosaka composition on the plant height of chili pepper from 7 to 63 DAT. [Note: Means followed by the same letter in the same age indicate no significant difference in the 5% HSD test].

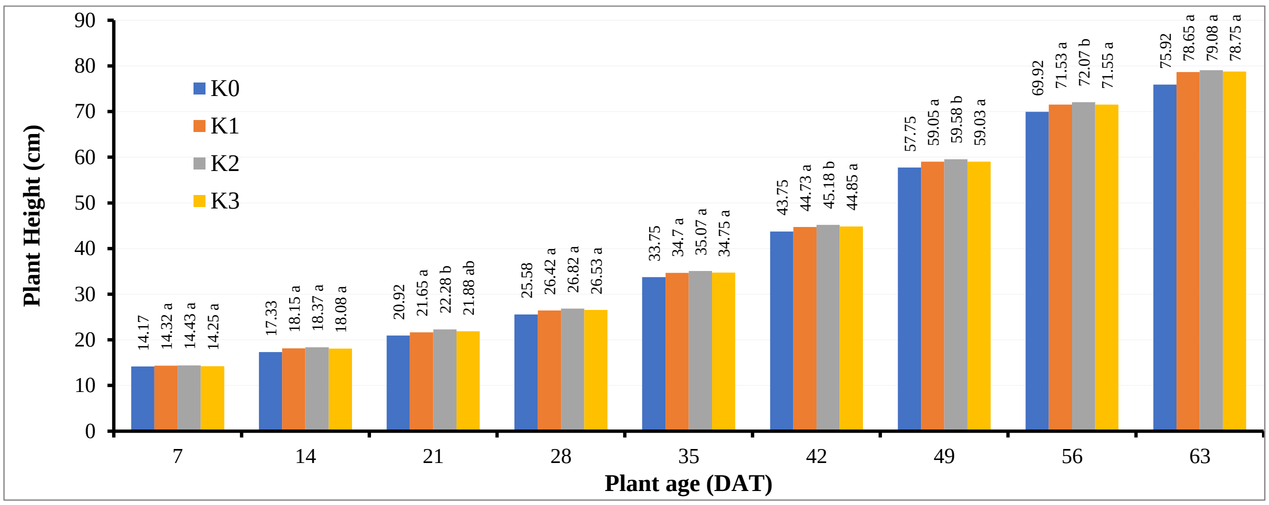

Figure 6. Effect of Biosaka concentration on the plant height of chili pepper from 7 to 63 DAT. [Note: Means followed by the same letter in the same age indicate no significant difference in the 5% HSD test].

period, indicating normal vegetative growth. The analysis of variance (ANOVA) revealed that Biosaka composition significantly affected plant height at 21–63 DAT, whereas Biosaka concentration significantly affected plant height at 21 DAT and 42–56 DAT.

During the first two weeks after transplanting, neither Biosaka composition nor Biosaka concentration significantly affected plant height. This result may be attributed to the relatively low nutrient requirements of young plants, which were likely satisfied by the nutrients available in the growing medium. Consequently, the effects of Biosaka application were not yet evident during the early growth stage. Similar observations have been reported in previous studies, where the response of plants to organic inputs and biostimulants became more pronounced as plant growth progressed and nutrient demand increased (Vitco *et al*., 2022).

Biosaka composition significantly influenced plant height throughout the vegetative growth period. The highest plant height was recorded in treatment J5 (BL + P4 + PK + ML + AA), which reached 81.50 cm at 63 DAT. The superior performance of J5 may be associated with the combined contribution of bioactive compounds from the five plant species used in the formulation. The greater diversity of plant materials may have enhanced the availability of growth-promoting substances, resulting in improved vegetative development compared with the formulations containing fewer species.

Similarly, Biosaka concentration significantly affected plant height at several observation periods (Figure 3). The K2 treatment (2.5 mL/L) produced the tallest plants, reaching 72.07 cm at 56 DAT. This result suggests that 2.5 mL/L was the optimum concentration for promoting plant growth under the conditions of this study. Lower concentrations may have provided insufficient stimulation, whereas higher concentrations did not result in additional growth improvement. These findings are consistent with previous studies reporting that moderate Biosaka concentrations were more effective in enhancing vegetative growth than either lower or higher application rates (Adiwijaya *et al*., 2023). Overall, the results indicate that both Biosaka composition and concentration influenced chili plant height, with the most favorable response obtained from the J5 formulation and the K2 concentration level.

3.2. Stem Diameter

Figure 7 illustrates the development of stem diameter in chili pepper plants as affected by Biosaka composition. In general, stem diameter increased progressively throughout the observation period, showing a growth pattern similar to that observed for plant height. The analysis of variance (ANOVA) indicated that Biosaka composition significantly affected stem diameter at 28–63 DAT, whereas Biosaka concentration did not significantly affect stem diameter at any observation time. The absence of significant differences during the early growth stage suggests that the nutrient requirements of young plants were still adequately supplied by the growing medium. As plant growth progressed, however, the effects of Biosaka composition became more apparent, resulting in significant differences among treatments from 28 DAT onward.

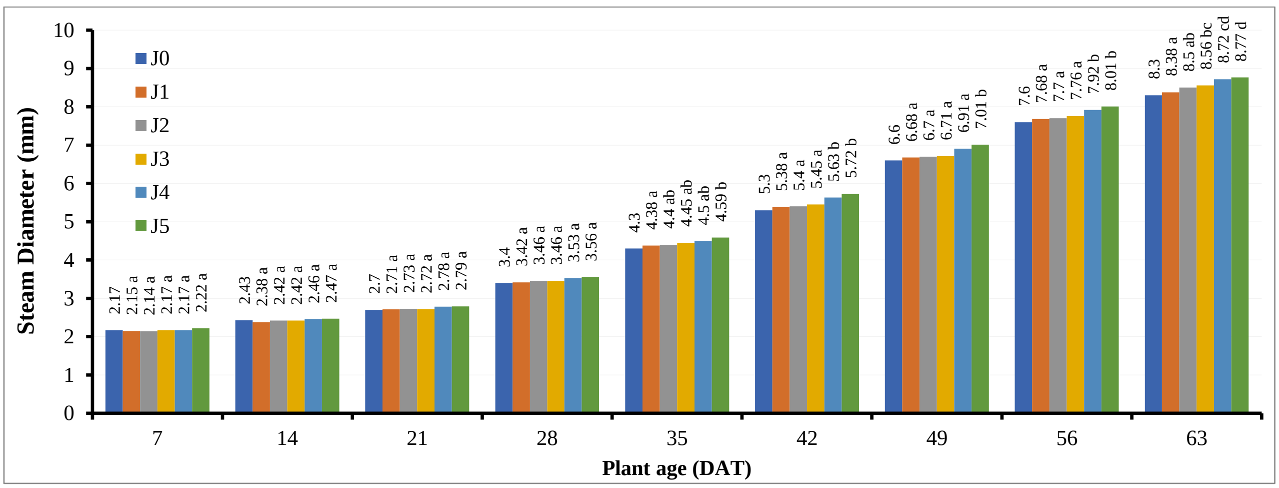

Figure 7. Effect of Biosaka composition on stem diameter of chili pepper plants from 7 to 63 DAT. [Note: Means followed by the same letter in the same age indicate no significant difference in the 5% HSD test].

As shown in Figure 7, the J5 treatment (babandotan + bunga pukul empat + patikan kebo + meniran + anting-anting) consistently produced the largest stem diameter throughout the observation period. At 28, 35, 42, 49, 56, and 63 DAT, the stem diameter values reached 3.56, 4.59, 5.72, 7.01, 8.01, and 8.77 mm, respectively. These results indicate that the J5 formulation was more effective in promoting stem development than the other Biosaka compositions. The superior performance of J5 may be associated with the greater diversity of plant materials used in the formulation. The combination of five plant species may have provided a wider range of bioactive compounds that enhanced plant physiological processes and supported vegetative growth. Improved vegetative growth is generally associated with increased assimilate production and translocation, which contribute to stem thickening and overall plant vigor. According to Nuraida & Yulia (2022), stem diameter development is closely related to nutrient availability because nutrients play important roles in carbohydrate synthesis and transport within the plant. Adequate nutrient availability supports cell division and cell enlargement, resulting in increased stem diameter. Therefore, the enhanced stem growth observed under the J5 treatment may indicate a more favorable physiological response to the Biosaka formulation.

3.3. Number of Leaves

Leaf number is an important indicator of vegetative growth because leaves serve as the primary organ for photosynthesis. An increase in leaf number generally reflects improved plant growth and greater photosynthetic capacity. As presented in Figure 8 and 9, the number of leaves increases with plant age with a pattern almost linear for all treatments. The analysis of variance (ANOVA) showed that Biosaka composition significantly affected leaf number at 21–63 DAT, whereas Biosaka concentration significantly affected leaf number at 49 and 56 DAT. The effects of Biosaka composition on leaf development are presented in Table 1. Among the tested formulations, the J5 treatment (babandotan + bunga pukul empat + patikan kebo + meniran + anting-anting) consistently produced the highest number of leaves throughout the observation period. At 21, 28, 35, 42, 49, 56, and 63 DAT, the average leaf numbers recorded under the J5 treatment were 15.00, 20.72, 27.67, 36.89, 46.89, 55.61, and 59.89 leaves per plant, respectively. Similarly, Biosaka concentration significantly influenced leaf number at 49 and 56 DAT. The K2 treatment (2.5 mL/L) produced the highest leaf numbers, with averages of 46.50 and 54.33 leaves per plant at 49 and 56 DAT, respectively. These results indicate that the intermediate concentration was more effective in promoting leaf development than either the lower or higher concentrations tested.

The superior performance of the J5 formulation may be associated with the greater diversity of plant materials used in its preparation. The combination of multiple plant species may have provided a broader range of bioactive compounds that enhanced physiological processes related to vegetative growth. Increased leaf formation contributes to a larger photosynthetic surface area, which may subsequently support greater biomass accumulation and plant development. The positive response observed under the K2 treatment suggests that an optimum Biosaka concentration is required to maximize plant growth. Similar responses have been reported in previous studies, where moderate concentrations of biostimulants or elicitors were more effective than excessive application rates. Thus, the J5 formulation combined with a concentration of 2.5 mL/L appears to be the most favorable treatment for promoting leaf development in chili pepper.

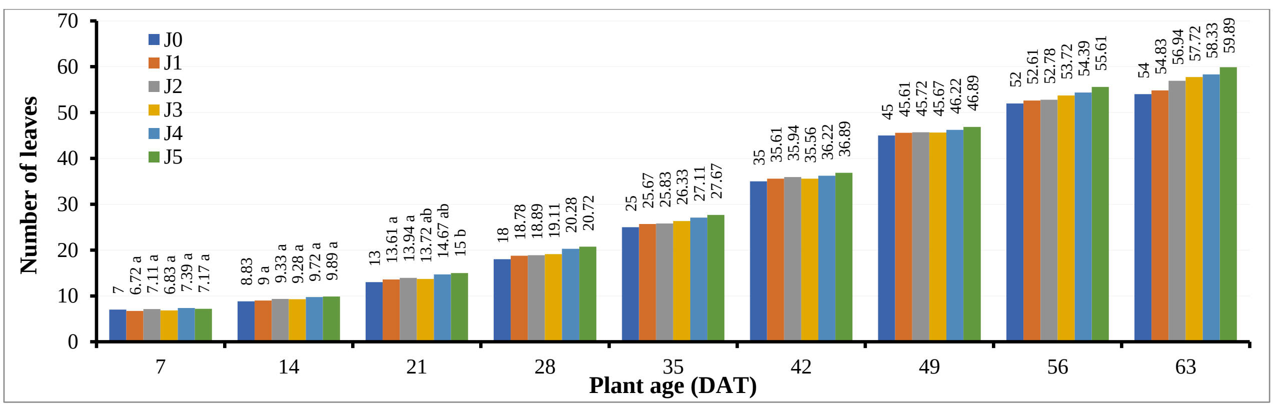

Figure 8. Effect of Biosaka concentration on leaf number of chili pepper plants from 7 to 63 DAT. [Note: Means followed by the same letter in the same age indicate no significant difference in the 5% HSD test]

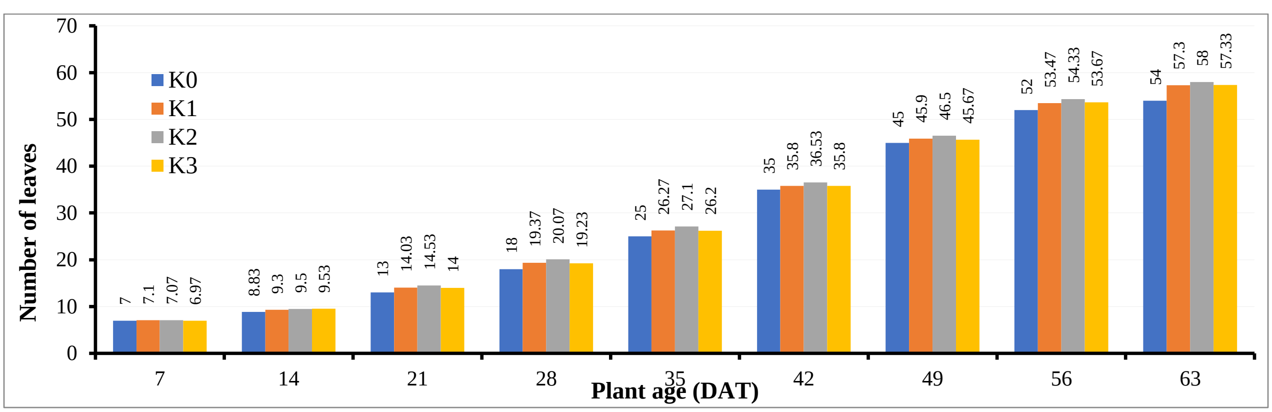

Figure 9. Growth of the number of chili leaves aged 7-63 days after planting (DAP) in the Biosaka concentration treatment

Table 1. Average number of leaves of chili pepper plants 7-28 DAT in single treatment of material composition and Biosaka concentration

Composition Biosaka Material	7 DAT	14 DAT	21 DAT	28 DAT	35 DAT	42 DAT	49 DAT	56 DAT	63 DAT
J0	14.17	17.33	20.92	25.58	7	8.83	13	18.00	54
J1	14.03	18.08	21.47 a	25.78 a	6.72	9	13.61 a	18.78 a	54.83 a
J2	14.14	18	21.58 a	25.89 a	7.11	9.33	13.94 ab	18.89 ab	56.94 b
J3	14.39	18.17	21.97 ab	26.61 b	6.83	9.28	13.72 a	19.11 ab	57.72 bc
J4	14.44	18.25	22.17 ab	27.11 bc	7.39	9.72	14.67 ab	20.28 bc	58.33 c
J5	14.67	18.5	22.5 b	27.56 c	7.17	9.89	15 b	20.72 c	59.89 d
HSD 5%	**ns**	**ns**	**0.90**	**0.72**	**ns**	**ns**	**1.12**	**1.43**	**1.34**
Biosaka Concentration									
K0	7	8.83	13	18.00	25	35	45	52	54
K1 (1.5 mL/L)	7.1	9.3	14.03	19.37	26.27	35.80	45.9 ab	53.47 a	57.30
K2 (2.5 mL/L)	7.07	9.5	14.53	20.07	27.10	36.53	46.5 b	54.33 b	58.00
K3 (3.5 mL/L)	6.97	9.53	14.00	19.23	26.20	35.80	45.67 a	53.67 ab	57.33
HSD 5%	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**0.78**	**0.83**	**ns**

3.4. Number of Productive Branches

The analysis of variance (ANOVA) showed that Biosaka composition did not significantly affect the number of productive branches of chili pepper plants. In contrast, Biosaka concentration significantly influenced this parameter. As presented in Table 2, the K2 treatment (2.5 mL/L) produced the highest number of productive branches, with an average of 20.20 branches per plant. This result indicates that the application of Biosaka at an intermediate concentration was more effective in promoting branch development than either lower or higher concentrations. The formation of productive branches is closely related to vegetative growth because branches provide additional sites for flowering and fruit formation. Therefore, the increased number of productive branches observed under the K2 treatment may contribute to improved reproductive performance and yield potential. The absence of significant differences among Biosaka compositions suggests that branch development was more responsive to application rate than to differences in plant material composition. The number of leaves in all treatments is lower than that of control without biosaka which is 20.33.

Table 2. Effect of Biosaka composition and concentration on the number of productive branch of chili pepper plants

2-way table	K1	K2	K3	Average
J1	19.7	20.3	19.3	19.78
J2	19.0	20.2	19.3	19.50
J3	19.8	20.3	19.8	20.00
J4	18.7	20.8	19.5	19.67
J5	20.2	19.3	20.2	19.89
Average	19.47 a	20.20 b	19.63 ab	-

Note: Numbers followed by the same letter indicate no difference under HSD test at significance level of $\alpha = 5\%$.

3.5. Flowering Age

The analysis of variance (ANOVA) showed that neither Biosaka composition nor Biosaka concentration significantly affected the flowering age of chili pepper plants with total average of 43.67 DAT (Table 3). The absence of significant treatment effects indicates that flowering initiation was primarily controlled by the genetic characteristics of the cultivar and environmental conditions rather than by Biosaka application. Similar observations have been reported in previous studies, where flowering time was influenced more strongly by plant genotype, growing conditions, and nutrient availability than by the application of biostimulants or elicitors (Nabila *et al*., 2024). In the present study, the control treatment (J0K0) flowered at 44.67 DAT, and the flowering ages observed under Biosaka treatments were statistically comparable. This finding suggests that Biosaka application mainly affected vegetative growth parameters, whereas its influence on the transition from vegetative to reproductive growth was limited. The lack of a significant effect on flowering age may also indicate that the nutrients and bioactive compounds supplied through Biosaka were insufficient to alter the physiological mechanisms regulating floral initiation. Nevertheless, Biosaka application contributed positively to several vegetative growth parameters, which may indirectly support subsequent plant productivity.

Table 3. Mean of flowering age (DAT) of chili pepper plants as affected by Biosaka composition and concentration

	K1	K2	K3	Average
J1	45.83	46.50	42.83	45.06
J2	42.67	42.67	43.83	43.06
J3	43.33	45.00	42.50	43.61
J4	40.33	42.00	45.33	42.56
J5	43.83	43.67	44.67	44.06
Average	43.20	43.97	43.83	43.67

3.6. Number of Flowers

The analysis of variance (ANOVA) showed that neither Biosaka composition nor Biosaka concentration significantly affected the number of flowers produced by chili pepper plants with total average of of 139.22 (Table 4). The absence of significant treatment effects suggests that flower production was primarily influenced by genetic and environmental factors rather than by Biosaka application. Although Biosaka treatments improved several vegetative growth parameters, these improvements were not accompanied by significant increases in flower number. Similar findings have been reported by Majkowska-Gadomska *et al*. (2021), who observed that biostimulant application did not significantly affect the number of flowers per plant despite influencing vegetative growth and yield-related traits. Likewise, Mezeyová *et al*. (2024) reported no significant differences in flowering intensity among treatments receiving humic-based biostimulants. The results indicate that the application of Biosaka elicitors was not sufficiently effective in modifying the physiological processes associated with flower initiation and development. Therefore, under the conditions of this study, Biosaka application had a limited influence on the flowering characteristics of chili pepper plants.

Table 4. Mean number of flower of chili pepper plants under different Biosaka composition (J) and concentration (K) treatments

	K1	K2	K3	Average
J1	145.50	135.33	143.17	141.33
J2	128.67	138.67	146.33	137.89
J3	140.17	130.50	134.83	135.17
J4	147.83	143.50	139.33	143.56
J5	134.83	134.33	145.33	138.17
Average	139.40	136.47	141.80	139.22

Table 5. Mean fruit set (%) of chili pepper plants under different Biosaka composition (J) and concentration (K) treatments

	K1	K2	K3	Average
J1	87.2	76.3	89.8	84.46
J2	80.1	91.6	81.3	84.33
J3	91.0	90.7	83.4	88.39
J4	70.5	95.9	88.1	84.83
J5	80.8	89.0	86.4	85.40
Average	81.94	88.71	85.80	85.48

3.7. Fruit Set (%)

Fruit set is an important indicator of reproductive success because it reflects the proportion of flowers that successfully develop into fruits. The analysis of variance (ANOVA) showed that neither Biosaka composition nor Biosaka concentration significantly affected fruit set. As presented in Table 5, fruit set values ranged from 84.33% to 88.39% among Biosaka composition treatments, with total average of 85.48%. For Biosaka concentration treatments, the highest fruit set was observed in K2 (2.5 mL/L), reaching 88.71%. However, these differences were not statistically significant. Fruit set is influenced by several physiological and environmental factors, including pollination success, pollen viability, nutrient availability, and environmental conditions during the reproductive stage. Utaminingsih *et al*. (2019) reported that drought stress can reduce pollen viability and disrupt pollination, resulting in flower abscission and lower fruit set. Conversely, excessive soil moisture may inhibit oxygen diffusion in the root zone, leading to flower and fruit drop and ultimately reducing fruit set (Pahlevi *et al*., 2021). Although environmental conditions were not evaluated as treatment factors in the present study, the relatively high fruit set values observed across all treatments suggest that the growing conditions were generally favorable for pollination and fruit development. The absence of significant differences among Biosaka treatments indicates that Biosaka composition and concentration had limited influence on fruit set compared with other physiological and environmental factors affecting reproductive success. The fruit set in all treatments is lower than that of control which is 92.75%.

3.8. Harvest Age

Harvest age is an important agronomic parameter because it determines crop maturity and influences production scheduling. The analysis of variance (ANOVA) showed that neither Biosaka composition nor Biosaka concentration significantly affected the harvest age of chili pepper plants (Table 6). As presented in Table 8, the average harvest age ranged from 89.33 to 91.28 DAT among Biosaka composition treatments with total average of 90.27 DAT. The earliest harvest was observed in the J5 treatment (89.33 DAT), whereas the latest harvest occurred in the J3 treatment (91.28 DAT). Similarly, among Biosaka concentration treatments, harvest age ranged from 89.53 to 90.77 DAT, with K2 (2.5 mL/L) showing the earliest harvest and K3 (3.5 mL/L) the latest. However, these differences were not statistically significant. For comparison, the harvest age in the control treatment is 88.83 DAT. The absence of significant treatment effects suggests that harvest age was primarily determined by the genetic characteristics of the cultivar and environmental conditions rather than by Biosaka application. Similar findings were reported by Ichwan *et al*. (2021), who observed no significant differences in several phenological parameters, including harvest age, among chili treatments. Although Biosaka application improved several vegetative growth parameters, these improvements did not accelerate fruit maturation sufficiently to produce significant differences in harvest age. Therefore, under the conditions of this study, Biosaka composition and concentration had limited influence on the timing of crop maturity.

Table 6. Mean harvest age (DAT) of chili pepper plants as affected by Biosaka composition (J) and concentration (K) treatments

	K1	K2	K3	AVERAGE
J1	91.2	89.0	88.8	89.67
J2	92.7	90.5	90.3	91.17
J3	90.5	90.5	92.8	91.28
J4	89.8	88.5	91.3	89.89
J5	88.3	89.2	90.5	89.33
AVERAGE	90.50	89.53	90.77	90.27

3.9. Fruit Characteristic

The average values of fruit characteristics are presented in Table 7. Fruit characteristics are important yield components because they directly determine crop productivity and market value. These characteristics are influenced by genetic factors, environmental conditions, nutrient availability, and the physiological status of the plant during fruit development. Harita *et al*. (2022) reported that fruit number and fruit weight are strongly influenced by nutrient availability and fertilizer application during the generative stage. In addition, water availability plays an important role in fruit development and contributes to fruit weight. The analysis of variance (ANOVA) showed that there was no significant interaction between Biosaka composition and Biosaka concentration on fruit number per plant, fruit weight per plant, fruit weight per fruit, fruit diameter, and fruit length of chili pepper. Similarly, the individual effects of Biosaka composition and Biosaka concentration were not significant for any of the fruit characteristics observed.

Although some treatments tended to produce higher values than others, the differences among treatments were not statistically significant. These findings suggest that the application of Biosaka did not substantially influence fruit development under the conditions of this study. Similar findings were reported by Arthur *et al*. (2023), who observed that biostimulant application did not significantly affect marketable yield in chile pepper, despite improving certain fruit quality attributes. The absence of significant differences in fruit characteristics indicates that the positive effects of Biosaka were more pronounced during the vegetative growth stage than during the reproductive stage. While Biosaka application significantly increased plant height, stem diameter, and leaf number, these improvements were not sufficient to produce significant changes in fruit size or fruit yield components. According to Aknantasari *et al*. (2022), an appropriate concentration of biostimulants can enhance chlorophyll formation and improve photosynthetic activity, thereby increasing the production and translocation of assimilates to developing fruits. However, the present study

Table 7. Effect of Biosaka material composition (J) and concentration (K) on the fruit characteristic of chili pepper

Composition of Biosaka Elicitor Materials	Number of fruits per plant	Fruit weight per plant (g)	Weight per piece (g)	Fruit length (cm)	Fruit diameter (mm)
J0	55.5	64.8	3.57	3.46	13.5
J1	50.2	57.3	3.53	3.48	13.3
J2	49.8	62.0	3.69	3.45	13.1
J3	50.8	62.2	3.64	3.48	13.4
J4	52.3	63.0	3.70	3.49	13.4
J5	50.4	59.8	3.60	3.47	13.4
HSD 5%	**Ns**	**ns**	**ns**	**ns**	**ns**
Biosaka Concentration (mL/L)					
0	55.5	64.8	3.57	3.46	13.5
K1 (1.5 mL/L)	48.3	58.8	3.59	3.45	13.3
K2 (2.5 mL/L)	52.0	62.2	3.68	3.50	13.1
K3 (3.5 mL/L)	51.7	61.6	3.62	3.47	13.6
HSD 5%	**Ns**	**ns**	**ns**	**ns**	**ns**

suggests that the Biosaka treatments applied were unable to generate a statistically significant improvement in fruit characteristics. Therefore, under the conditions of this experiment, Biosaka application contributed more effectively to vegetative growth than to fruit development and quality.

4. CONCLUSION AND SUGGESTION

The composition and concentration of Biosaka elicitor influenced several vegetative growth parameters of chili pepper (*Capsicum frutescens* L.). Biosaka composition significantly affected plant height, stem diameter, and leaf number, with the J5 formulation (babandotan + bunga pukul empat + patikan kebo + meniran + anting-anting) producing the most favorable vegetative growth response. Biosaka concentration significantly affected plant height, leaf number, and the number of productive branches, with the optimum response obtained at a concentration of 2.5 mL/L (K2). In contrast, Biosaka composition and concentration did not significantly affect flowering age, number of flowers, fruit set, harvest age, or fruit characteristics, including fruit number, fruit weight, fruit diameter, and fruit length. These findings indicate that Biosaka application was more effective in promoting vegetative growth than reproductive development under the conditions of this study. Therefore, the J5 formulation applied at a concentration of 2.5 mL/L can be recommended as a promising Biosaka treatment to enhance vegetative growth in chili pepper cultivation.

Further studies should evaluate a wider range of Biosaka concentrations to determine the optimum application rate under different environmental conditions. Research conducted across multiple locations and growing seasons is also recommended to assess the consistency and stability of Biosaka performance. In addition, future studies should investigate the effects of Biosaka on fruit quality attributes, such as vitamin content, capsaicin concentration, and moisture content, as well as its potential integration with organic and inorganic fertilization strategies to improve crop productivity and sustainability.

AUTHOR CONTRIBUTION STATEMENT

Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
ATS	✓	✓			✓	✓		✓	✓	✓				
Mak	✓	✓		✓						✓		✓		
JS	✓	✓		✓						✓		✓		

C: Conceptualization	Fo: Formal Analysis	O: Writing - Original Draft	Fu: Funding Acquisition
M: Methodology	I: Investigation	E: Writing - Review & Editing	P: Project Administration
So: Software	D: Data Curation	Vi: Visualization	
Va: Validation	R: Resources	Su: Supervision	

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