



The Effectiveness of Weed Extracts as Biopesticides and the Frequency of Application Against Chrysanthemum Pests

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ABSTRACT

The continued use of synthetic pesticides can negatively affect the environment, human health, and the sustainability of crop cultivation. Therefore, weed extracts as plant-based biopesticides offer an environmentally friendly alternative for controlling pests on chrysanthemum plants. This study aims to analyze the effects of the type of weed solution and application frequency on the growth, flower yield, and pest infestation levels of chrysanthemum plants. The study employed a nested randomized block design consisting of two factors: the type of weed solution, which included *Chromolaena odorata* L. (A), *Ageratum conyzoides* L. (B), *Euphorbia hirta* L. (C), *Isotoma longiflora* (D), and *Echinochloa crus-galli* (E), and application frequency of 1 time (K1), 2 times (K2), and 3 times (K3). The observed variables included flower stalk length, flower stalk weight, flower diameter, fresh weight of marketable flowers, and the percentage of infected leaves. The data were analyzed using analysis of variance (ANOVA), followed by a BNT test at the 5% significance level. The results showed that the type of weed solution significantly affected flower stalk length, flower stalk weight, flower diameter, and fresh weight of marketable flowers, but not the number of infected leaves. The *Isotoma longiflora* extract treatment produced the best flower growth and quality, with a flower stalk length of 81.16 cm, a flower stalk weight of 50.44 g, a flower diameter of 4.63 cm, and an economic fresh flower weight of 44.73 g. The application frequency at 9 weeks after planting (K3) yielded the best results for nearly all observed parameters.

Contribution to Sustainable Development Goals (SDGs):

SDG 12: Responsible Consumption and Production

SDG 13: Climate Action

SDG 15: Life on Land

1. INTRODUCTION

1.1. Research Background

Pest control in chrysanthemum (*Chrysanthemum morifolium* Ramat) cultivation is a major challenge in horticultural production because pest infestations can significantly reduce flower quality and productivity. The use of synthetic pesticides has long been the primary solution, but it has adverse effects on the environment and human health, and can lead to pest resistance

to certain active ingredients [1]. Therefore, the development of biopesticides based on local plant extracts is a sustainable, environmentally friendly, and cost-effective strategy within an integrated pest management system.

Weeds are a potential source of active ingredients for biopesticides because they contain secondary compounds such as flavonoids, alkaloids, saponins, tannins, and terpenoids, which have been reported to exhibit insecticidal, antifeedant, or insect growth-inhibiting activity. However, the composition and concentration of these phytochemicals may vary considerably among weed species because of differences in plant taxonomy,



plant parts, growth stage, environmental conditions, and secondary metabolic pathways. Flavonoids and tannins are commonly associated with antifeedant and growth-inhibitory effects, while alkaloids may exert toxic or neuroactive effects on insects. Saponins can interfere with insect feeding and disrupt cell membranes, whereas terpenoids are frequently associated with repellent, insecticidal, and growth-regulating activities. Therefore, differences in the phytochemical profiles of the tested weed species may contribute to differences in their biopesticidal effectiveness. Identifying these variations is important for understanding each weed species' potential as a source of bioactive compounds for pest management [2]. *Ageratum conyzoides* has insecticidal potential against various pests, including mosquito larvae and other insects, through mechanisms of toxicity and disruption of pest physiology [3].

In addition, the weed *Euphorbia hirta* L., traditionally known as a medicinal plant, also contains metabolites that have been shown to reduce the severity of leaf and fruit pest infestations in vegetable crops through their antifeedant and toxic effects on several pest species, such as *Diaphania indica* and *Bemisia tabaci* [4]. Testing the effectiveness of these bioactive compounds on chrysanthemum plants is relevant because pests attack them through similar mechanisms. However, the botanical activity of weeds against agricultural pests remains limited; some pharmacological studies indicate that weeds contain phytochemical compounds with potential as biological agents (alkaloids, flavonoids, tannins, saponins, terpenoids) that can be utilized in botanical pesticide formulations or as natural pest control agents [5][6][7][8]. The application of a weed extract containing active insecticidal compounds, such as tannins, can reduce the severity of pest infestations and have a positive effect on plant growth, as evidenced by increases in stem diameter, leaf diameter, plant height, and fresh plant weight [9].

The frequency of application of weed extract-based biopesticides is an important factor influencing pest-control effectiveness. This is consistent with the view of Untung [10], who states that botanical pesticides have a short residual effect—lasting 7–10 days—and therefore require repeated applications. Furthermore, according to Marwoto [11], the rapid life cycle of thrips causes their population to increase every 2–3 weeks. Therefore, applying the biopesticide three times—at 3, 6, and 9 weeks after planting—is more effective at controlling thrips populations than applying it just once or twice.

Previous studies have shown that the timing and intervals of application relative to the developmental stages of plants and pests can modulate toxic effects, feeding aversion, and mortality in target insects (for example, in tests of botanical pesticides on vegetables). Therefore, this study evaluated the effectiveness of four types of weed extracts as biopesticides against pests on chrysanthemum plants, as well as the optimal application frequency for productive and environmentally friendly chrysanthemum cultivation. Renkema et al [12] state that three applications can reduce thrips attack intensity by up to 65%.

2. MATERIALS AND METHODS

2.1 Research Location and Time

The research will be conducted in Pancasari Village, Sukasada Subdistrict, Buleleng Regency, at an elevation of 1,247 meters

above sea level and with an average temperature of 17°C to 20°C. This research will be carried out at the partner's site. The research is scheduled to last for one year in 2026. The research will take place from February to September 2026.

2.2 Research Design

The research method used a nested randomized block design conducted in the field inside a greenhouse. This study examined two factors: Factor I was the type of weed solution, and Factor II was the application frequency. The production data were analysed using analysis of variance (ANOVA), followed by the BNT 5% post-hoc test, while the chrysanthemum flower quality data were compared with SNI 01-4478-1988. This study used a nested randomized block design consisting of two factors. The first factor was the type of weed solution, which consisted of five levels: *Chromolaena odorata* L. solution (A), *Ageratum conyzoides* L. weed solution (B), *Euphorbia hirta* L. weed solution (C), *Isotoma longiflora* weed solution (D), and *Echinochloa crus-galli* weed solution (E). The second factor was the frequency of weed control solution application, which consisted of three levels: a single application—at 3 weeks after planting (K1), two applications—at 3 and 6 weeks after planting (K2)—and three applications—at 3, 6, and 9 weeks after planting (K3). The combination treatment was repeated three times, requiring 45 experimental plots. With a plot size of 1.5 x 1.5 m, a spacing of 30 cm between plots, and a spacing of 50 cm between replicates, a total of 10 plant samples were collected.

2.3 Equipment and Materials

Research materials and equipment included: chrysanthemum seedlings, weeds, a caliper, an electric scale, labels, PHP mulch, plant support netting, a lamp, a timer, and stakes.

2.4 Research Implementation

The experiment involved preparing the growing medium, applying fertilizer, planting, applying treatments, maintaining the plants (watering, thinning, weeding), observing plant growth and development, harvesting, and analyzing the data.

Plant maintenance involved applying a fungicide containing azoxystrobin (200 g/l) and difenoconazole (125 g/l) to prevent rust disease. The fungicide is applied once a week at a concentration of 1 ml/l. Weeding is done weekly, while watering is done daily. Supplementary lighting began at planting and was provided for 4 hours per day for 1 month, from 10:00 p.m. to 2:00 a.m. continuously, using 75-watt incandescent bulbs spaced 3 m apart and positioned 1 m above the plant canopy. Bioinsecticides were tested to control infestations of *Thrips sp.* and *Aphis sp.* according to the treatment protocol. Treatments were applied when the plants were 9 weeks old by spraying the entire plant. Applications were made once a week in the afternoon until harvest, for a total of four applications.

2.5 Observed Variables

Observed variables included flower stalk length, flower stalk weight, flower diameter, economic weight of fresh flowers per plant, number of infected leaves, and infestation intensity (formula shown below).

The following formula is used to calculate the attack intensity:

$$IS = \frac{\sum(n \times v)}{Z \times N} \times 100\%$$

Notes:

IS = Infestation intensity

n = Number of damaged leaves per infestation category

v = Scale value for each infestation category

Z = Scale value for the highest infestation category

N = Total number of leaves observed

Category	Plant Infestation Rate (%)
Light	If the attack rate is $\leq 10\%$
Moderate	If the attack rate is $\leq 25\%$
Heavy	If the attack rate is $\leq 85\%$
Very Heavy	If the attack rate is $> 85\%$

3. RESULT AND DISCUSSION

3.1. Research Findings

The analysis of variance results showed that the type of herbicide solution had a highly significant effect ($P < 0.01$) on flower stalk length, flower stalk weight, flower diameter, and fresh weight of marketable flowers. Still, they had no significant effect ($P > 0.05$) on the number of infected leaves. The effect of application frequency differed among herbicide solution types. Application frequency had a significant to highly significant effect on most growth and yield parameters, particularly flower diameter and fresh weight of marketable flowers. In addition, application frequency significantly reduced the number of infected leaves for most weed extract types. These results indicate that chrysanthemum plants' response to application frequency depends on the type of weed extract used. Table 1 shows the significance of the treatments.

Statistical analysis showed that the type of weed solution had a significant effect on the flower stalk length, flower stalk weight, and flower diameter of chrysanthemum plants (Table 2). The *Isotoma longiflora* (D) weed solution treatment produced the longest flower stalk, at 81.16 cm, which was significantly different from the *Chromolaena odorata* L (A) and *Ageratum conyzoides* L. (B) weed solutions, but not significantly different from *Euphorbia hirta* L. (C) and *Echinochloa crus-galli* (E). Treatment D also produced the highest flower stalk weight (50.44 g), although it was not significantly different from treatments A, C, and E. Meanwhile, treatment D produced the largest flower diameter (4.63 cm), which was significantly different from treatments B and E but not from treatment C.

Application frequency showed a trend: later applications led to better plant growth. For the *Chromolaena odorata* L extract solution (A), three applications (K3) resulted in the highest flower stalk weight (71.33 g) and flower diameter (7.17 cm). In contrast, flower stalk length did not differ significantly across application frequencies. The same pattern was observed in the *Ageratum conyzoides* L. (B) solution, where three applications of the biopesticide produced the largest flower diameter (6.87 cm) but did not result in any significant differences in flower stalk length or weight.

Table 1. The Significance of Weed Type Treatments and the Interaction of Treatment and Frequency on Chrysanthemum Flowers

Variable	Weed Type (J)	The Effect of Frequency Interactions on Each Type of Weed Solution				
		F dl A	F dl B	F dl C	F dl D	F dl E
1 Flower stem length (cm)	**	ns	ns	ns	*	*
2 Flower stem weight (g)	**	*	ns	*	*	ns
3 Flower diameter (cm)	**	**	*	*	*	ns
4 Fresh weight of market-grade flowers (g)	**	**	**	*	*	**
5 Percentage of infected leaves (%)	ns	**	**	**	*	*

Notes: * = significant effect, ** = highly significant effect, ns = not significant

Table 2. The effects of the type of weed solution and the frequency of application for each type of weed solution on the average flower stalk length (cm), flower stalk weight (g), and flower diameter (cm)

Interactions Among Different Types of Weed Solutions			
Treatment	Flower stem length (cm)	Weight of the flower stalk (g)	Flower Diameter (cm)
A	60.42 bc	39.95 a	3.66 bc
B	55.13 c	36.01 b	3.83 bc
C	72.57 ab	45.47 a	4.14 ab
D	81.16 a	50.44 a	4.63 a
E	64.71 abc	44.49 a	3.34 c
BNT 5%	16.177	10.931	0.658
The effect of frequency on each type of weed solution			
F dl A			
F1	98.40 a	62.67 c	5.33 c
F2	100.17 a	65.77 b	5.80 b
F3	103.53 a	71.33 a	7.17 a
F dl B			
F1	88.80 a	57.43 a	5.97 c
F2	91.70 a	59.80 a	6.33 b
F3	95.17 a	62.83 a	6.87 a
F dl C			
F1	115.33 a	71.47 c	6.43 c
F2	120.57 a	74.87 b	6.97 b
F3	126.93 a	81.00 a	7.30 a
F dl D			
F1	128.02 c	80.90 b	7.40 b
F2	134.70 b	82.47 b	7.55 b
F3	143.07 a	88.83 a	8.22 a
F dl E			
F1	100.30 c	72.20 a	5.38 a
F2	109.27 b	74.23 a	5.52 a
F3	114.00 a	76.00 a	5.78 a
BNT 5%	4.187	2.916	0.294

Note: Values in the same column for each factor that are followed by the same letter are not significantly different based on the BNT test at the 5% significance level

Overall, the results show that the *Isotoma longiflora* weed extract solution was the most effective treatment for improving

chrysanthemum flower quality. In addition, three applications (K3) produced a better generative growth response than one application (K1) or two applications (K2). This indicates that the effectiveness of biopesticides made from weed extracts is influenced not only by the type of weed used but also by the timing of application, particularly during the plant's generative phase when flower formation and development occur intensively.

Table 3. The effects of different weed solution types and different frequencies in each combination of weed solutions on the average fresh weight of economically important flowers (g) and the percentage of infected leaves (%)

Interactions Among Different Types of Weed Solutions		
Treatment	Fresh weight of flowers (g)	Percentage of Infected Leaves (%)
A	32.81 b	4.92 a
B	32.53 b	5.71 a
C	42.15 a	5.46 a
D	44.73 a	4.21 a
E	39.02 a b	4.92 a
BNT 5%	7.072	ns
The relationship between frequency and each combination of weed solutions		
F dI A		
F1	46.03 c	9.97 a
F2	55.73 b	8.17 b
F3	62.28 a	6.45 b
F dI B		
F1	48.76 c	14.83 a
F2	52.98 b	5.90 b
F3	60.92 a	7.82 c
F dI C		
F1	65.08 c	10.98 a
F2	70.67 b	8.95 b
F3	75.00 a	7.38 c
F dI D		
F1	68.57 c	8.25 a
F2	74.62 b	6.72 b
F3	80.48 a	6.09 b
F dI E		
F1	56.90 c	9.44 a
F2	64.97 b	8.18 b
F3	73.25 a	6.98 c
BNT 5%	3.163	0.697

Note: Values in the same column for each factor that are followed by the same letter are not significantly different based on the BNT test at the 5% significance level

Further tests showed that the type of weed extract significantly affected the fresh weight of economically important flowers, but not the number of infected leaves (Table 3). The highest fresh weight of economically important flowers was obtained in the *Isotoma longiflora* (D) weed solution treatment, namely 44.73 g, which was not significantly different from *Euphorbia hirta* L. (C) and *Echinochloa crus-galli* (E). Still, it was significantly different from the *Chromolaena odorata* L. (A) and *Ageratum conyzoides* L. (B) weed solutions. Meanwhile, the percentage of infected leaves ranged from 4.21–5.71% and showed no significant differences among the weed solution types.

Application frequency showed that three applications (K3) produced the highest fresh weight of economically valuable flowers across all weed solution types. In the *Chromolaena odorata* L solution (A), the fresh weight of economically valuable flowers increased from 46.03 g (K1) to 62.28 g (K3). A similar increase was also observed in *Ageratum conyzoides* L. (B),

Euphorbia hirta L. (C), *Isotoma longiflora* (D), and *Echinochloa crus-galli* (E), with the highest values of 60.92 g, 75.00 g, 80.48 g, and 73.25 g, respectively, observed in K3.

Application frequency also significantly affected the number of infected leaves for each herbicide solution. In general, later applications reduced the percentage of infected leaves more effectively than early applications. The highest percentage of infected leaves was generally observed 1 time (K1), while the lowest values were recorded 3 times (K3) or 2 times (K2), depending on the type of weed extract solution. These results indicate that the timing of biopesticide applications made from weed extracts plays a crucial role in increasing the yield of economically valuable flowers while reducing pest infestation in chrysanthemum plants.

3.2 Discussion

The results of the study indicate that the type of weed extract has a significant effect on the flower stalk length, flower stalk weight, and flower diameter of chrysanthemum plants. The treatment using *Isotoma longiflora* weed extract (D) yielded the highest values for all three parameters: flower stalk length of 81.16 cm, flower stalk weight of 50.44 g, and flower diameter of 4.63 cm. In contrast, the *Ageratum conyzoides* L. (B) treatment produced the shortest flower stalks and the lowest flower stalk weight, while the smallest flower diameter was observed in the *Echinochloa crus-galli* (E) treatment. These differences in response indicate that each weed species contains different secondary metabolites, resulting in varying levels of biopesticide effectiveness [13].

The increase in flower stalk length in the *Isotoma longiflora* treatment is thought to be related to the extract's ability to reduce the intensity of pest infestation, thereby allowing photosynthesis and the distribution of assimilated products to proceed more optimally [14]. The reduction in leaf damage maintains a high effective leaf area, allowing accumulated photosynthates to be utilized for both vegetative growth and the formation of reproductive organs [15], [16], [17]. These conditions ultimately promote optimal flower stalk elongation and flower development. Botanical pesticides reduce pest pressure without adversely affecting plant physiology, allowing plants to grow better than those subjected to higher pest infestation levels. [18].

In addition to suppressing pest populations, weed extracts also contain various secondary metabolites such as flavonoids, phenolics, terpenoids, alkaloids, saponins, and essential oils, which are known to exhibit insecticidal, antifeedant, repellent, and insect growth-inhibiting activities [19]. These compounds work through various mechanisms, including inhibiting feeding activity, disrupting the nervous system, inhibiting the molting process, and reducing the pests' reproductive success [20], [21], [22]. As pest pressure decreases, plants allocate more energy to biomass formation and flower development.

The results also show that flower stalk weight increases with flower stalk length. This relationship indicates that better vegetative growth supports the formation of the tissues that make up the flower stalk, thereby increasing its weight. Longer flower stalks generally have better-developed vascular tissues, enabling them to translocate water and photosynthetic products to the flowers more efficiently [23], [24]. These conditions contribute to larger, higher-quality flowers.

Flower diameter is one of the key indicators of cut flower quality because it is directly related to the product's economic

value. The largest flower diameter in the *Isotoma longiflora* treatment indicates that the plants received a greater supply of photosynthates during flower formation. Reduced leaf damage caused by pest attacks allowed photosynthetic efficiency to remain high, enabling optimal cell differentiation and enlargement in the flowers. [25], [26]. Conversely, the smaller flower diameters observed in some treatment groups indicate that the plants still use some photosynthetic products to repair pest-damaged tissues, resulting in suboptimal flower formation.

Differences in efficacy among the weed extracts are thought to reflect variations in the types and concentrations of bioactive compounds in each plant. *Ageratum conyzoides* is known to contain flavonoids, chromones, alkaloids, coumarins, sterols, and terpenoids, which exhibit relatively high biological activity [27], [28]. However, their effectiveness depends on the extraction method, concentration, target organism, and environmental conditions at the application site. Therefore, although all weed extracts have the potential to serve as biopesticides, their ability to enhance the growth and quality of chrysanthemums varies [29], [30].

Overall, the results indicate that using weed extracts as biopesticides not only controls pests but also enhances chrysanthemum growth and quality. The *Isotoma longiflora* treatment yielded the best results in flower stem length, flower stem weight, and flower diameter, suggesting its potential as an environmentally friendly, plant-based biopesticide to support sustainable chrysanthemum cultivation systems.

4. CONCLUSION

The type of weed extract affects growth, yield, and pest-control effectiveness in chrysanthemum plants. *Isotoma longiflora* weed extract produced the longest flower stems, the heaviest flower stems, the largest flower diameters, and the highest fresh flower weight compared with the other treatments. In contrast, weed solution type had no significant effect on the percentage of infected leaves. The frequency of weed solution application for each extract significantly influenced most of the observed parameters. In general, three applications at 3, 6, and 9 weeks after planting (K3) resulted in better flower growth and quality and a lower percentage of infected leaves than a single application at 3 weeks after planting (K1) or two applications at 3 and 6 weeks after planting (K2). Among the tested weed extracts, *Isotoma longiflora* applied three times at 3, 6, and 9 weeks after planting (K3) was the most effective botanical biopesticide treatment, improving flower quality while reducing pest infestation in chrysanthemum plants.

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