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Effect of application frequency of tauge extract and dosage of liquid organic fertilizer from mangrove leaf sap on growth and flower yield of butterfly pea

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ABSTRACT

This study aims to determine the effect of the frequency of sprout extract application and the dosage of liquid organic fertilizer derived from mangrove leaf sap on the growth and yield of butterfly pea flowers. The butterfly pea is an ornamental vine with potential as a food and medicinal plant but still faces challenges related to low productivity in Indonesia. A Randomized Complete Block Design (RCBD) was used with two factors: organic fertilizer dosage (0, 100, 150, and 200 ml) and frequency of sprout extract application (every 0, 5, 10, and 15 days). A total of 60 experimental units were assessed, focusing on plant height, number of flowers, dry and fresh flower weight, as well as protein and flavonoid content. The results showed that the combination of organic fertilizer dosage and sprout extract application frequency had a significant effect on growth parameters. Treatment P4 (200 ml) and frequency H1 (every 5 days) produced the highest plant height (158.37 cm) and the greatest number of flowers (50). Additionally, certain treatments led to increased protein and flavonoid content, supporting the butterfly pea's potential as a nutritional and medicinal resource. These findings are expected to provide practical recommendations for farmers to sustainably improve butterfly pea flower productivity.

Key words: Growth regulators, secondary metabolites, flavonoids, protein, flower productivity.

INTRODUCTION

Clitoria ternatea L., commonly known as butterfly pea flower, is a well-known herb renowned not only for its aesthetic beauty but also for its significant health benefits. As a natural source of flavonoids and other bioactive compounds, butterfly pea flower has been widely used in traditional medicine and modern research. Its high anthocyanin content gives it promising economic value. However, the productivity of butterfly pea in Indonesia remains relatively low, with average yields ranging from 0.5 to 1 ton per hectare. Several factors contribute to this low productivity, including suboptimal cultivation practices such as poor variety selection, inadequate planting techniques, and ineffective fertilizer use. Under improved management, the yield per harvest (at 42 days old) can reach 25–29 tons of dry weight per hectare, with seed production of 2.2 tons per hectare (Sutedi, 17).

The use of organic fertilizers offers a sustainable solution to the issues caused by chemical fertilizers. Liquid organic fertilizers (LOFs), particularly those made from mangrove leaf sap, are promising alternatives as they contain essential macro- and micronutrients and natural growth hormones. Studies indicate that LOFs can enhance vegetative growth and crop yields by 20–30%. Sapareng *et al*. (15) found that mangrove leaf extract is rich in nutrients vital for plant growth, while Ayu *et al*. (5) reported that mangrove ecosystems can produce organic biomass suitable for LOF production.

Bean sprout extract, a natural growth regulator, is effective in promoting plant growth and flowering due to its content of auxins, cytokinins, and gibberellins. According to Triani *et al.* (19), proper gibberellin use can increase flower numbers by 40% and hasten flowering by 7–10 days. The combination of mangrove-based LOF and bean sprout extract may have a synergistic effect on growth and yield. However, information on their interaction in *Clitoria ternatea* cultivation remains limited. This study aims to evaluate the effects of LOF dosage and sprout extract application frequency, and to offer practical guidance for improving butterfly pea flower productivity sustainably.

MATERIALS AND METHODS

The present study was conducted from June to October, 2023 at the Field Laboratory of the Faculty of Agriculture, UNS Jumantono, Karanganyar and the Food Chemistry and Biochemistry Laboratory of the Food Technology Science Study Program, UNS. The tools and materials used are: Butterfly pea flower seeds, organic growth regulator bean sprout extract,

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liquid organic fertilizer mangrove leaf sap, planting media, agricultural equipment and observation. The research design used was Complete Randomized Group Design with 2 factors: 1. Dosage of organic fertilizer (P0-P4): 0, 100, 150, 200 ml. 2. Frequency of organic growth regulator application (H0-H3): (0, 5, 10, 15 days) with a total of 20 treatment combinations, repeated 3 times, resulting in 60 experimental units. Observations of variables observed included plant height, number of flowers, dry weight and fresh weight of flowers, and tests were carried out to determine the protein and flavonoid content in butterfly pea flowers. The Kjeldahl method was used to determine the protein content in the sample by measuring the total nitrogen, which was then converted to protein value. The spectrophotometric method was used to measure the flavonoid concentration. The data obtained were analyzed using analysis of variance (Anova) at the 5% level. If there is a significant difference, then data testing is continued with Duncan Multiple Range Test (DMRT) at the 95% level.

RESULTS AND DISCUSSION

Different combinations of bean sprout extract application frequency and liquid organic fertilizer dose resulted in varying plant height measurements. The P4H2 treatment did not differ significantly from P4H1, while P1H3 differed significantly from P1H1 (Table 1). Increasing the fertilizer dose from P0 to P4 led to higher plant heights across most sprout extract frequencies. The 250 ml dose (P4) gave the best results in nearly all frequency treatments, suggesting that a higher dose enhances nutrient absorption. The 150 ml dose (P2) also performed well, though not as effectively as P4, and was better than the lower doses (P0, P1) (Table 1).

The P4H2 combination (250 ml liquid organic fertilizer and bean sprout extract every 10 days) produced the highest plant height (184.33 cm), while P1H1 resulted in the lowest (97.37 cm). This suggests that a high fertilizer dose combined with moderately frequent bean sprout extract application (every 10 days) promotes optimal plant growth. This may relate to plant energy allocation, as absorption and metabolism of growth regulators require energy (Arif, 3). Overly frequent application can divert energy from growth, reducing efficiency.

The interaction between sprout extract frequency and fertilizer dose showed a positive effect on plant height. More frequent application and higher fertilizer doses generally enhanced growth, with a clear increase from P0 to P4. This aligns with Liebig's "law of the minimum," where growth is limited by the scarcest nutrient. Significant height gains were only evident at the highest dose (250 ml), indicating a threshold effect, where plants respond only after a critical nutrient level is reached (Sulistyowati *et al.*, 16). Fatima *et al*. (9) also noted that POC concentration significantly affects chrysanthemum height, and Krisnarini *et al*. (12) found rabbit urine-based POC positively impacted chickpea height.

The P4H2 treatment did not differ significantly from P4H1, P3H3, and P2H3, but showed a significant difference compared to the control (P0H0) in term of number of flowers. Plants without liquid organic fertilizer (P0) produced a low number of flowers (12). The average flower count in P2 treatments was stable, though no frequency resulted in significantly higher values than others. Variations in bean sprout extract frequency had no significant effect on flower number in the H0 group (no sprout extract applied) (Table 2).

The P4H2 fertilizer combination gave the best results for flower number. Combinations of P4 with frequencies H1, H2, and H3 produced the highest flower count (50 strands), indicating that high doses of liquid organic fertilizer applied regularly are very

Table 1: Average plant height (cm) as affected by the dosage and frequency of application of liquid organic fertilizers.

Dose of liquid organic fertilizer	Frequency of application of sprouts extract			
	H0 (0 times)	H1 (once every 5 days)	H2 (once every 10 days)	H3 (once every 15 days)
P0 (0 ml)	96,40c*	105,57c	114,83b	105,90c
P1 (100 ml)	97,37c	112,23b	107,80c	130.43a
P2 (150 ml)	112,60b	110,73b	136,10a	116,57b
P3 (200 ml)	109,77b	114,37b	121,03b	148,07b
P4 (250 ml)	112b	158,37a	184,33a	117,70b

*Numbers followed by the same notation in the column group show no significant difference according to DMRT analysis at 5% level.

Table 2: Average number of flowers (strands) as influenced by the dosage and frequency of application of liquid organic fertilizers.

Dosage treatment of liquid organic fertilizer	Frequency of application of sprouts extract			
	H0 (0 times)	H1 (once every 5 days)	H2 (once every 10 days)	H3 (once every 15 days)
P0 (0 ml)	12,00c*	25,67c	36,33b	15,67c
P1 (100 ml)	22,33c	27,33b	41,33b	26,33b
P2 (150 ml)	28,67b	27,00b	24,00b	22,00c
P3 (200 ml)	15,67c	19,00c	25,67b	35,00a
P4 (250 ml)	34,67b	44,67a	50,00a	41,33a

*Numbers followed by the same notation in the column group show no significant difference according to DMRT analysis at 5% level.

effective. Biostimulants like liquid organic fertilizers increase nutrient availability, accelerating flowering and improving flower quality (Das *et al*., 8).

Hormones in bean sprout extract also influence flower formation. Regular application helps maintain soil nutrient and phytohormone levels, boosting flower numbers. However, external factors such as light, temperature, humidity, and soil conditions affect plant response. During the study, low rainfall and high temperatures increased transpiration, causing dehydration that limited the effectiveness of bean sprout extract under stress conditions.

Seed sources also impact butterfly pea flower formation. Genetic differences among seed populations influence germination rates and environmental tolerance. Organic fertilizer benefits plant branching by increasing nutrient availability in the growth medium (Adiwijaya *et al*., 2).

Flower fresh weight results corresponded with the flower numbers in each treatment (Table 3). The P4H2 treatment combination, with 50 flowers, produced the highest fresh flower weight of 13.83 g. In contrast, the treatment without fertilizer and bean sprout extract yielded the lowest average weight of 5.01 g, corresponding to only 12 flowers (Table 3). Flower weight is also affected by flower surface size, which can be influenced by liquid organic fertilizer application. Abubakar *et al*. (1) reported that different concentrations of liquid organic fertilizer significantly impacted flower petal size at 2, 4, 6, 8, and 10 weeks after flowering. Higher fertilizer concentrations resulted in wider petals, with the largest petal area observed at 8 weeks, followed by a decrease at 10 weeks. This supports the finding that a 250 ml dose of liquid organic fertilizer significantly improves petal size.

Dry weight indicates how efficiently a plant uses resources like water, nutrients, and light for growth. The combination of P4 with H2 or H3 showed significantly better flower dry weight results compared to other treatments (Table 4). Dry weight measurements are important for assessing plant health and productivity, as dry biomass reflects photosynthetic efficiency, nutrient use, and final yield. The high dry weight in the P4 treatment (250 ml fertilizer) indicates efficient photosynthesis. P4 not only produced the highest dry weight but also showed increased values across all extract application frequencies (H0–H3), demonstrating better nutrient utilization at the right fertilizer dose.

The P4H2 treatment showed the highest average flower number (Table 2), consistent with Arnawa *et al*. (4), who found that plants with greater dry biomass generally produce more flowers and seeds. The increases in dry weight for P1 and P2 compared to P0 suggest that improved fertilizer doses and extract frequency benefit plant growth and final yield, which is crucial in sprout cultivation. Bean sprout extract contains growth hormones that stimulate branching and enhance growth quality (Thana, 18). Overall, the data highlight how different treatments significantly impact final yield.

Phytochemical screening results from ethanol extracts of butterfly pea flowers, which successfully identified the presence of flavonoids, phenolic compounds, and anthocyanins (Cahyaningsih *et al*., 7). Yumni *et al*. (20) also highlighted the antioxidant profile and flavonoid levels in the water and ethyl acetate fractions of butterfly pea flower extracts, showing results that support the hypothesis that butterfly pea flowers contain significant amounts of flavonoids.

Treatment H1 in each dose showed better flavonoid content results, although P4H1 had lower results. The highest flavonoid content was obtained in the P0H1 treatment (43.91 mg QE/g), with the most frequent frequency of administration of bean

Table 3: Average flower fresh weight (g) as affected by the dosage and frequency of application of liquid organic fertilizers.

Treatment dosage of liquid organic fertilizer	Frequency of application of sprouts extract			
	H0 (0 times)	H1 (once every 5 days)	H2 (once every 10 days)	H3 (once every 15 days)
P0 (0ml)	5,01c*	7,39c	8,32c	5,36c
P1 (100 ml)	6,40c	8,13c	12,05b	7,55c
P2 (150 ml)	8,58b	7,37b	7,36b	7,13b
P3 (200 ml)	5,05c	6,31c	7,58b	8,50b
P4 (250 ml)	8,64b	12,46a	13,83a	10,28a

*Numbers followed by the same notation in the column group show no significant difference according to DMRT analysis at 5% level.

Table 4: Effect of dosage and frequency of application of liquid organic fertilizers on average flower dry weight (g).

Dosage of liquid organic fertilizer	Frequency of application of sprouts extract			
	H0 (0 times)	H1 (once every 5 days)	H2 (once every 10 days)	H3 (once every 15 days)
P0 (0ml)	1,86d*	3,29c	3,83b	2,12d
P1 (100 ml)	2,88c	3,58c	5,64a	3,21c
P2 (150 ml)	4,24a	3,45c	3,43c	3,03c
P3 (200 ml)	2,15d	2,68d	3,41c	3,89b
P4 (250 ml)	3,92b	5,89a	6,61a	4,74a

*Numbers followed by the same notation in the column group show no significant difference according to DMRT analysis at 5% level sprout extract, namely once every 5 days. This is because bean sprouts contain glutathione, which functions as an antioxidant. Antioxidants in bean sprouts extract can help reduce oxidative stress in plants, thus encouraging the production of secondary metabolites such as flavonoids. Giving bean sprout extract to plants can stimulate the activity of enzymes involved in flavonoid biosynthesis, thereby increasing the accumulation of these compounds (Baba and Afolabi, 6). Mangrove leaf sap (*Rhizophora mucronata*) contains biologically active compounds that can increase antioxidant activity and support plant growth (Ridlo *et al*., 14). Butterfly pea flowers contain significant flavonoids and are able to show good antioxidant activity using the FRAP (Ferric Reducing Antioxidant Power) method. Hariadi *et al*. (10) showed that butterfly pea flowers have antihypertensive activity and contain flavonoid and saponin components that make them an option in making functional drinks.

Fertilization generally affects the content of secondary metabolites in almost all plants. The results above show that the application of liquid organic fertilizer has an effect on flavonoid content compared to untreated plants. However, the treatment with the highest dose of liquid organic fertilizer tended to show lower results than the other treatments although it was still better than the untreated ones. This can be caused by the availability of excess nutrients that are no longer absorbed by plants in synthesizing flavonoids. Flavonoid synthesis is influenced by the enzyme phenyl alanine amonialiase (PAL) (Ramadhan *et al*., 13), where enzyme activity depends on nitrogen and potassium in adequate conditions and decreases when high fertilizer doses are applied. Excess nutrients in the growing medium will result in a decrease in flavoinoid and anthocyanin content.

Protein content varied and did not show a consistent pattern. P0H0 and P0H1 showed relatively high protein levels (34.61% and 34.925%), indicating that the application of liquid organic fertilizer had no effect on increasing the protein content in butterfly pea flowers with a consistent frequency of application of bean sprout extract once every 5 days showing better results (Table 5). Liquid organic fertilizer doses that are too high can cause nutritional imbalances in plants. Liquid organic fertilizer containing high amounts of nitrogen, if given in excess, can trigger excessive vegetative growth and reduce the accumulation of protein compounds that the plant already has. When plants grow too fast, their focus is more on the growth of leaves and stems, thus reducing the protein synthesis necessary for the formation of flowers or other parts of the plant such as the protein content in them.

Table 5: Influence of the dosage and frequency of application of liquid organic fertilizers on protein and flavanoid contents of butterfly pea.

Treatment	Protein (5% weight basis)	Flavonoid (mg QE/g)
P0H0	34,61	31,255
P0H1	34,925	43,91
P0H2	32,84	38,36
P0H3	33,08	40,81
P1H0	31,88	36,05
P1H1	32,785	39/12
P1H2	27,56	39,60
P1H3	32,58	37,03
P2H0	31,125	38,71
P2H1	32,275	38,03
P2H2	32,985	36,17
P2H3	32,93	38,81
P3H0	27,29	38,81
P3H1	29,535	44,16
P3H2	27,585	35,21
P3H3	30,76	36,08
P4H0	29,37	34,20
P4H1	29,88	33,70
P4H2	30,35	34,90
P4H3	28,69	34,56

An abiotic or biotic constraint that reduces a plant's ability to convert energy into biomass can be referred to as plant stress (Kaveh *et al.*, 11). The use of high doses of liquid organic fertilizer can affect the protein content of plants, such as bay flowers, by increasing soil salinity. High salinity causes osmotic stress and produces oxidative stress in plant cells. The accumulation of Na+ ions in the soil can inhibit the uptake of K+ ions that are essential for various cellular functions, including protein biosynthesis. Consequently, oxidative stress arising from these conditions increases the production of reactive oxygen species (ROS) that damage cell structures and metabolic processes, including protein production. Under these circumstances, plants prioritize defense mechanisms to overcome oxidative stress rather than increasing protein synthesis, which can decrease the overall protein content of the plant (Kaveh *et al.*, 11).

The application of 250 ml liquid organic fertilizer and the application of bean sprout extract every 10 days (P4H2) produced the highest plant height, number of flowers, and fresh and dry weight of flowers. The more frequent application of bean sprout extract increases flavonoid content, however, too high doses of liquid organic fertilizer can cause stress to plants and reduce protein content.

AUTHORS' CONTRIBUTION

Experiment design (AOP) and conduct of experiment (FR, AOP, AY), manuscript preparation (FR, AOP, AY).

DECLARATION

The authors declare that there is no conflict of interest.

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