Vol. 10 No. 1, Mei 2025, pp. 14-29
Media Pertanian
DOI : 10.37058/mp.v10i1.14370

ISSN : 2085-4226
e-ISSN : 2745-8946

ALLELOPATHY EFFECT OF *Ageratum conyzoides* LEAVES AND *Imperata cylindrica* ROOTS ON SEED GERMINATION AND PLANT GROWTH OF MUNG BEANS

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Received February 03, 2025; Revised May 14, 2025; Accepted May 16, 2025

ABSTRACT

Ageratum conyzoides, and *Imperata cylindrica* are cosmopolite weeds in agricultural land that can reduce the productivity of cultivated plants. This study aims to analyze the effects of *A. conyzoides* leaf biomass and *I. cylindrica* grown in the planting medium on the germination percentage and growth of mung beans (*Vigna radiata*). The research was conducted by making 3 (three) replications of each treatment. Treatment A involves a planting medium mixed with *A. conyzoides* leaf biomass, Treatment B consists of a used planting medium overgrown with *I. cylindrica*, and the Control Treatment serves as a reference. ANOVA test and Tukey HSD test were conducted using R-Studio. The results indicated that both Treatments A and B reduced the germination success of mung beans compared to the control group, which had a germination rate of 97%. Treatment A achieved only a 60% germination rate, while Treatment B recorded 50%. Notable changes were observed in leaf number and root length, while plant height changes were less significant. The allelopathic effect was stronger in Treatment A than in Treatment B. The biomass of *A. conyzoides* and the used media from *I. cylindrica* demonstrated potential to inhibit the germination and early growth of mung beans. This study also emphasizes the potential of utilizing allelopathic compounds from both species as environmentally sustainable bioherbicides. Their use can reduce chemical exposure, reduce production costs, and maintain the ecosystem. These bioherbicides have the opportunity to be integrated into integrated pest management (IPM) strategies in food crops to support sustainable agriculture.

Keywords: Allelopathy; *A.conyzoides*; *I.cylindrica*; Mung beans

INTRODUCTION

Mung bean (*Vigna radiata* (L.) R.Wilczek) is a legume crop that is rich in vegetable protein content, reaching 22%. In Indonesia, mung bean cultivation ranks third among legume crops, after soybeans and peanuts (Hastuti *et al.,* 2018). Mung beans are one of the grains most commonly used

Cite : Utari, N., Anisah, S. N., Krisdianto, K. & Sulistijorini, S. (2025). Allelopathy Effect of *Ageratum conyzoides* Leaves and *Imperata cylindrica* Roots on Seed Germination and Plant Growth of Mung Beans. *Media Pertanian*, 10 (1), 14-29. doi: https://doi.org/10.37058/mp.v10i1.14370

ISSN : 2085-4226
e-ISSN : 2745-8946

by Indonesians to produce food products. The average consumption of mung beans in Indonesia reaches 350,000 tons/year (Dirjen Tanaman Pangan, 2012). From an economic perspective, mung beans have a stable price that is generally higher than other beans. In addition to serving as an industrial and export raw material, mung beans can be processed into various food products, including porridge, vegetables, cakes, drinks, noodles, and hunkwe flour. Mung beans are rich in nutrients, making them a functional food that can increase the nutritional value of rice by adding the amino acid lysine (Andrianto *et al.*, 2023). However, farmers often face challenges from weeds in mung bean cultivation, which can negatively impact production yields (Suprapto, 1993; Suwahyono, 2011). Some weeds can influence the growth of other plants through allelopathy, interfering with the germination and development of desirable crops (Talahatu & Papilaya, 2015).

Bandotan (*Ageratum conyzoides* L.) and alang-alang (*Imperata cylindrica* (L.) Raeusch.) are two common types of weeds found in agricultural land (Katuuk *et al.*, 2019; Kanedi *et al.*, 2024). *Ageratum conyzoides* grow in various environments and is considered a nuisance to crops. Meanwhile, *I. cylindrica* is an invasive plant that reproduces quickly, spreads extensively, and produces allelopathic substances that inhibit the growth of surrounding plants (Kanedi *et al.*, 2024). These weeds can potentially exert allelopathic effects on other plants, including mung beans, by releasing chemical compounds from their leaves or root exudates, which can hinder seed germination and compete aggressively with other plants (Setyowati, 2001; Budi & Oetami, 2013).

Weeds are plants that grow on agricultural or plantation land that are undesirable because they can interfere with the growth of cultivated plants. Weeds that exert allelopathic effects can harm plants by reducing the yield of cultivated plants. In corn crops, weeds can reduce yields by 5-26% (Azizu *et al.*, 2021), while in coffee plants, weeds can reduce seed production by up to 35%, affecting the quantity and quality of beans produced (Widiyanti, 2013; Hikmah *et al.*, 2018). Weeds release large amounts of allelochemicals to the soil, which inhibit germination and shoot formation of receptor plants. Compounds such as phenolics, lignans, cyanogenins, phenolic glycosides, and flavonoids released through root exudates, leachates, or residue decomposition, interfere with seed germination (Lalbiak *et al.*, 2022). Weeds also compete with cultivated plants for important resources such as water, light, and nutrients, space, and CO_2 which further inhibit plant growth conditions (Hardjosuwarno, 2020). Research on the allelopathic effects of *A. conyzoides* leaves and *I. cylindrica* roots on the germination of mung bean seeds are crucial for understanding the interactions between weeds and cultivated plants. This knowledge can support the development of environmentally friendly weed management strategies and contribute to increasing agricultural yields. Allelopathic compounds from both species also have potential as natural bioherbicides in sustainable agricultural systems.

ISSN : 2085-4226
e-ISSN : 2745-8946

Therefore, this study aims to analyze the impact of allelopathy in weeds on mung bean seed germination and is expected to improve integrated pest management (IPM) strategies by investigating the allelopathic properties of *Ageratum conyzoides* and *Imperata cylindrica*.

MATERIALS AND METHODS

This research was conducted from March to May 2021 and involved several stages: preparation of the planting media, treatment, conditioning, and harvesting 21 days after planting (DAP). The study included two Treatment groups and a Control Treatment for comparison.

Treatment A involved using mung bean seeds planted in media mixed with *A. conyzoides* leaf biomass, while Treatment B used mung bean seeds planted in soil that had previously been overgrown with *I. cylindrica*. For Treatment A, 150 grams of fresh *A. conyzoides* leaves were mashed and mixed into 3 kg of soil. This mixture was then allowed to stand in a container for one week before planting.

Treatment B involved selecting land overgrown with *I. cylindrica* at the IPB Soil Science Field Laboratory, where 3 kg of soil was collected and conditioned for one week. The control treatment refers to a planting medium that does not undergo any treatment. The planting media were transferred into polybags and labeled according to their Treatment. Each polybag was planted with 10 mung bean seeds.

To increase the validity of the results, the experiment was repeated three times for each treatment, and environmental conditions (watering, lighting, temperature) were kept constant for 21 days.

After one week of planting, three individual mung bean plants from each polybag, which exhibited good health and uniform height, were selected for observation. Measurements for height and the number of leaves were recorded daily until 21 DAP, while root length was observed after harvesting at 21 DAP. Additionally, the morphological characteristics of mung bean plants were documented during the study.

Data analysis for the germination percentage was conducted one week after planting. The germination percentage is calculated by taking the ratio of the number of seeds that germinate generally to the total number of seeds planted and then multiplying by 100% (Sutopo, 1988). The percentage of germination was calculated using the following formula:

$$P = a/b \times 100\%$$

P : Germination percentage
a : Number of seeds that germinate
b : Total number of seeds

Data on plant height, number of leaves, and root length were analyzed using ANOVA and the Tukey test in R-Studio.

RESULTS AND DISCUSSION

Germination Success Rate of Mung Bean Seeds

The results showed that the percentage of success of mung bean seed germination in treating *A. conyzoides* biomass and *I. cylindrica* plant media had a lower value than the Control Treatment. The phenomenon

ISSN : 2085-4226
e-ISSN : 2745-8946

described is attributed to the allelopathic mechanism resulting from the treatment of the planting media. Allelopathic mechanisms vary among different plant species. Some plants release allelopathic compounds through root exudation, while others do so via leaf decomposition or volatile allelochemicals. In this study, *Ageratum conyzoides* may release active compounds such as chromene and flavonoids by decomposing its leaf biomass, whereas *Imperata cylindrica* primarily releases compounds through its roots. According to (de Albuquerque *et al.*, 2011; Rice, 1984; Scavo *et al.*, 2018) the phytotoxic activity of allelochemicals is indeed very complex and is determined by their chemical nature, climatic conditions (such as temperature, rainfall, radiation), soil characteristics (such as pH, texture, organic matter), and donor and target plant factors (species, growth stage, plant part). The release pathways and effects of these allelochemicals have been widely studied. Rice (1984) and Putnam & Duke (1978) also reported that allelopathy can occur specifically based on the characteristics of the donor (the allelopathic source plant) and the recipient (the target plant), as well as the conditions of the growing media and various environmental factors.

The results of the germination percentage are detailed in Table 1.

Table 1. Germination Percentage of Mung Bean Seeds

Treatments	Percentage of Germination (%)
Control	97
A	60
B	50

The percentage of mung bean seed germination in the Control Treatment was 97% while Treatment A resulted in only 60% germination. *Ageratum conyzoides* is an annual weed belonging to the Asteraceae family and possesses a high level of allelopathic properties, including alkaloids, flavonoids, polyphenols, chromene, benzofuran, and terpenoids. These compounds can negatively affect surrounding plant species (Utami *et al.,* 2020).

Allelopathy can inhibit the activity of enzymes responsible for breaking down seed food reserves. As a result, the energy available for growth becomes very low, leading to longer germination times and ultimately reducing the seeds' germination ability. Inhibition of germination is a common impact of allelopathy on plants, as allelopathic compounds can disrupt enzyme activity during the germination process, which may either delay or entirely prevent seed germination (Li *et al.,* 2021; Susanto *et al.,* 2024). The allelopathic compounds found in *A. conyzoides* leaves significantly affect the germination percentage of mung bean seeds. Generally, weeds release large amounts of allelochemicals through leaching, decomposition, evaporation, and root exudation. These chemicals can inhibit germination and growth, reducing crop yields (Widhayasa, 2023). The allelochemical stress induced by phenolic compounds from *A. conyzoides* leads to excessive accumulation of reactive oxygen species (ROS) in soybean plants. Based on Ogunsusi *et al.,* (2018) reported that overproduction of ROS triggers oxidative stress, manifested by inhibited seed germination and impaired plant growth

ISSN : 2085-4226
e-ISSN : 2745-8946

in *Phaseolus vulgaris* L. As reported by Li *et al.* (2010), phenolic compounds suppress plant growth by altering membrane permeability, thereby disrupting nutrient uptake, affecting endogenous hormone synthesis, impairing enzymatic activities and photosynthetic processes, inhibiting protein synthesis, and ultimately interfering with cell division and elongation.

Ageratum conyzoides, a broadleaf weed, shows high potential as a bioherbicide due to its ability to inhibit growth by producing short hypocotyls and abnormal sprouts. This effect is caused by low organ function due to the influence of allelochemicals that affect cell division and elongation. At low concentrations, this inhibition is thought to be due to the content of allelochemicals that affect cell division and elongation, and increase water relations, mineralization, and nutrient absorption at low concentrations, but at high concentrations, it disrupts seed dormancy and early metabolism and inhibits sprout growth in mung beans (Handayani *et al.*, 2024). Germination inhibition by allelopathy can inhibit plant growth with mechanisms similar to synthetic herbicides, by affecting photosynthesis, protein synthesis, and stomatal opening, thereby slowing plant growth (Susilo *et al.*, 2022; Siregar, 2017).

The success rate of mung bean seed germination in Treatment B was only 50%. The germination success of mung bean seeds planted in the *I. cylindrica* medium was inhibited due to the allelopathic compounds released through the root exudates of *I. cylindrica*. This finding aligns with research conducted by Susilo *et al.* (2024), which demonstrated that *I. cylindrica* contains allelopathic substances that hinder the germination of mung bean seeds, both in laboratory settings and in polybags. The research indicated that fewer seeds germinate as the concentration of these allelopathic substances increases. Further explanations by Susanto et al. (2024) and Kurniati *et al.* (2018) reveal that allelopathy can inhibit the activity of enzymes necessary for breaking down seed food reserves.

This results in a low energy supply for growth and prolongs the germination process, ultimately reducing the seeds' germination ability. The inhibition is because of allelopathic compounds, such as phenols, which can damage enzymes and plasma membranes and disrupt respiration and ion uptake. These effects lead to decreased ATP production and insufficient growth of energy for the sprouts, ultimately inhibiting their growth.

Height Gain of Mung Bean Plants

The height increases of mung bean plants observed starting from the eighth day after transplanting, indicated that the average height growth in the Control Treatment was considerably more stable compared to Treatments A and B. The average height gain of mung bean plants in each Treatment is presented in Figure

ISSN : 2085-4226
e-ISSN : 2745-8946

1.

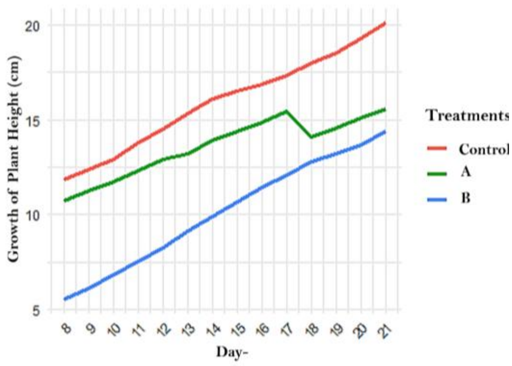

Figure 1. Average height gain of mung bean plants for 21 days in each Treatment

According to Figure 1, the height gain of mung bean plants in the Control Treatment consistently increased each day compared to Treatments A and B. One of the plants in Treatment A died on day 17, which caused the average height gain graph for that Treatment to decline. Meanwhile, the height gain of mung bean plants in Treatment B was lower compared to the other two treatments.

At harvest time, the tallest mung bean plant belonged to the Control Treatment, measuring 20.9 cm, while the shortest plants were from Treatment B, reaching only 10.5 cm. The average heights of the plants in Treatments A and B indicate a significant inhibition of mung bean growth compared to the Control Treatment, as shown in Figure 2.

According to the ANOVA test, there is no significant difference in the average height of mung bean plants among Treatment A, Treatment B, and the Control Treatment at the 95% confidence level (Table 2).

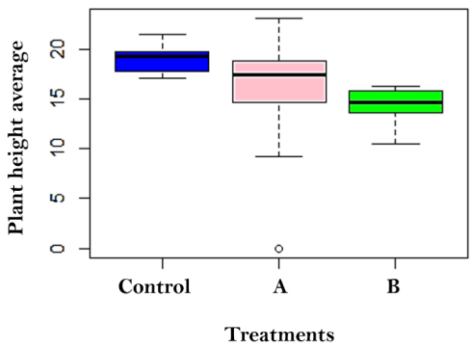

Figure 2.Average height of mung bean plants during 21 days of planting.

Table 2. Anova Test Results Average height of mung beans in various Treatments

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treatment	2	107.5	53.75	2.896	0.0747
Residuals	24	445.4	18.56		

Desc: Signif. Codes 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The results of the Tukey test, shown in Table 3, indicate no significant difference in the average height of mung bean plants among the Treatment groups at the 5% significance level ($\alpha = 0.05$). However, the comparison between Treatment B and Control Treatment approached significance at the 10% significance level ($\alpha = 0.1$), with the Control Treatment showing a higher average plant height than Treatment B.

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Table 3. Tukey HSD test results of average mung bean height in various Treatments

	diff	lwr	upr	p adj
Treatment A-Control	-3.511111	-8.582736	1.5605140	0.2152842
Treatment B-Control	-4.700000	9.771625	0.3716251	0.0729424
Treatment B-Treatment A	-1.188889	-6.260514	3.8827362	0.8291699

The average height of mung bean plants in Treatments A and B was lower than that of the Control Treatment. This reduction in height was caused by the allelopathic substances produced from the leaf biomass of *A. conyzoides* and the allelopathy from the roots of *I. cylindrica*, which remained in the planting media. According to Yuliani *et al.* (2019), allelochemical compounds from weeds can inhibit the growth of cultivated plants by disrupting their physiological processes. Additionally, Mohammad *et al.* (2021) found that decreased plant growth results from the inhibition of cell division and photosynthesis due to the disruption of chlorophyll cells. The allelopathic compounds in the leaves of *A. conyzoides* can be extracted during routine watering, which can naturally occur when it rains. As these allelopathic substances dissolve in the water, they are absorbed by the roots of the mung bean plants. This leads to chlorosis in the mung bean leaves (see Figure 4) and disrupts photosynthesis, ultimately inhibiting plant growth.

The average height of mung bean plants in Treatment B indicates that the use of *I. cylindrica* as a planting medium negatively affects the growth of these plants. Specifically, the average height of mung bean plants in this Treatment is shorter compared to Treatment A. These findings align with research conducted by Kato-Noguchi (2022), which reported that *I. cylindrica* has inhibitory effects on a variety of plants, including rice, cucumber, mustard, eggplant, tomatoes, mung beans, chickpeas, and spinach. Additionally, the aqueous extract of *I. cylindrica* contains a range of compounds—such as fatty acids, terpenoids, simple phenolics, benzoic acid, phenolic acids, phenolic aldehydes, phenylpropanoids, flavonoids, quinones, and alkaloids—identified through chromatographic analysis, which may contribute to the inhibition of mung bean plant height.

Number of Mung Bean Leaves in Treatment

Based on the study's results, it is known that the number of leaves in Treatments A and B has a smaller number of leaves compared to the Control Treatment (Figure 3). The difference in leaf morphology is visible in Treatment A and the Control Treatment. The application of *A. conyzoides* leaf biomass to the planting media resulted in a damaging effect on mung bean leaves. Previous research reported by Maria *et al.* (2023) also revealed that the presence of *I. cylindrica* has a significant allelopathic effect on the growth of chili plants (*Capsicum annuum* L.), which is indicated by a significant decrease in plant height and number of leaves.

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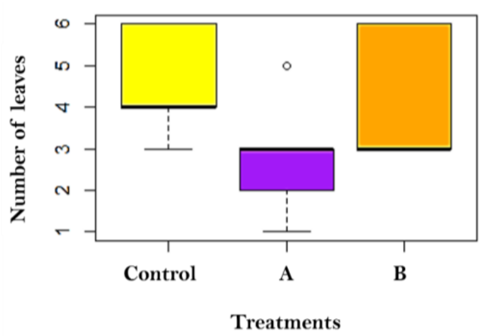

Figure 3. Average number of leaves of mung bean plants during 21 days of planting.

The results of the ANOVA test on the number of leaves for each Treatment (Table 4) indicate a significant difference between the average number of leaves in the Treatment groups and the Control Treatment. This is evidenced by a p-value of 0.00202 < 0.05, suggesting a meaningful difference in the average number of leaves among the Control, Treatment A, and Treatment B — the Tukey test results presented in Table 5.

Table 4. Anova Test Results of the number of leaves of mung bean plants in each Treatment

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treatment	2	38.22	19.111	8.126	0.00202 **
Residuals	24	56.44	2.352		

Desc: Signif. Codes 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 5. Tukey HSD test results of the average number of mung bean leaves in various Treatments

	diff	lwr	Upr	p adj
Treatment A-Control	-2.888889	-4.69426296	-1.083515	0.0014896
Treatment B-Control	-1.111111	-2.91648518	0.694263	0.2920432
Treatment B-Treatment A	1.777778	-0.02759629	3.583152	0.0541699

Based on the Tukey test presented in Table, Treatment A resulted in significantly fewer leaves than the Control Treatment (p-value = 0.0015). This difference is evident in the morphological changes observed in the mung bean leaves in Treatment A (see Figure 4). Symptoms of leaf damage in Treatment A began manifesting on the 10th day after planting. The damage to the mung bean plants includes yellowing, wilting, and chlorosis. These symptoms result from applying *A. conyzoides* leaf biomass in the planting media. Chlorosis is an abnormal condition in leaves due to chlorophyll deficiency. Allelopathic compounds from *A. conyzoides* in the planting media. This finding aligns with research conducted by Sepe *et al.* (2024), which indicates that allelopathic compounds can hinder the growth of corn, leading to stunted growth, loss of chlorophyll (chlorosis), which causes yellowing of the leaves, and tissue death (necrosis), characterized by brownish foliage.

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Figure 4. Symptoms of mung bean leaf damage in the Treatment of leaf biomass in the growing medium.

Damage to mung bean leaves observed in the Treatment using *A. conyzoides* leaf biomass aligns with the findings of Rahmah *et al.* (2024). Their research showed that applying *A. conyzoides* leaf extract to spinach thorn plants led to abnormal growth and eventually resulted in the plants' death. The death of the spinach thorns initially presented as yellowing and drying of the leaves, resembling burns. The edges of the leaves curled, the stem diameter decreased, the leaves fell off, and ultimately, the shoots died, leading to the complete death of the plant. These results indicate that the allelopathic compounds found in *A. conyzoides* leaves inhibit cytokinin activity in mung bean plants.

In Treatment B, the mung bean planting using soil previously occupied by *I. cylindrica* did not show a significant difference in the number of leaves compared to the Control Treatment (p-value = 0.2920). Morphologically, the leaves of the mung bean plants in Treatment B were similar in color to those in the Control Treatment, with only a few plants exhibiting some yellowing, though they did not die. This mild yellowing is likely due to the allelopathic effects produced by the roots of *I. cylindrica* being less potent than the effects of the leaves of *A. conyzoides*. The Tukey test supports this observation, indicating that the difference between Treatment B and Treatment A approaches significance at the 5% level and is significant at the 10% level (p-value = 0.0542).

Root Length of Mung Bean Plants

The root length of mung bean plants in the Control Treatment has a higher value than the Treatment of *A. conyzoides* leaf biomass in the planting media and planting on the *I. cylindrica* plant media. The average root length of mung bean plants in the control reached 4.94 cm, while in Treatment A, it was 3.00 cm and 3.84 cm in Treatment B. After harvest in the Control Treatment, the average root length of mung bean plants was 4.94 cm. The average root length of mung bean plants after harvest in Control, Treatment A, and B are presented in Figure 5.

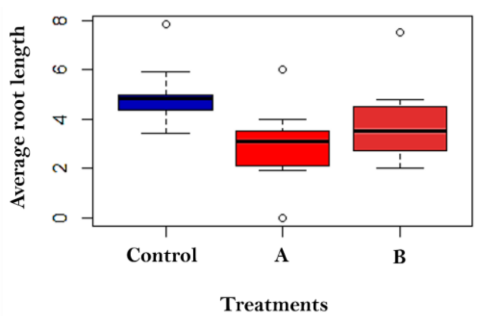

Figure 5. Average root length of mung bean plants

The analysis of variance (ANOVA) results presented in Table 6 indicate a p-value of 0.0468, suggesting a significant

ISSN : 2085-4226
e-ISSN : 2745-8946

difference in the root lengths of mung bean plants across the various Treatments. Additionally, a Tukey HSD test was performed to identify the specific differences between the Treatments, detailed in Table 7.

Table 6. Anova test results of root length of mung bean plants in each Treatment

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treatment	2	17.01	8.505	3.488	0.0468 *
Residuals	24	58.52	2.438		

Desc: Signif. Codes 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

The Tukey HSD test results (Table 7) indicate a significant difference in root length between Treatment A and the Control, with a difference of -1.9389 and a p-value of 0.0373. In contrast, the differences between Treatment B and the Control (-1.0944; p = 0.3148) and between Treatment B and Treatment A (0.8444; p = 0.4953) were insignificant.

Table 7. Tukey (HSD) test results on root length of mung bean plants in each Treatment.

	diff	lwr	upr	p adj
Treatment A-Control	-1.9388889	-3.7770955	-0.1006823	0.0373252
Treatment B-Control	-1.0944444	-2.9326511	0.7437622	0.3147744
Treatment B-Treatment A	0.8444444	-0.9937622	2.6826511	0.4952931

The study's results align with research conducted by Sari *et al.* (2022), which found that high concentrations of *I. cylindrica* extract can inhibit the growth of mung bean sprouts, including their root length. This suggests that the reeds release allelopathic compounds. Treatment B's root length was shorter, likely due to a higher concentration of allelopathic compounds from *A. conyzoides* leaves in the planting medium. Root growth inhibition is attributed to the allelopathic compounds released by both *A. conyzoides* leaves and *I. cylindrica* roots. Roots are crucial in absorbing nutrients and water from the soil, which is essential for plant physiological processes. Therefore, the root growth in Treatments A and B was inhibited due to allelopathy, resulting in shorter root lengths than the Control Treatment.

Research has shown that the leaf extract of *A. conyzoides* can inhibit the growth of roots and stems in various plants, including *Eleusine indica* L. Gaertn (grass) (Setiani *et al.,* 2019), mung beans (Handayani *et al.*, 2024), and *Amaranthus spinosus* L. (spinach thorns) (Zikri *et al.*, 2024). *Ageratum conyzoides* contain alkaloids, flavonoids, and steroidal triterpenoids, as identified in the phytochemical tests conducted by Jungjunan *et al.* (2022). Flavonoids are a type of phenolic compound and are considered one of the secondary metabolites. According to Cahyati *et al.* (2022), phenolic compounds in *A. conyzoides* extract inhibit root growth and affect photosynthesis, leading to abnormal plant growth. Allelopathic substances, mainly phenolic compounds, can damage phospholipids, releasing metabolites and cellular building

ISSN : 2085-4226
e-ISSN : 2745-8946

materials, ultimately decreasing root wet weight. Based on Mustaq & Fauconnier (2024) The allelochemicals in *A. conizoides* can disrupt root elongation, impair cell division, and alter cell structure, leading to reduced biomass and stunted growth

The study showed that *I. cylindrica* root exudates and allelopathy on the roots influenced the inhibition of mung bean root elongation. According to Xuan *et al.* (2009), root exudates of *I. cylindrica* also demonstrated inhibitory effects on the root and shoot growth of *Echinochloa crus-galli* (L.) Beauv. The results of this study align with the findings of Indarwati (2023), which suggest that *I. cylindrica* produces allelopathic compounds that can disrupt the physiological processes of nearby plants. This disruption includes inhibiting root formation and vegetative growth. One of the allelopathic compounds identified in the roots of *I. cylindrica* is phenolic compounds. According to Winarti (2019), these phenolic compounds inhibit the growth and decay of roots in surrounding plants. Additionally, research by Tyas (2023) indicates that phenolic compounds can interfere with the mitotic process by damaging spindle fibers during the metaphase phase, ultimately hindering cell proliferation. When cell proliferation is disrupted, it can inhibit cell multiplication in plant organs, leading to slowed growth or even complete cessation of growth.

Allelopathic compounds that accumulate in plant cells can be toxic, leading to changes in cell elasticity, which causes the cells to become stiff. These compounds also inhibit the transport of soluble ions that are supposed to pass through the cell membrane. This disruption in transport results in an imbalance in the cell's physiological processes, leading to abnormal plant growth. If this condition goes unchecked, accumulating these negative effects can cause severe damage and ultimately result in the death of the plant (Susilo *et al.*, 2022).

Plants that have allelopathic compounds can potentially be used as bioherbicides, such as *Eucalyptus pellita* F. Muell leaves (Guntoro *et al.*, 2024). Bioherbicides are natural herbicides derived from living organisms such as bacteria or fungi to control weeds in an environmentally friendly way. Unlike chemical herbicides, bioherbicides target vital plant processes such as metabolism and photosynthesis, and are easily biodegradable (Triolet *et al.*, 2020). Although their effects are slower and require repeated applications, bioherbicides are suitable for organic farming and sensitive areas because they have minimal impact on the environment and non-target organisms (Hasan *et al.*, 2021).

Imperata cylindrica is a weed and based on phytochemical analysis, it contains two types of phenolic compounds, namely tannins and flavonoids, which can reduce the growth of other plants so that this plant has the potential as a bioherbicide (Sinuraya, 2020). *Ageratum conyzoides* contains active compounds such as alkaloids, saponins, flavonoids, anthraquinones, terpenes, steroids, tannins, and phenols, which have high levels and are effective in controlling various plant pest organisms, and are known as multipurpose botanical pesticides (Kamboja and Saluja, 2008).

ISSN : 2085-4226
e-ISSN : 2745-8946

Bioherbicides are an environmentally friendly solution for sustainable weed management, but their development is still limited due to formulation challenges, pathogen strains, and field effectiveness. Potential sources include fungi, bacteria, natural extracts, and allelopathic compounds, the production of which can be improved through genetic engineering. To overcome rapid degradation and high costs, more stable and efficient formulations need to be developed, including the option of synthesizing allelopathic compounds. Bioherbicides are particularly promising for organic farming and areas where the use of chemical pesticides is restricted (Islam *et al.*, 2024).

CONCLUSIONS

The treatment of *Ageratum conyzoides* leaf biomass and *Imperata cylindrica* planting media negatively impacted the germination and growth of mung beans. The control treatment achieved the highest germination percentage at 97%, while Treatments A and B recorded 60% and 50%, respectively, indicating an allelopathic effect.

Additionally, growth measurements including plant height, number of leaves, and root length were lower in Treatments A and B compared to the control treatment. Statistical analysis revealed significant differences in the number of leaves and root length between the control and the treatments; however, there were no significant differences in plant height. Treatments that included *A. conyzoides* biomass displayed more potent inhibitory effects than those using *I. cylindrica* as the growing medium. These findings confirm the allelopathic effects of *A. conyzoides* and *I. cylindrica* on mung bean germination and early growth.

This research also presents opportunities for using these two weeds as bioherbicide active ingredients in an integrated pest management (IPM) strategies. Developing bioherbicides from allelopathic compounds such as these can reduce dependence on synthetic chemicals and strengthen the direction of environmentally sustainable agriculture.

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