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EFFECTS OF ORGANIC, MINERAL, AND GROWTH REGULATOR-ENHANCED FOLIAR FERTILIZERS ON THE GROWTH AND YIELD OF BOK CHOY *(BRASSICA CHINENSIS* L*)*

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ABSTRACT

The study aimed to evaluate the effects of various foliar fertilizers on the growth and yield of Bok choy (Brassica chinensis L.) under net house and field conditions at An Giang University. The experiment, which was designed using a randomized complete block design with four replications, focused on four different types of foliar fertilizers: Lactora (an organic foliar fertilizer derived from seaweed and fish), Silimax (a mineral-organic foliar fertilizer), Grow 16 N -16 P - 8 K (a mineral foliar fertilizer with added growth regulators), and Hi-Potassium C30 (an organic-mineral foliar fertilizer). The results from both experimental phases showed that the Lactora treatment produced the highest plant growth at 35 days after planting in terms of plant height (29.9 cm), leaf number (22.6 leaves), leaf blade length (17.8 cm), and leaf blade width (12.3 cm), as well as the greatest yield (34.2 t/ha in the field). These findings suggest that Lactora organic foliar fertilizer significantly enhances the growth and yield of Bok choy compared to the other treatments tested, making it a practical and effective option for improving Bok choy cultivation in diverse growing environments.

1. INTRODUCTION

Foliar fertilizers have become an essential component in modern agriculture, particularly for enhancing crop productivity and addressing specific nutrient needs throughout the plant growth stages (Ishfaq et al., 2022; Toor et al., 2021). Bok choy (Brassica chinensis L.), a widely cultivated leafy vegetable, is particularly responsive to nutrient applications, making it a suitable candidate for studying the effects of foliar fertilizers (Niu, Liu, Huang, Liu, & Yan, 2021). In recent years, a variety of foliar fertilizers - ranging from organic to mineral-based formulations - have been introduced to improve crop growth, nutrient efficiency, and yield (Abdulraheem, Hu, Ahmed, Li, & Naqvi, 2023; Arslan, 2022), yet their comparative effects on Bok choy remain underexplored.

This study aims to evaluate the effectiveness of four different foliar fertilizers commonly used by vegetable farmers in An Giang Province: Lactora, Silimax, Grow 16-16-8, and Hi-Potassium C30. While these fertilizers are popular in local agricultural practices, their specific effects on the growth and yield of Bok choy (*Brassica chinensis* L.) have not been

extensively studied, leaving a gap in practical knowledge. Lactora, a fully organic fertilizer derived from seaweed and fish, is known for its potential to boost plant growth naturally, while Silimax integrates mineral nutrients with organic matter to enhance nutrient availability. Grow 16-16-8 is a mineral-based fertilizer fortified with growth regulators aimed at promoting vigorous development, and Hi-Potassium C30 is a mineral-organic blend with high potassium content to support overall plant health. Despite the widespread use of these foliar fertilizers, there is limited research comparing their direct impacts on Bok choy growth parameters and yield outcomes.

Given Bok choy's significance as a leafy vegetable crop in the region, optimizing foliar fertilizer use is essential for improving production efficiency and ensuring high-quality harvests. This study seeks to bridge the gap by examining the effects of these fertilizers on key growth parameters such as plant height, leaf blade length and width, and total yield. By conducting experiments under both net house and field conditions, the article will offer an assessment of how each fertilizer performs across different growing environments.

2. MATERIALS AND RESEARCH METHODS

2.1 Research materials

The study was conducted from January to May 2023 on Bok choy (*Brassica chinensis* L.), with seeds sourced from the Bok choy Seeds TN 216 variety, provided by Trang Nong Seed Company. The foliar fertilizer treatments included: (1) Lactora (a completely organic foliar fertilizer, extracted 100% from seaweed and fish), (2) Silimax (a mineral-organic foliar fertilizer, with key nutrient contents including 3% organic matter, 2.7% available potassium, 6.9% calcium oxide (CaO), and 4.9% available SiO_2), (3) Grow 16-16-8 (a mineral foliar fertilizer supplemented with growth regulators, containing N (80 g/L), P_2O_5 (30 g/L), K_2O (40 g/L), B_1 (5 ppm), with added NAA and GA_3 in unspecified amounts by the manufacturer), and (4) Hi-Potassium C30 (a mineral-organic foliar fertilizer containing 250 g/L organic matter and 300 g/L available K_2O).

The plants were grown in rectangular black plastic pots, measuring 65 cm x 42 cm x 20 cm, placed in a net house. In the field, raised beds measuring 1 m in width and 30 cm in height were prepared by hand weeding, loosening the soil, applying agricultural lime, and sun-drying the soil for five days to sterilize it. Straw mulching was applied on the beds to suppress weeds, following the common practice of local farmers, instead of using agricultural plastic mulch.

2.2 Research methods

2.2.1 Experimental setup

The net house experiment was conducted using vegetable pots and a pilot field set up on agricultural land on the campus. The chemical fertilizer formula applied uniformly across both the greenhouse and field experiment at the campus was 82.5 N - 82.5 P_2O_5 - 82.5 K_2O kg/ha. Seeds were soaked in warm water at 40°C for 3 hours, then incubated overnight until germination. The planting distance was 20 cm x 25 cm (as recommended planting distance in the seed's commercial packaging).

Basal fertilization: Decomposed manure (equivalent to 1200 kg/1000 m^2) was applied.

First fertilization (calculated for 1000 m^2): 7 days after transplanting, 25 kg of NPK 15-15-15 was applied (using Phu My 15-15-15 + TE commercial fertilizer).

Second fertilization (calculated for 1000 m^2): 17 days after transplanting, 30 kg of NPK 15-15-15 was applied.

The experiment was conducted in a completely randomized block design (CRBD) with five treatments and four replications. Each replication was represented by a 1m x 10m plot, as follows:

Table 1. Foliar fertilizer amount per 1000 m^2

Application time	Treatment 1 (Lactora)	Treatment 2 (Silimax)	Treatment 3 (Grow)	Treatment 4 (Hi potassium C30)	Treatment 5 (Control)
10 DAP	35 mL	50 mL	50 mL	50 mL	-
25 DAP	35 mL	50 mL	50 mL	50 mL	-

2.2.2 Growth and yield parameters

Measurements were taken at 7-day intervals, on days 21, 28, and 35 after planting. Five plants were selected from each replication, and the average values were calculated for each treatment, totaling 20 plants per treatment.

- Plant height (cm): Measured using a ruler, from the base of the plant to the tip of the tallest leaf.
- Leaf number: Counting fully expanded leaves capable of photosynthesis, with a leaf blade length greater than 1 cm.
- Leaf blade width (cm): Measured on the third leaf from the top at the widest point of the leaf.
- Leaf blade length (cm): Measured from the base to the tip of the same leaf used for measuring width.
- Yield: Average fresh weight per plant (g/plant). Actual yield was calculated by weighing the total yield from the entire plot and converting it to 1 ha.

2.3 Data analysis

The data were averaged using Excel and analyzed for variance (ANOVA) with SPSS software. Duncan's multiple range test at a 5% significance level was applied to evaluate the differences in growth and yield parametersamong the fertilizer treatments.

3. RESULTS AND DISCUSSION

3.1 Growth parameters

3.1.1 Plant height

Table 1 shows that the plant height was significantly affected by the different foliar fertilizer treatments. At 35 days after planting (DAP), plants treated with Lactora consistently had the highest plant height in both net house and field, with final heights of 24.2 cm and 29.9 cm, respectively. These values were significantly higher compared to the control, which had lower plant heights (15.6 cm and 20.3 cm). This indicates that Lactora, an organic fertilizer derived from seaweed and fish, promotes plant growth better, compared to other fertilizers. Silimax, on the other hand, resulted in significantly lower plant heights, particularly at 35 DAP, where the height was only 18.3 cm in pots and 26.4 cm in the field. This suggests that although Silimax provided some beneficial effects on plant height, it is less effective compared to Lactora and Hi-Potassium C30. The control treatment consistently resulted in the lowest plant height throughout all measurement periods, confirming the positive impact of foliar fertilizers on the growth of Bok choy. The data also demonstrate that the application of Hi-Potassium C30 and Grow 16-16-8 foliar fertilizers moderately improved plant height, though not as significantly as Lactora.

Table 2. Plant height (cm) in days after planting (DAP)

Treatments	Nethouse			Field		
	21 DAP	28 DAP	35 DAP	21 DAP	28 DAP	35 DAP
Lactora	19.2 a	21.8 a	24.2 a	21.5 a	25.5 a	29.9 a
Silimax	14.5 c	16.0 d	18.3 c	19.6 c	22.7 c	26.4 c
Grow	14.4 c	17.0 c	17.9 d	20.3 b	23.2 b	28.4 bc
Hi-P	16.0 b	18.7 b	22.1 b	19.5 b	22.4 c	25.2 c
Control	11.6 d	13.5 e	15.6 e	18.0 d	20.6 d	20.3 d
Sig.	*	*	*	*	*	*
CV(%)	13.9	11.2	16.9	21.5	15.5	19.9

*The means followed by the same letter within a column are not significantly different based on Duncan's multiple-range test. Symbols * denote statistical significance at the 5% .*

Hi-P: Hipotassium C30 fertilizer.

These results showed the effectiveness of Lactora, an organic foliar fertilizer derived from seaweed and fish, in enhancing the growth of Bok choy, as indicated by the highest plant heights observed at 35 days after planting. These findings align with research by Kalasariya, Patel, Jain, Prajapati, and Patel (2021), which showed that Lactora significantly improved plant height and leaf development in lettuce, attributed to its nutrient-rich composition and bioactive compounds like cytokinins and auxins (Bell, Bound, & Buntain, 2022). Overall, the results reinforce the benefits of using seaweed-based organic fertilizers to promote growth in various vegetable crops (Nasmia, Rosyida, Masyahoro, Putera, & Natsir, 2021), highlighting Lactora's role as a valuable growth enhancer.

3.1.2 Leaf number

As shown in Table 3 show that foliar fertilizer treatments had a significant impact on the number of leaves in bok choy. At 35 DAP, the plants treated with Lactora had the highest number of leaves in both the pot (20.2 leaves) and soil tests (22.6 leaves). This shows that the organic Lactora foliar fertilizer had a stronger effect on leaf growth than other treatments. In contrast, the control group consistently had the fewest leaves, indicating that without the addition of foliar fertilizers, bok choy plants produce significantly fewer leaves. Silimax and Grow 16-16-8 treatments performed moderately, with Silimax showing higher leaf numbers than Grow in the soil test (20.2 leaves compared to 19.2 leaves at 35 DAP), but both were still lower than Lactora. Interestingly, the Hi-Potassium C30 treatment resulted in comparable leaf numbers to Silimax in the soil test (20.1 leaves at 35 DAP), suggesting that this mineral-organic fertilizer can also positively influence leaf development. The significant differences in leaf number between treatments, as highlighted by the Duncan test, give emphasis to the importance of selecting an appropriate foliar fertilizer for maximizing leaf production in bok choy.

The application of foliar fertilizers on vegetable crops, such as Bok choy, has been shown to significantly increase leaf production due to enhanced nutrient availability and improved physiological processes (Anandakumar, Ranjith, Senthamilselvi, Rajadurai, & Sivakumar, 2024). By supplying essential nutrients directly to the leaves, foliar fertilizers stimulate growth and

promote the development of additional leaves, ultimately contributing to higher overall yields (Niu et al., 2021).

Table 3. Number of bok choy leaves in days after planting

Treatments	Nethouse			Field		
	21 DAP	28 DAP	35 DAP	21 DAP	28 DAP	35 DAP
Lactora	13.0 a	17.3 a	20.2 a	20.2 a	22.2 a	22.6 a
Silimax	10.5 bc bc	12.2 c	15.5 b	16.7 b	18.2 b	20.2 b
Grow	11.5 b	12.9 c	14.2 b	17.2 b	18.1 b	19.2 c
Hi-P	9.2 c	13.2 b	15.5 b	15.6 c	18.2 b	20.1 b
Control	7.7 d	7.9 d	11.5 c	11.7 d	13.7 c	14.7 d
Sig.	*	*	*	*	*	*
CV(%)	8.4	14.3	16.7	13.6	13.5	14.4

*The means followed by the same letter within a column are not significantly different based on Duncan's multiple-range test. Symbols * denote statistical significance at the 5%;*

Hi-P: Hipotassium C30 fertilizer.

3.1.3 Leaf size

3.1.3.1 Leaf blade length

The results presented in Table 4 indicate that the leaf blade length of bok choy was significantly affected by the different foliar fertilizer treatments. Statistical differences at the 5% significance level were observed at 21, 28, and 35 DAP, while a more pronounced difference was noted at the 5% level at 21 DAP.

Table 4. Leaf blade length (cm) of bok choy leaves in days after planting (DAP)

Treatments	Nethouse			Field		
	21 DAP	28 DAP	35 DAP	21 DAP	28 DAP	35 DAP
Lactora	16,3 a	19,2 a	22,7 a	15,4 a	16,5 a	17,8 a
Silimax	13,4 b	16,1 c	16,7 d	13,6 b	14,3 c	16,4 b
Grow	13,2 b	15,5 c	18,6 c	14,2 b	15,4 b	16,6 b
Hi-P	10,8 c	18,3 b	20,6 b	12,6 c	15,3 b	16,3 b
Control	10,6 d	14,3 d	18,4 c	10,8 d	13,6 d	15,1 c
Sig.	**	*	*	*	*	*
CV(%)	14,4	13,8	11,5	10,9	12,4	10,7

*The means followed by the same letter within a column are not significantly different based on Duncan's multiple-range test. An asterisk * denotes statistical significance at the 5%.*

Hi-P: Hipotassium C30 fertilizer.

Table 4 shows that Lactora produced the longest leaf blades at every stage, reaching 22.7 cm at 35 DAP in pots and 17.8 cm in the field. This suggests that Lactora significantly boosts leaf

growth, with statistically significant differences. Hi-Potassium C30 had a moderate effect, measuring 20.6 cm in pots and 16.3 cm in soil, still better than the control group, which reached 18.4 cm and 16.0 cm. Silimax and Grow had smaller impacts, while the control consistently resulted in the shortest leaves, emphasizing the key role of foliar fertilizers in promoting leaf growth.

3.1.3.2 Leaf blade width

Table 5 shows that Lactora produced the widest leaf blades throughout all growth stages, reaching 16.4 cm in net house and 12.3 cm in field at 35 DAP, significantly higher than other treatments. Silimax and Grow 16-16-8 had moderate effects, with leaf widths of 13.6 cm and 13.7 cm in net house, and around 9.3 cm and 10.4 cm in field. Hi-Potassium C30 was less effective but still outperformed the control, which consistently produced the narrowest leaves.

Table 5. Leaf blade width (cm) of bok choy leaves across growth stages in days after planting (DAP)

Treatments	Nethouse			Field		
	21 DAP	28 DAP	35 DAP	21 DAP	28 DAP	35 DAP
Lactora	12,2 a	13,4 a	16,4 a	9,3 a	10,2 a	12,3 a
Silimax	11,3 b	12,4 b	13,6 b	8,2 b	9,1 c	9,3 c
Grow	11,2 b	12,2 b	13,7 b	8,2 b	9,5 b	10,4 b
Hi-P	9,5 c	12,3 b	13,5 b	8,2 b	9,2 c	10,2 b
Control	7,3 d	10,3 c	12,5 c	7,5 c	7,8 d	8,7 d
Sig.	**	*	**	**	*	**
CV(%)	14,31	7,25	7,73	11,21	10,76	10,97

*Notes: Means followed by a similar letter in the column are not significantly different according to Duncan's test; ** indicates statistical significance at the 1% level; * at the 5% level. DAP: Days after planting. Hi-P: Hi-Potassium C30 fertilizer.*

The findings from this study on bok choy were in line with previous research that highlights the positive effects of organic and foliar fertilizers on the growth of leafy vegetables, particularly regarding leaf blade length and width. Similar to our results, studies by Machado, Alves-Pereira, Lourenço, and Ferreira (2020) and Wozniak, Blaszczak, Wiatrak, and Canady (2020) reported significant improvements in leaf length and width when various leafy vegetables were treated with organic foliar fertilizers compared to untountreated controls or mineral-based fertilizers.

In the current study, the application of Lactora resulted in the longest leaf blades, reaching 22.7 cm at 35 DAP in pots and 17.8 cm in field conditions, along with a broader leaf width at different growth stages. These findings where seaweed-based organic fertilizers increased leaf blade length by 25-30% and leaf width by approximately 20% over the control group, highlighting the growth-promoting effects of organic foliar nutrients (Rakkammal, Maharajan, Ceasar, & Ramesh, 2023). Similarly, Olson, Crawford, & Vyn (2022) observed that foliar applications of organic compounds

significantly enhanced leaf expansion at mid-growth stages, paralleling our data showing pronounced differences at 21 DAP.

The Hi-Potassium C30 treatment demonstrated a moderate effect on both leaf blade length and width (Yang et al., 2021), with measurements of 20.6 cm and 16.3 cm, respectively, which were better than the control but less effective than Lactora. This outcome is consistent with findings in related studies where potassium-enriched foliar applications produced intermediate growth responses, enhancing leaf dimensions but not to the extent of more nutrient-rich organic treatments.

In contrast, the results for Silimax and Grow treatments, which exhibited less substantial increases in leaf length and width, align with research where non-organic or silicon-based fertilizers showed limited influence on leaf expansion (Le Thanh et al., 2023). This further emphasizes the superior impact of organic options like Lactora, which likely enhances nutrient uptake and utilization, leading to statistically significant growth across multiple parameters, including both leaf length and width.

3.2 Yield

3.2.1 Average weight per plant

The average weight per plant is a key indicator in determining the yield of bok choy, as it is influenced by the variety's characteristics, the amount of fertilizer used, the nutrients absorbed by the plant, and external environmental conditions.

Table 6. Average weight per bok choy plant (g/plant) across different treatments

Treatment	Nethouse	Field
Lactora	114.3 a	171,2 a
Silimax	85.1 bc	139,1 b
Grow	89.3 b	142,5 b
Hi-P	82.1 c	136,2 bc
Control	78.8 d	112,5 c
Sig.	*	*
CV (%)	9,43	11,5

The means followed by the same letter within a column are not significantly different based on Duncan's multiple-range test. An asterisk (*) denotes statistical significance at the 5% level.

Table 6 presents it is evident that the different foliar fertilizers had a significant impact on the average weight of bok choy plants. The Lactora treatment resulted in the highest average plant weight, with 114.3 g per plant in the net house and 171.2 g per plant in the field test. This demonstrates that Lactora effectively enhances plant growth compared to other treatments. Both Silimax and Grow treatments showed moderate results, with average weights between 85.1 g and 142.5 g. Interestingly, these two treatments did not show a statistically significant difference from each other, indicating a similar effect on plant weight. The Hi-P treatment produced slightly lower weights compared to Silimax and Grow, though it was still better than the control group, which had the lowest average plant weight at 78.8 g in the net house and 112.5 g in the field. The statistical analysis confirmed that the Lactora treatment was significantly different from all other treatments at the 5% significance level, suggesting its superior effect on increasing

the average weight of bok choy plants. In contrast, the control group consistently exhibited the lowest average weight, highlighting the importance of foliar fertilization in improving crop yield.

The use of mineral and organic foliar fertilizers has

been shown to enhance the size of leaves in vegetable crops significantly compared to those that do not receive such treatments (Zahed, Kumar, Mahale, Krishna, & Mufti, 2021). In this study, plants treated with mineral-organic fertilizers exhibited larger leaf dimensions, attributed to the immediate nutrient availability and improved metabolic activity. Conversely, the control group, which did not receive foliar fertilizers, consistently produced smaller leaves, highlighting the critical role of nutrient application in maximizing leaf growth and overall plant health.

3.2.2 Actual yield

Figure 1 presents the actual yield of bok choy in t/ha from two experiments: the net house test and the field test. In the net house, the Lactora treatment yielded the highest final yield at 22.9 t/ha, significantly outperforming the other treatments. The Grow and Silimax treatments had similar results, with 17.9 t/ha and 17.0 t/ha respectively, indicating moderate yield improvements. The Hi-Potassium C30 treatment showed a slightly lower yield of 16.4 t/ha, while the control treatment produced the lowest yield at 15.8 t/ha. This clearly demonstrates the positive impact of foliar fertilization on yield, with Lactora being the most effective treatment in this environment.

In the field, the Lactora treatment again achieved the highest yield, with 34.2 t/ha, further highlighting its superior efficacy in increasing bok choy productivity. The Grow and Silimax treatments also performed well, yielding 28.5 t/ha and 27.8 t/ha respectively, showing a significant improvement over the control. The Hi-Potassium C30 treatment achieved a yield of 27.2 t/ha, which, while lower than Lactora, still marked a considerable increase over the control yield of 22.5 t/ha.

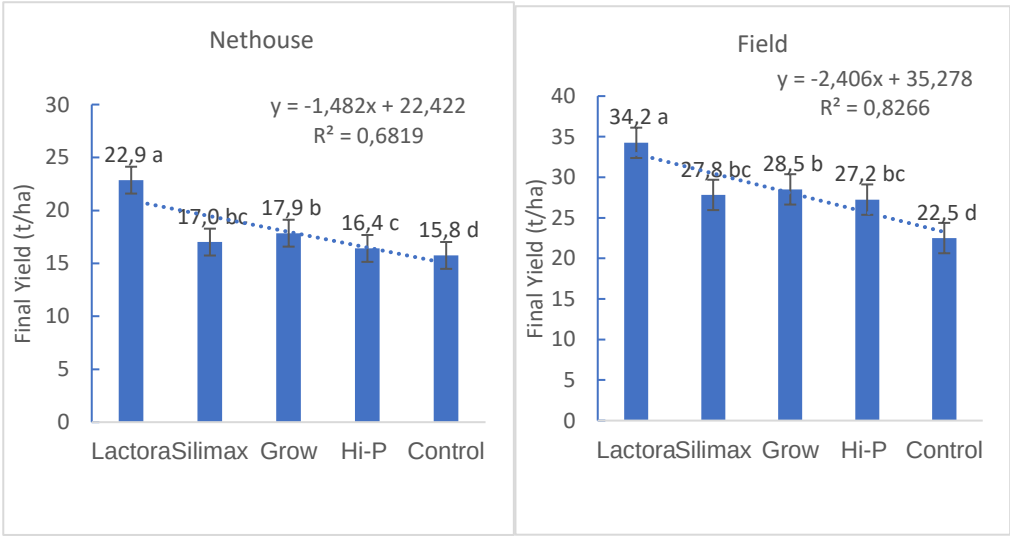

Figure 1. Actual yield of bok choy

The results from both experiments clearly demonstrate that the use of foliar fertilizers significantly enhances bok choy yield compared to the control treatment, which consistently resulted in the lowest yields in both settings.//Overall, the Lactora treatment proved to be the most effective in enhancing the actual yield of bok choy, followed by Grow and Silimax. The results emphasize the importance of selecting appropriate foliar fertilizers to maximize yield potential, particularly in high-demand crops like bok choy. The control treatment's significantly lower yields across both environments further reinforce the necessity of foliar fertilization for achieving optimal results. Lactora, a completely organic foliar fertilizer made 100% from seaweed and fish, enhances nutrient absorption through the leaves, promoting the growth and development of vegetables. This organic composition supplies marked increase in leaf production, leading to higher yields. Additionally, the use of mineral foliar fertilizers complemented the organic treatments, providing essential nutrients that support optimal growth (Niu et al., 2021). The findings align with previous research, underscoring the importance of incorporating both organic and mineral sources into agricultural practices.

4. CONCLUSION

This study evaluated the effects of different foliar fertilizers on the growth and yield of bok choy (Brassica chinensis L.) under both net house and field conditions. The results clearly demonstrated that the use of foliar fertilizers significantly enhanced growth parameters, such as plant height, leaf number, leaf size, and ultimately, yield. The Lactora treatment consistently outperformed all other treatments in both the net house and field tests, providing the highest yields of 22.9 t/ha in the net house and 34.2 t/ha in the field. This indicates that organic essential micronutrients that improve both yield and quality while being environmentally sustainable.

The results of this study highlight the significant impact of both organic and mineral foliar fertilizers on the growth and yield of leafy vegetables, particularly Bok choy. Notably, fertilizers derived from seaweed and fish, such as Lactora (Reppun, Deenik, Martin, & Hoy, 2021), demonstrated remarkable effectiveness in enhancing leaf size and overall plant vigor. This enhancement is attributed to the rich nutrient profile and bioactive compounds found in these organic fertilizers, which stimulate metabolic processes and promote cell division (Phooi, Azman, & Ismail, 2022). In comparison to control groups that received no foliar application, the treated plants exhibited a

foliar fertilizers derived from seaweed and fish, such as Lactora, are highly effective in promoting optimal plant growth and productivity. Grow and Silimax also contributed to considerable increases in yield compared to the control, making them suitable alternatives for enhancing bok choy yield.

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