

Research Article

Phytotoxic potential of actinomycetes isolated from *Mimosa pudica* and *Oryza sativa*

Alimuddin Ali^{1, 2*}, Muhammad Junda¹, Arni Putri Merdeka Wati¹, Oslan Jumadi^{1, 2} and Herlina Rante³

1. Biology Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar, Makassar, Indonesia 90224.

2. Biotechnology Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar, Makassar, Indonesia 90222.

3. Laboratory of Pharmacy Microbiology, Faculty of Pharmacy, Hasanuddin University, Jl. Perintis Kemerdekaan Km 10, Makassar, Indonesia 90245.

Abstract: This study aims to evaluate the phytotoxic activity produced by actinomycetes isolated from rhizosphere and endophytic plants. The study was conducted using 12 actinomycete strains recovered from various plants in South Sulawesi, Indonesia. The phytotoxin from the culture filtrate of fermentation broth of all strains was bioassayed on filter paper against seed germination of *Mimosa pudica* and *Oryza sativa*. The results showed that the actinomycetes culture filtrate of strain AAE05 and AAE16 has an 80% and 50% reduction in mimosa and paddy seed germination, respectively. Meanwhile, strain AAE16 reduced both test plants in the pre-emergence condition. Furthermore, the AAE16 strain's 16S rRNA sequence was highly related to that of the *Streptomyces pseudogriseolus* strain NRRL B-3288. The phytotoxic activity of culture filtrates from AAE16 was also evident in germinated seedlings of both plants, as indicated by leaf curling, wilting, and burning in the post-emergence period. These results suggested that actinomycetes are a promising source of phytotoxic agents. Therefore, further investigations are recommended to explore these substances for structure elucidation, which may prove to be promising bioherbicide agents.

Keywords: Actinomycetes, Bioherbicide, Germination, Metabolite, Phytotoxic

Introduction

Weeds are a significant constraint to achieving higher crop production, as they greatly reduce the quality and quantity of agricultural products (Mohidem *et al.*, 2021; Chauhan, 2020). Crop losses due to biotic stress, particularly from weed competition, can result in significant economic impacts. In India, it has been estimated that weeds alone contribute to approximately \$16 billion in

annual agricultural losses, accounting for the highest proportion (33%) of yield and economic loss among major pests, surpassing insects, pathogens, and animal pests (Gharde *et al.*, 2018). One of the primary methods for reducing weeds is the use of chemical herbicides.

Chemical herbicides, such as xenobiotics, are widely used in agriculture to control weeds and pests. However, this reliance carries significant consequences. Their application leads to harmful

Handling Editor: Naser Safaie

*Corresponding authors: muddin_69@unm.ac.id

Received: 04 October 2023, Accepted: 07 November 2025

Published online: 17 November 2025

accumulation and excessive persistence in the environment, resulting in irreversible soil pollution (Wolejko *et al.*, 2022). Additionally, these substances promote weed resistance and disrupt soil microbial activity and the community structure of essential soil microflora (Dentzman and Burke, 2021). It is imperative to reduce reliance on these chemicals and seek sustainable alternatives, such as biodegradable, selective, and non-pathogenic microbial agents, to protect ecosystems (Lee *et al.*, 2003; Geiger *et al.*, 2010).

In recent years, the use of natural products derived from microbial metabolites has become an alternative method for biological weed control in modern agriculture (Ocán-Torres *et al.*, 2024). The efforts to reduce growth, density, and adverse effects of weeds on cultivated plants by environmentally friendly, biological weed control are an important technique. These efforts are linked to the growing use of synthetic chemicals, which pose a threat to both humans and the environment (Naidu *et al.*, 2021).

Several investigations have been conducted on biological weed control, particularly within the actinobacteria group. *Bialaphos* is produced by *Streptomyces hygroscopicus* SF1293 (Xu *et al.*, 2009), while glufosinate ammonium is a metabolite manufactured by *S. hygroscopicus* M40 (Ha *et al.*, 2017). Furthermore, blasticidin S is a constituent of the extracts of *Streptomyces griseohromogenes*, while herbicidin is a type of metabolite produced by actinomycetes with bioherbicide activity toward dicotyledonous plants (Shi *et al.*, 2019). It was also isolated from *Streptomyces saganonensis* (Qi *et al.*, 2017) and *Streptomyces* sp. CB01388 (Chen *et al.*, 2018).

Oryza sativa L. is a major cereal crop and belongs to the family *Poaceae*. It was selected for this study due to its agronomic importance as a staple food crop in many countries, particularly in Asia, and its physiological characteristics as a representative C3 plant species. Evaluating the bioherbicidal effects on paddy provides insights into the selectivity and potential crop safety of the tested compounds. In contrast, *Mimosa pudica* L., a member of the *Fabaceae* family, was chosen as it represents both a C3 plant and a

problematic invasive weed species commonly found in agricultural fields in Indonesia. Its sensitivity to bioherbicidal agents offers a relevant model for assessing weed control efficacy under local agronomic conditions.

Therefore, this study aims to assess the phytotoxic activity of filtrate culture produced by actinomycete strains. The results are expected to make promising bioherbicide agents with environmentally friendly agrochemicals, particularly for weed control.

Materials and Methods

Sample collection

Samples of root, stem bark, and leaf samples from 12 plants were collected from different locations in South Sulawesi, Indonesia (27°31'037.000 S 152°59'051.700 E), and transported to the Laboratory of Microbiology, Department of Biology, Universitas Negeri Makassar. Large soil particles were removed from the plant root samples, which were then placed in a new plastic bag and stored at 4 °C for further use. The plant genera included in this study are listed in Table 1.

Isolation of actinomycetes

Endophytic actinomycetes were isolated using the method described by Igarashi *et al.* (2002) with slight modifications. The 4-5 cm plant's tissue was transferred into a tube containing 9 mL distilled water and shaken vigorously using a vortex mixer for 5 minutes. Surface sterilization was conducted by immersing the sample in 70% ethanol for 5 minutes, followed by immersion in a 1% sodium hypochlorite (NaOCl) solution for an additional 5 minutes. Subsequently, the sample was rinsed with sterilized water and crushed in a mortar and pestle with phosphate buffer. The crushed plant tissue was plated onto SNA (Soluble starch 20.0; K₂ HPO₄ 1.0; KNO₃ 2.0; MgSO₄ · 7H₂ O 0.5; CaCO₃ 3.0; NaCl 1.0; Agar 20.0; Trace salt solution 1.0 mL; Distilled water 1000.0 mL. Trace salt solution (per 100 mL): FeSO₄ · 7H₂ O 0.1; MnCl₂ · 4H₂ O 0.1; ZnSO₄ · 7H₂ O 0.1 g).

Table 1 Screening of actinomycetes strains and their isolation source.

Actinomycetes strains codes ^ψ	Botanical name	Source	Presumptive genus
AAE05	<i>Actinodaphne macrophylla</i>	Stem bark	<i>Streptomyces</i> sp.
AAE16	<i>Barringtonia</i> sp.	Root	<i>Streptomyces</i> sp.
AAR17	<i>Xylopiya malayana</i>	Root	Non-streptomyces
AAE20	<i>Ailanthus triphyssa</i>	Root	<i>Streptomyces</i> sp.
AAE22	<i>Peronema</i> sp.	Leaf	<i>Streptomyces</i> sp.
AAE25	<i>Adina</i> sp.	Root	<i>Streptomyces</i> sp.
AAE32	<i>Globba</i> sp.	Leaf	Non-streptomyces
AAR33	<i>Polyalthia glauca</i>	Root	<i>Streptomyces</i> sp.
AAE34	<i>Aglaia</i> sp.	Stem bark	<i>Streptomyces</i> sp.
AAE35	<i>Adenanthera</i> sp.	Leaf	<i>Streptomyces</i> sp.
AAR36	<i>Cyathocalyx</i> sp.	Root	<i>Streptomyces</i> sp.
AAE40	<i>Ageratum conyzoides</i>	Root	<i>Streptomyces</i> sp.

^ψ: letter E in strain codes means endophyte, while R mean rhizosphere.

media containing nystatin (100 µg/mL nystatin) by the pour-plate method. The isolation of rhizosphere actinomycetes was carried out using the washing water obtained from the first step of sample surface sterilization, which was then transferred onto SNA medium as previously described. All plates were incubated for 2 weeks at 35 °C until typical actinomycetes colonies grew. Moreover, all plant tissue was processed in triplicate.

Characterization of strains

All strains were cultured in various media SNA for 2 weeks at 35 °C. The features of the colony, such as substrate and aerial mycelia, colour, and soluble pigment diffused into the medium, were visually recorded. The morphological characteristics, including spores in chains and the forms of these chains, were observed using the slide culture technique. The SNA agar block, 2 mm thick (1 cm²), was transferred onto the objective glass in a Petri dish. Subsequently, each colony of the strain was inoculated at the edge of the agar block, covered with a coverslip, and incubated at 35 °C for one week. The spore chain was observed by using a microscope with 400X magnification.

Preparation of strain culture filtrate

The 10-day cultured strains were transferred to 50 mL of SN broth in a 250 mL Erlenmeyer

flask. The flasks were incubated on a rotary shaker at 140 rpm and 35 °C to assess the presence of phytotoxic substances. Culture filtrate was collected by filtration through Whatman No. 1 filter paper to separate the biomass and supernatant.

Phytotoxic activity

The screening of the phytotoxic activity of the strain culture filtrate was first evaluated using an in vitro seed germination bioassay on a Petri plate against *Oryza sativa* (monocot) and *Mimosa pudica* (dicot). The in vivo phytotoxic activity of the culture filtrate was determined in pots against test plant species, both pre- and post-emergence.

Screening of strain for phytotoxic activity

Phytotoxic effects of strain culture filtrates were evaluated using a seed germination and seedling growth test under pre-emergence conditions. The experiment was conducted using a completely randomized design with three replications for each treatment. A total of 20 seeds from each plant species (paddy and mimosa) were soaked in the respective strain culture filtrates for 12 hours. The treated seeds were then placed in sterile 9 cm diameter Petri dishes lined with Whatman No.10 filter paper. Each dish was moistened with 3 mL of sterilized distilled water and incubated under

dark conditions. Paddy seeds were incubated for 3 days, while mimosa seeds were incubated for 7 days. As a negative control, seeds were soaked in sterilized water and treated in the same manner as the experimental seeds.

Germination percentage calculation

Seed germination was monitored daily, and a seed was considered germinated when the radicle protruded at least 2 mm. The germination percentage (GP) was calculated using the following formula:

$$GP (\%) = (n / N) \times 100,$$

Where n is the number of germinated seeds and N is the total number of seeds per treatment.

Evaluation of root and shoot length

At the end of the incubation period, germinated seedlings were carefully uprooted. Root and shoot lengths were measured for each seedling, and average values were calculated from three replications for each treatment group and plant species.

Phytotoxic effect at post-emergence conditions

To investigate the effect of culture filtrate on seed germination and early seedling development of two plant species, approximately 200 g of sterilized soil was placed in disposable plastic pots (8 cm diameter $\times$ 14 cm height). Although the plants were subsequently sprayed with the culture filtrate at later growth stages, seed treatment was also included to examine the potential phytotoxic effects at the very early stages of development. For this purpose, germinated seeds were soaked in the respective strain culture filtrate for 15 minutes, then five seeds were planted on the soil surface in each pot. This approach allowed evaluation of both pre-emergence and post-emergence effects of the culture filtrate.

The post-emergence effect of the strain culture filtrate was evaluated by applying 4 mL of the filtrate in two stages (2 mL + 2 mL) using a syringe spout with slight modification. The first application was conducted when the

seedlings reached the early vegetative stage (approximately 5–7 days after germination), followed by a second application two days later. For each application, 2 mL of the culture filtrate was gently sprayed onto the aerial parts of each plant. The control plants were treated with uninoculated SNA broth to ensure that any observed effects were due to the microbial metabolites and not the culture medium itself. Plant responses were monitored for phytotoxic symptoms, including leaf curling, burning, and wilting.

Phylogenetic tree

PCR amplification of 16S rRNA gene of selective strains that show the phytotoxic activity was carried out by sequencing using primers 27F (5'AGAGTTTGATCCTGGCTCAG-3'), and 1492R (5'GGTTACCTTGTTACGACTT-3') (Weisburg *et al.*, 1991). The amplification was performed for 30 cycles, consisting of 97 °C for 5 minutes, followed by 95 °C and 55 °C for 30 seconds each, and then 72 °C for final extension and 2 minutes. The DNA fragments' amplicon was sequenced using an ABI 3100 sequencer model, based on the manufacturer's directions (ABI PRISMA 3100 Genetic Analyser User's Manual). The sequences were aligned with the corresponding 16S rDNA sequences of the closest known relatives of the actinomycete member strains, retrieved from GenBank using the BLAST program (<http://www.ncbi.nlm.nih.gov>). Multiple sequence alignment and molecular phylogenetic analysis were performed using BioEdit. Subsequently, multiple sequence alignments were performed using the Clustal X program (Thompson *et al.*, 1994). Phylogenetic tree calculation was conducted through the Neighbour-joining method (Hong *et al.*, 2021), implemented in Clustal X, and visualized with the TreeView program.

Statistical analysis

The data were subjected to ANOVA using SPSS software version 16.0 for Windows. Statistical differences between means were

compared using the least significant difference (LSD) test at $p = 0.05$.

Results

A total of 12 bacterial strains that exhibit morphological differences were selected for their phytotoxic effect against paddy and mimosa. Based on the morphological spore chain outlined by Bergey's Manual of Systematic Bacteriology, the strains were grouped into streptomycete and non-streptomycete genera (Table 1). Approximately 80% of the *Streptomyces* strains were successfully isolated from both endophytic root tissues and rhizospheric soils.

Phytotoxic activity on seeds at pre-emergence conditions

The effect of culture filtrate strain on seed germination in the pre-emergence of two plant species, namely mimosa and paddy, was evaluated (Fig. 1). This study was conducted to demonstrate the phytotoxin potential of compounds produced by actinomycetes under pre- and post-emergence conditions on paddy and mimosa seed germination.

The experimental results indicated that almost all strains exhibited no inhibitory activity against seed germination, while AAE05 and AAE16 had a significant effect. The AAE05 strain culture filtrate showed a maximum decrease in mimosa seed germination from < 80% to 50% for paddy seeds. However, the highest decrease for both seeds reaching < 20% was observed in the AAE16 strain culture filtrate effect. Strains AAR33 and AAR36 did not inhibit mimosa seed germination, while paddy seed germination decreased to approximately 60% compared with the 100% control.

The findings reveal that five actinomycete strains, AAE05, AAE16, AAE20, AAR33, and AAR36 effectively inhibited the growth rate of shoot length in mimosa sprouts. The other strains showed no significant difference in shoot length inhibition compared with the control under pre-emergence conditions. A similar result was found in the growth of shoot length in paddy seeds, where strains AAR33 and AAR36 had a significant effect. It was also found that only one strain AAR17, stimulated shoot elongation compared to the control (Fig. 2).

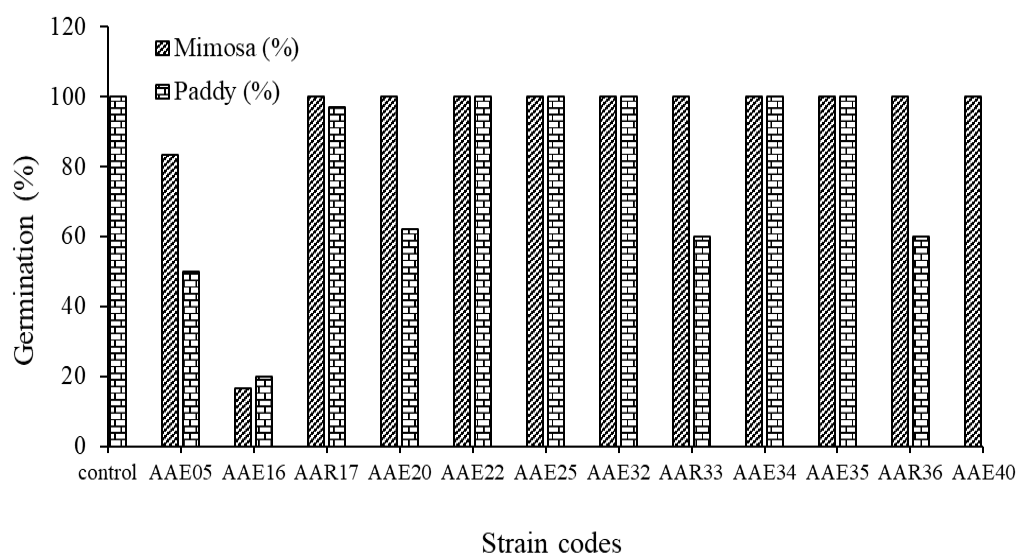


Figure 1 Effect of culture filtrate of actinomycetes strains on germination of *Oryza sativa* and *Mimosa pudica* in pre-emergence condition.

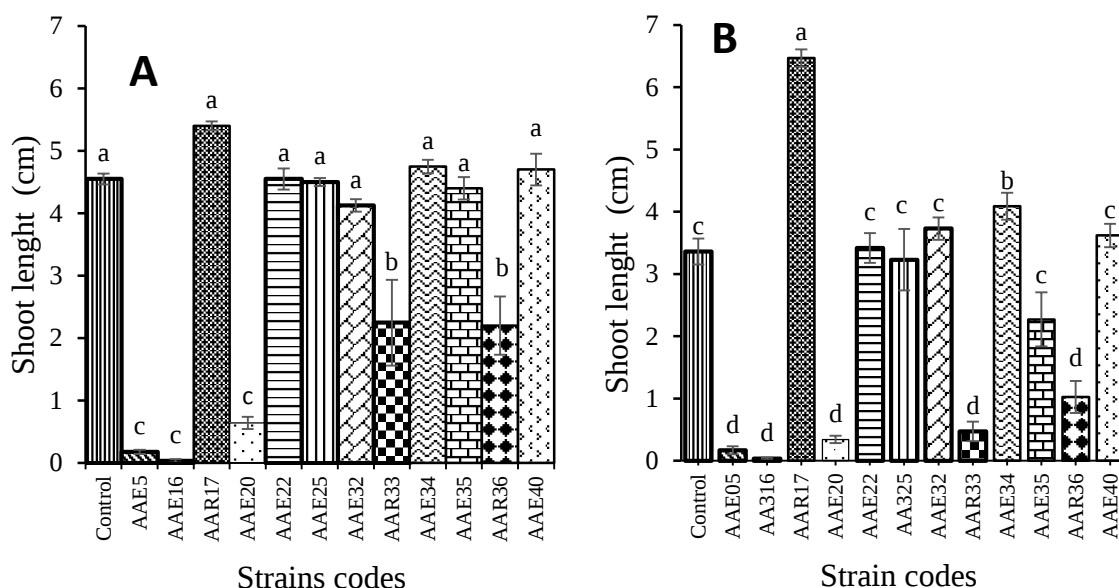


Figure 2 Effect of culture filtrate of actinomycete strains on shoot length of seed germination in pre-emergence conditions: (A) *Mimosa pudica* and (B) *Oryza sativa*.

Five strains of actinomycetes can inhibit root elongation in the test plants, while seven strains stimulated paddy root elongation (Fig. 3). However, a different response was observed in mimosa, where eight strains inhibited root elongation. The inhibition consistency of metabolites in the test plants was revealed by strains 05 and 16 for all test parameters. This is similar to strain 17, which shows increased root elongation in both test plants.

Based on the effect of strain culture filtrate on the number of roots in the two test plants, all strains had a significant effect on germinated mimosa seedlings, but it was lower than that of the control. Although strains AAE05 and AAE16 reduced the number of roots, the reduction was not significantly different from that caused by the other strains. In germinated paddy seedlings, all strains decreased root number, with AAE05 and AAE16 causing a greater reduction than the other strains (Fig. 4).

Phytotoxic activity at post-emergence conditions

Some of the culture filtrates have significant effects on leaf wilting and curl on paddy plants'

seedlings. Strains AAE22 and AAE25 showed post-growth of paddy seedlings after the application of culture filtrate, causing a wilting and leaf curl effect (Table 2). Furthermore, strains AAE05 and AAE16 showed a burning effect on paddy seedlings only, while AAE20 affected post-growth paddy seedlings. In the mimosa seedlings, most of the culture filtrate showed wilting and burning effects. The strains AAE25, AAE32, AAR33, and AAE40 demonstrated that the post-emergence of mimosa seedlings treated with actinomycetes isolate culture filtrate resulted in wilting, burning, and leaf curl effects. The strains AAE05, AAE20, AAE22, and AAE40 revealed the post-emergence of mimosa seedlings with wilted and burnt leaves.

Phylogenetic tree of the selective strain

The one strain exhibited phytotoxin activities against the test plant, such as inhibiting the germination process, leaf curling, burning, and wilt, which was selective for a partial 16S rRNA gene sequence. The neighbour-joining technique is used in the reconstruction of the phylogenetic tree (Fig. 5).

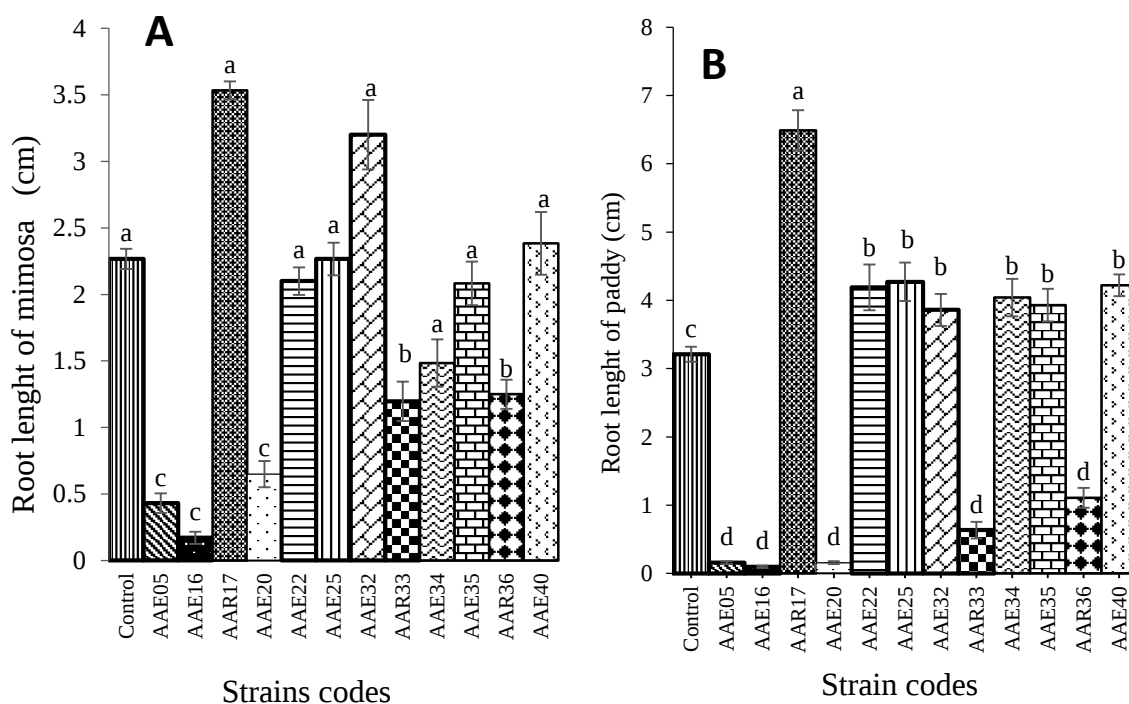


Figure 3 Effect of culture filtrate of strains on root length of seed germination in pre-emergence condition: (A) *Mimosa pudica* and (B) *Oryza sativa*

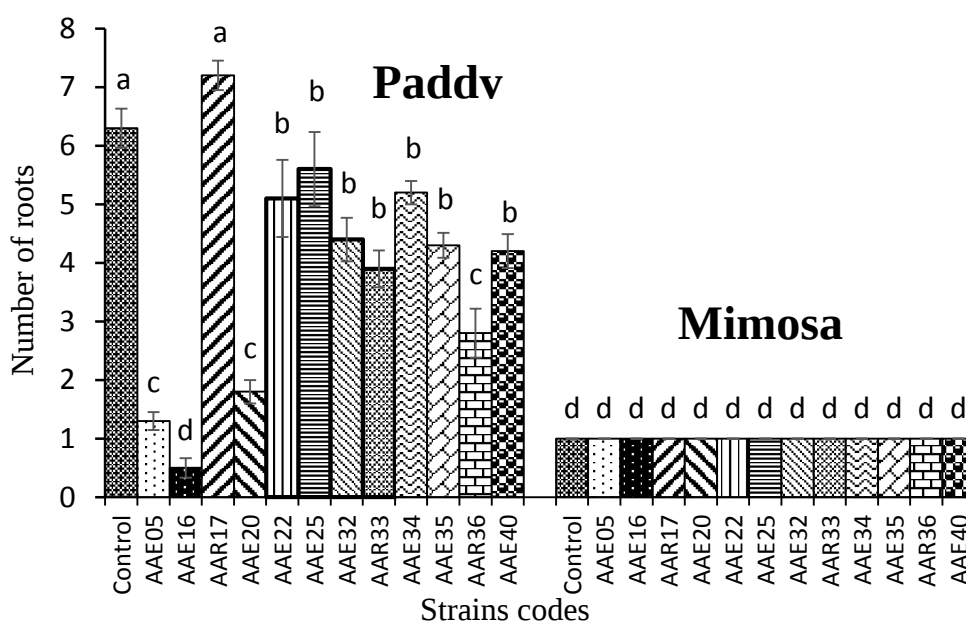


Figure 4 Effect of culture filtrate on roots number of *Oryza sativa* and *Mimosa pudica* in pre-emergence condition.

Table 2 Effect of culture filtrate of actinomycetes strains on *Oryza sativa* and *Mimosa pudica* seedlings in post-emergence condition.

Strains	Effect on paddy seedling (%)			Effect on mimosa seedling (%)		
	Leaf curl	Burned	Wilted	Leaf curl	Burned	Wilted
Control	-	-	-	-	-	-
AAE05	-	33.77 ± 2.54 ^b	-	-	33.33 ± 1.15 ^b	16.67 ± 1.34 ^a
AAE16	-	77.77 ± 2.54 ^a	-	-	66.67 ± 1.15 ^a	
AAR17	-	-	-	-	-	-
AAE20	-	-	33.33 ± 1.15 ^a	33.33 ± 1.15 ^a	-	33.33 ± 1.72 ^a
AAE22	-	-	33.33 ± 1.72 ^a	-	33.33 ± 1.15 ^a	33.33 ± 1.15 ^a
AAE25	33.33 ± 1.15 ^a	-	33.33 ± 1.15 ^a	16.67 ± 1.42 ^b	33.33 ± 1.72 ^b	16.67 ± 1.15 ^b
AAE32	-	-	-	16.67 ± 1.44 ^b	16.67 ± 1.15 ^c	16.67 ± 1.42 ^b
AAR33	-	-	-	16.67 ± 1.15 ^b	16.67 ± 1.44 ^c	16.67 ± 1.42 ^b
AAE34	-	-	-	-	-	-
AAE35	-	-	-	-	-	-
AAR36	-	-	-	-	-	-
AAE40	-	-	-	33.33 ± 1.15 ^a	-	16.67 ± 1.15 ^b

(-): no effect; values are mean of triplicates ± SD.

Treatments sharing the same superscript letter do not differ significantly according to one-way ANOVA followed by LSD test ($p < 0.05$), while treatments with different letters are significantly different.

Discussion

Biological agents are an important step in controlling weeds due to their less negative environmental impact compared to chemical herbicides, such as xenobiotics. In this study, among the actinomycetes recovered from endophyte and exorhizosphere plants, the *Streptomyces* genus is more abundant than others. This finding aligns with previous reports on endophytic and rhizosphere actinomycetes, particularly the genus *Streptomyces*, which is dominant (Birtel *et al.*, 2015; Bonaldi *et al.*, 2015; Zappelini *et al.*, 2018). Actinomycetes constitute a substantial part of microbial communities in the soil of plant roots, rhizospheric and endospheric compartments. By classical cultivation methods, thousands of strains belonging to the genus *Streptomyces* have been isolated from plant environments (Viaene *et al.*, 2016).

In the present study, the effect of culture filtrates from actinobacteria on seed germination and seedling growth of mimosa and paddy was investigated under pre- and post-emergence conditions. Based on the results, the successive inhibition of seed germination was demonstrated by the culture filtrates of strains AAE05 and AAE16 when exposed to seed paddy and mimosa. This finding aligns with the investigation of *Streptomyces* endophytes, where the culture filtrate of the strain was reported to suppress shoot and root growth in seedlings of *Ageratum conyzoides*, *Bidens biternata*, and *Parthenium hysterophorus* (Singh *et al.*, 2018). Moreover, seed germination is the most important and vulnerable stage in the plant life cycle. During this period, seeds face environmental stress that not only influences when plants enter the natural and agricultural ecosystems, but also has a direct effect on the yield and quality of crop seeds (Gong *et al.*, 2019).

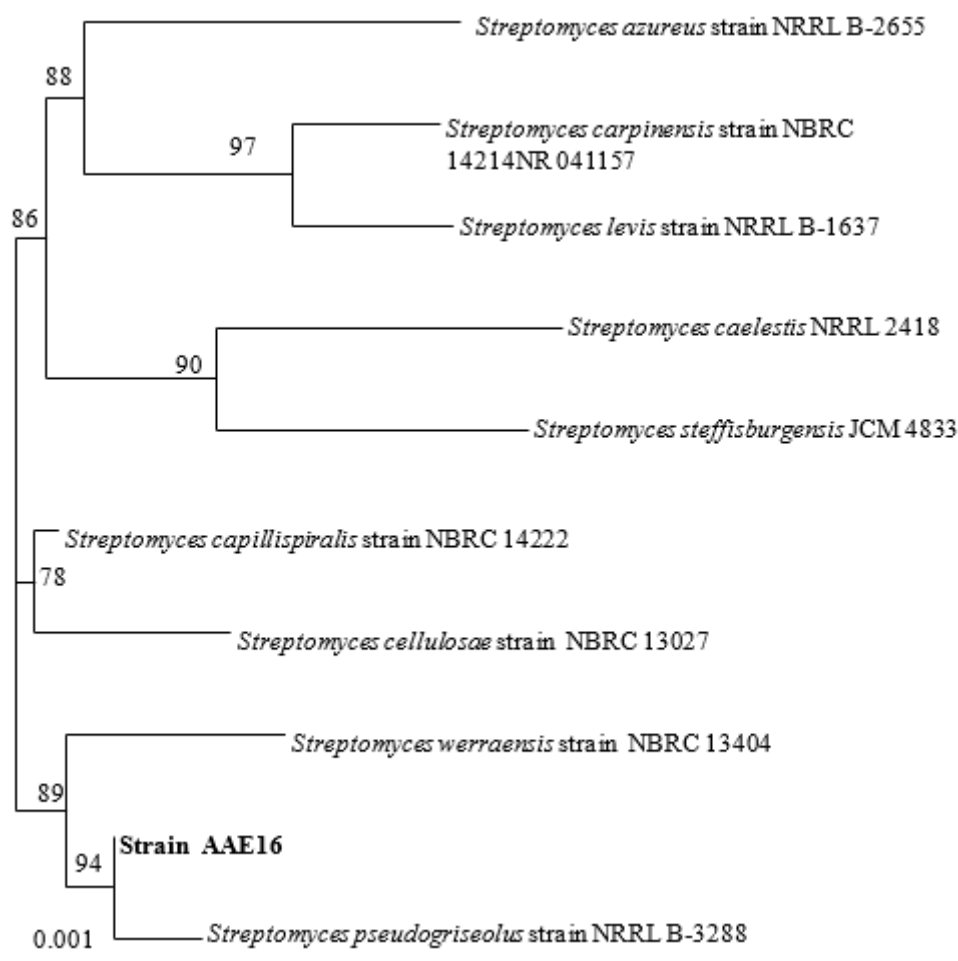


Figure 5 Neighbor-joining phylogenetic tree based on 16S rRNA gene sequences showing the relationships between selective strain and members of the genus *Streptomyces*. The numbers at the nodes indicate the level of bootstrap support based on a neighbor-joining analysis of 1,000 resampled datasets; only values above 50% are shown. The scale bar indicates 0.1 substitutions per nucleotide position.

Germination is a sequential process of molecular events during the transition from maturation to the development of seedlings. Following germination, most plant growth is dependent on the cell divisions that occur in both the root and the shoot meristems within the mature plant embryo. The increase in percentage germination in response to favourable conditions is a significant determinant of the success of invasive species over crops (Gioria and Pyšek, 2017).

The secondary metabolite produced by the strain might decrease the seed germination rate

by inhibiting substances that support protein function during germination. However, the other metabolite substance may help the seed germination rate by stimulating active molecules in the case of the strain AAR17. As reported by Yea and Zhao (2016), the exotic active molecule may act as an agonist or antagonist for seed germination.

The data showed that the highest final inhibition of mimosa and paddy seeds was obtained in the culture filtrate of strains AAE05 and AAE16. This indicates that the actinomycetes strains evaluated are a source of

metabolites with a phytotoxic effect that can suppress the growth of certain plants. However, in other contexts or at lower concentrations, these metabolites may act as signalling molecules that promote plant growth through mechanisms such as inducing stress tolerance or stimulating root development. Therefore, efforts to determine the compound's chemical structure are necessary to suppress weed growth, which causes losses in environmentally friendly crop cultivation. Minamor and Odamtten (2017) stated that metabolites of non-pathogenic microbes have both adverse and beneficial effects on plants, such as suppressing seed germination, malformation, and growth retardation. Endophytic bacteria have also been isolated from diverse plants and show beneficial effects on the growth of host plants, as well as tolerance to biotic and abiotic stress (Wu *et al.*, 2021). However, some endophytic bacteria exhibit phytotoxic activity or produce herbicidal secondary metabolites. The endophytic bacterium *Klebsiella pneumoniae* strain YNA12 from evening primrose significantly inhibited seed germination and reduced the seedling length and biomass (Kang *et al.*, 2020).

It was also found that strains AAE05 and AAE16 not only inhibited seed germination, including shoot and root elongation, but also showed phytotoxic effects, namely leaf curl, burn, and wilt. Bataineh *et al.* (2008) reported that different actinomycete isolates exhibited phytotoxic activity against cucumber seeds *Cucumis sativus*, and ryegrass *Lolium perenne*. In this study, the ability to inhibit seed germination, radicle, and plumule growth of both plants was identified. These findings suggest that the misuse or overuse of herbicides may contribute to the development of weed resistance, which is generally associated with random genetic mutations. Generally, herbicides control susceptible plants by binding to essential proteins for weed development, leading to plant death (Nam and Kim, 2015). Several mechanisms in plants can lead to herbicide resistance. At the population level, organisms may exhibit slight mutations in their genes, while some of these mutations are lethal to

individuals, others are beneficial, and others are neutral. Bardley *et al.* (2014) stated that the target site of an herbicide can be affected by one of these chance mutations. Microbes are a primary source of phytotoxins that can be explored. Although many non-pathogenic soil microbes produce potent phytotoxins, the role of these compounds in chemical ecology is unclear (Bucheli, 2014).

The strain AAE16 was closely related to *Streptomyces pseudogriseolus* strain NRRL B-3288. The genera *Actinomadura*, *Nocardiodetes*, *Streptomyces*, *Saccharopolyspora*, and *Microbispora* also demonstrated the ability of the strains' metabolites to act as bioherbicides (Bo *et al.*, 2019; Dhanasekaran *et al.*, 2010). Therefore, it can be concluded that actinomycetes are a rich source of herbicidal metabolites.

A total of 12 actinomycete strains were evaluated; only two strains showed considerable phytotoxicity, but an apparent bioherbicidal effect was achieved with *Streptomyces* sp. AAE16. A significant positive correlation was found between the phytotoxic activity of the strain's culture filtrate under pre- and post-emergence treatments in the tested plant. The culture filtrate of strain AAE16 exhibited desirable phytotoxic activity due to its bioherbicidal properties, which have a broad weed host range. This strain could be used as a bioherbicide with the potential to control weeds.

Competing interests

The authors declare that there are no interests to declare.

Acknowledgments

This work was supported by the Indonesian Ministry of Research, Technology and Higher Education under a grant DIPA Universitas Negeri Makassar (570/UN36/HK/2022)

References

- Bardley, D. H., Albert, J. F., Alan, M., Marie, J., Anil, S. and Amit, J. J. 2014. Herbicide

- resistant weeds and crops. Principle of Weed Control (4th edition): 169-188. California Weed Science Society.
- Bataineh, S. M., Saadoun, I., Hameed, K. M. and Ababneh, Q. 2008. Screening for soil Streptomycetes from North Jordan that can produce herbicidal compounds. Polish Journal of Microbiology, 57(4): 297-305.
- Birtel, J., Walser, J.-C., Pichon, S., Bürgmann, H. and Matthews, B. 2015. Estimating bacterial diversity for ecological studies: methods, metrics, and assumptions. PLoS One, 10: e0125356. <https://doi.org/10.1371/journal.pone.0125356>.
- Bo, A. B., Kim, J. D., Kim, Y. S., Sin, H. T., Kim, H. J., Khaitov, B., Ko, Y. K., Park, K. W. and Choi, J. S. 2019. Isolation, identification and characterization of *Streptomyces* metabolites as a potential bioherbicide. PLoS One, 14: e0222933. <https://doi.org/10.1371/journal.pone.0222933>.
- Bonaldi, M., Chen, X., Kunova, A., Pizzatti, C., Saracchi, M. and Cortesi, P. 2015. Colonization of lettuce rhizosphere and roots by tagged *Streptomyces*. Frontiers in Microbiology, 6: 25. <https://doi.org/10.3389/fmicb.2015.00025>.
- Bruce, T. J. 2012. GM as a route for delivery of sustainable crop protection. Journal of Experimental Botany, 63: 37-41. <https://doi.org/10.1093/jxb/err306>.
- Bucheli, T. D. 2014. Phytotoxins: environmental micropollutants of concern? Environmental Science & Technology, 48: 13027-13033. <https://doi.org/10.1021/es504342w>.
- Chauhan, B. S. 2020. Grand challenges in weed management. Frontiers in Agronomy, 1: 3. <https://doi.org/10.3389/fagro.2020.00003>.
- Chen, J. J., Rateb, M. E., Love, M. S., Xu, Z., Yang, D., Zhu, X., Huang, Y., Zhao, L. X., Jiang, Y., Duan, Y., McNamara, C. W. and Shen, B. 2018. Herbicidins from *Streptomyces* sp. CB01388 showing anti-Cryptosporidium activity. Journal of Natural Products, 81: 791-797. <https://doi.org/10.1021/acs.jnatprod.7b00850>.
- Dentzman, K. and Burke, I. C. 2021. Herbicide resistance, tillage, and community management in the Pacific Northwest. Sustainability, 13: 1937. <https://doi.org/10.3390/su13041937>.
- Dhanasekaran, D., Thajuddin, N. and Panneerselvam, A. 2010. Herbicidal agents from actinomycetes against selected crop plants and weeds. Natural Product Research, 24(6): 521-529. <https://doi.org/10.1080/14786410902949434>.
- Geiger, F., Bengtsson, J., Berendse, F., Weisser, W. W., Emmerson, M., Morales, M. B., Ceryngier, P., Liira, J., Tschamntke, T., Winqvist, C. and Eggers, S. 2010. Persistent negative effects of pesticides on biodiversity and biological control potential on European farmland. Basic and Applied Ecology, 11: 97-105. <https://doi.org/10.1016/j.baae.2009.12.001>.
- Gharde, Y., Singh, P. K., Dubey, R. P. and Gupta, P. K. 2018. Assessment of yield and economic losses in agriculture due to weeds in India. Crop Protection, 107: 12-18. <https://doi.org/10.1016/j.cropro.2018.01.007>.
- Gioria, M. and Pyšek, P. 2017. Early bird catches the worm: germination as a critical step in plant invasion. Biological Invasions, 19: 1055-1080. <https://doi.org/10.1007/s10530-016-1349-1>.
- Gong, C., Wang, L., Li, X., Wang, H., Jiang, Y. and Wang, W. 2019. Responses of seed germination and shoot metabolic profiles of maize (*Zea mays* L.) to Y₂ O₃ nanoparticle stress. RSC Advances 9: 27720-27731. <https://doi.org/10.1039/C9RA04544A>.
- Ha, S., Lee, K. J., Lee, S. I., Gwak, H. J., Lee, J. H., Kim, T. W., Choi, H. J., Jang, J. Y., Choi, J.-S., Kim, C.-T., Kim, J.-C., Kim, H. H. and Park, H. W. 2017. Optimization of herbicidin A production in submerged culture of *Streptomyces scopuliridis* M40. Journal of Microbiology and Biotechnology, 27: 947-955. <https://doi.org/10.4014/jmb.1611.11005>.
- Hong, Y., Guo, M. and Wang, J. 2021. ENJ algorithm can construct triple phylogenetic trees. Molecular Therapy: Nucleic Acids, 23: 286-293. <https://doi.org/10.1016/j.omtn.2020.12.017>.
- Igarashi, Y., Iida, T., Sasaki, T., Saito, N., Yoshida, R. and Furumai, T. 2002. Isolation of

- actinomycetes from live plants and evaluation of antiphytopathogenic activity of their secondary metabolites. *Actinomycetologica*, 16: 9-13. <https://doi.org/10.11276/actino16.9>.
- Joseph, B. and Sujatha, S. 2012. Insight of botanical based biopesticides against economically important pest. *International Journal of Pharmacy & Life Sciences*, 3(11): 2126-2134.
- Kang, S. M., Bilal, S., Shahzad, R., Kim, Y. N., Park, C. W., Lee, K. E., Lee, J. R. and Lee, I. J. 2020. Effect of ammonia and indole-3-acetic acid producing endophytic *Klebsiella pneumoniae* YNA12 as a bio-herbicide for weed inhibition: special reference with evening primroses. *Plants* 9: 761. <https://doi.org/10.3390/plants9060761>.
- Kent, A. D. and Triplett, E. W. 2002. Microbial communities and their interactions in soil and rhizosphere ecosystems. *Annual Review of Microbiology*, 56: 211-236. <https://doi.org/10.1146/annurev.micro.56.012302.160640>.
- Lee, H. B., Kim, C. J., Kim, J. S., Hong, K. S. and Cho, K. Y. 2003. A bleaching herbicidal activity of methoxyhygromycin (MHM) produced by an actinomycete strain *Streptomyces* sp. 8E-12. *Letters in Applied Microbiology*, 36: 387-391. <https://doi.org/10.1046/j.1472-765X.2003.01332.x>.
- Massenssini, A. M., Bonduki, V. H. A., Melo, C. A. D., Totola, M. R., Ferreira, F. A. and Costa, M. D. 2014. Soil microorganisms and their role in the interactions between weeds and crops. *Planta Daninha*, 32: 873-884. <https://doi.org/10.1590/S0100-83582014000400021>.
- Minamor, A. A. and Odamtten, G. T. 2017. Influence of the culture filtrate of three *Paecilomyces* species on some growth parameters, chlorophyll content, and root anatomy of two Ghanaian maize varieties (Abeleehi and Obaatanpa) and on germination capacity of tomato and pepper seeds. *American Journal of Microbiological Research*, 5(3): 51-58. <https://doi.org/10.12691/ajmr-5-3-1>.
- Mohidem, N. A., Che'Ya, N. N., Juraimi, A. S., Fazlil Ilahi, W. F., Mohd Roslim, M. H., Sulaiman, N., Saberioon, M. and Mohd Noor, N. 2021. How can unmanned aerial vehicles be used for detecting weeds in agricultural fields? *Agriculture*, 11: 1004. <https://doi.org/10.3390/agriculture11101004>.
- Naidu, R., Biswas, B., Willett, I. R., Cribb, J., Singh, B. K., Nathanail, C. P., Coulon, F., Semple, K. T., Jones, K. C., Barclay, A. and Aitken, R. J. 2021. Chemical pollution: a growing peril and potential catastrophic risk to humanity. *Environment International*, 156: 106616. <https://doi.org/10.1016/j.envint.2021.106616>.
- Nam, K. H. and Kim, C. G. 2015. Effects of water stress on chemical composition of rice grains. *Korean Journal of Agricultural Science*, 42: 1-5. <https://doi.org/10.7744/cnujas.2015.42.1.001>.
- Ocán-Torres, D., Martínez-Burgos, W. J., Manzoki, M. C., Soccol, V. T., Neto, C. J. D. and Soccol, C. R. 2024. Microbial bioherbicides based on cell-free phytotoxic metabolites: analysis and perspectives on their application in weed control as an innovative sustainable solution. *Plants*, 13(14): 1996. <https://doi.org/10.3390/plants13141996>.
- Onwona-Kwakye, M., Plants-Paris, K., Keita, K., Lee, J., Van den Brink, P. J., Hogarh, J. N. and Darkoh, C. 2020. Pesticides decrease bacterial diversity and abundance of irrigated rice fields. *Microorganisms*, 8: 318. <https://doi.org/10.3390/microorganisms8030318>.
- Qi, X., Wang, X., Ren, H., Zhang, F., Zhang, X., He, N., Guo, W., Chen, R., Xie, Y. and He, Q. 2017. NC1404, a novel derivative of bleomycin with modified sugar moiety obtained during the preparation of boningmycin. *Journal of Antibiotics*, 70: 970-973. <https://doi.org/10.1038/ja.2017.77>.
- Šantrić, L., Radivojević, L., Umiljendić, J. G., Sarić-Krsmanović, M. and Đurović-Pejčev, R. 2016. Effects of herbicides on growth and number of actinomycetes in soil and in vitro. *Pesticides and Phytomedicine*, 31: 121-128. <https://doi.org/10.2298/PIF1604121S>.
- Saxena, S. and Pandey, A. K. 2001. Microbial metabolites as eco-friendly agrochemicals for

- the next millennium. *Applied Microbiology and Biotechnology*, 55: 395-403. <https://doi.org/10.1007/s002530000517>.
- Shi, Y., Gu, R., Li, Y., Wang, X., Ren, W., Li, X., Wang, L., Xie, Y. and Hong, B. 2019. Exploring novel herbicidin analogues by transcriptional regulator overexpression and MS/MS molecular networking. *Microbial Cell Factories*, 18: 175. <https://doi.org/10.1186/s12934-019-1225-4>.
- Singh, H., Naik, B., Kumar, V. and Bisht, G. S. 2018. Screening of endophytic actinomycetes for their herbicidal activity. *Annals of Agrarian Science*, 16: 101-107. <https://doi.org/10.1016/j.aasci.2018.02.001>.
- Singh, R., Kumar, M., Mittal, A. and Mehta, P. K. 2017. Microbial metabolites in nutrition, healthcare and agriculture. *3 Biotech*, 7(1): 15. <https://doi.org/10.1007/s13205-016-0586-4>.
- Thompson, J. D., Higgins, D. G. and Gibson, T. J. 1994. Clustal X Version 1.6 User Manual. European Molecular Biology Laboratory, Heidelberg.
- Todero, I., Confortin, T. C., Luft, L., Brun, T., Ugalde, G. A., de Almeida, T. C., Arnemann, J. A., Zabot, G. L. and Mazutti, M. A. 2018. Formulation of a bioherbicide with metabolites from *Phoma* sp. *Scientia Horticulturae*, 241: 285-292. <https://doi.org/10.1016/j.scienta.2018.07.009>.
- Viaene, T., Langendries, S., Beirinckx, S., Maes, M. and Goormachtig, S. 2016. *Streptomyces* as a plant's best friend? *FEMS Microbiology Ecology*, 92(8): fiw119. <https://doi.org/10.1093/femsec/fiw119>.
- Weisburg, W. G., Barns, S. M., Pelletier, D. A. and Lane, D. J. 1991. 16S ribosomal DNA amplification for phylogenetic study. *Journal of Bacteriology*, 173: 697-703. <https://doi.org/10.1128/jb.173.2.697-703.1991>.
- Wolejko, E., Wydro, U., Odziejewicz, J. I., Koronkiewicz, A. and Jabłońska-Trypuć, A. 2022. Biomonitoring of soil contaminated with herbicides. *Water*, 14: 1534. <https://doi.org/10.3390/w14101534>.
- Wu, W., Chen, W., Liu, S., Wu, J., Zhu, Y., Qin, L. and Zhu, B. 2021. Beneficial relationships between endophytic bacteria and medicinal plants. *Frontiers in Plant Science*, 12: 646146. <https://doi.org/10.3389/fpls.2021.646146>.
- Xu, W., Tao, L., Gu, X., Shen, X. and Yuan, S. 2009. Herbicidal activity of the metabolite SPRI-70014 from *Streptomyces griseolus*. *Weed Science*, 57: 547-553. <https://doi.org/10.1614/WS-09-003.1>.
- Yea, Y. and Zhao, Y. 2016. The pleiotropic effects of the seed germination inhibitor germostatin. *Plant Signaling & Behavior*, 11(4): e1144000. <https://doi.org/10.1080/15592324.2016.1144000>.
- Zappellini, C., Alvarez-Lopez, V., Capelli, N., Guyeux, C. and Chalot, M. 2018. *Streptomyces* dominate the soil under *Betula* trees that have naturally colonized a red gypsum landfill. *Frontiers in Microbiology*, 9: 1772. <https://doi.org/10.3389/fmicb.2018.01772>.
- Zhao, C., Xie, H., Zhang, J., Xu, J. and Liang, S. 2013. Spatial distribution of organochlorine pesticides (OCPs) and effect of soil characters: a case study of a pesticide producing factory. *Chemosphere*, 90: 2381-2387. <https://doi.org/10.1016/j.chemosphere.2012.10>.

پتانسیل فیتوتوکسیک اکتینومیست‌های جدا شده از *Mimosa pudica* و برنج *Oryza sativa*

علی‌الدین علی^{۱،۲*}، محمد جندا^۱، آرنی پوتری مردکا واتی^۱، اوسلان جمادی^{۱،۲} و
هرلینا رانت^۳

۱- برنامه تحصیلی زیست‌شناسی، دانشکده ریاضیات و علوم طبیعی، دانشگاه نگری
ماکاسار، ماکاسار، اندونزی.

۲- برنامه مطالعاتی بیوتکنولوژی، دانشکده ریاضیات و علوم طبیعی، دانشگاه
نگری ماکاسار، ماکاسار، اندونزی.

۳- آزمایشگاه میکروبیولوژی داروسازی، دانشکده داروسازی، دانشگاه حسن-
الدین، ماکاسار، اندونزی.

پست الکترونیکی نویسنده مسئول مکاتبه: muddin_69@unm.ac.id

دریافت: ۱۲ مهر ۱۴۰۲؛ پذیرش: ۱۶ آبان ۱۴۰۴

چکیده: هدف از این مطالعه ارزیابی فعالیت گیاه‌سوزی
تولید شده توسط اکتینومیست‌های جدا شده از ریزوسفر و
گیاهان اندوفیت است. این مطالعه با استفاده از ۱۲ سویه
اکتینومیست بازیابی شده از گیاهان مختلف در جنوب
سولاوسی، اندونزی انجام شد. فیتوتوکسین حاصل از کشت
فیلتر شده از محیط تخمیر همه سویه‌ها روی کاغذ صافی علیه
جوانه‌زنی بذر *Mimosa pudica* و برنج *Oryza sativa* مورد سنجش زیستی
قرار گرفت. نتایج نشان داد که کشت فیلتر شده
اکتینومیست‌های سویه AAE05 و AAE16 به ترتیب ۸۰ و ۵۰ درصد
کاهش در جوانه‌زنی بذر *Mimosa* و برنج دارد. در همین حال،
سویه AAE16 هر دو گیاه آزمایشی را در شرایط قبل از ظهور
کاهش داد. علاوه بر این، توالی rRNA 16S سویه AAE16 ارتباط
زیادی با سویه *Streptomyces pseudogriseolus* NRRL B-3288 داشت. اثرات
گیاه‌سوزی عصاره صاف شده از کشت AAE16 نیز در نهال‌های
جوانه زده هر دو گیاه مشهود بود، همان‌طور که با پیچ-
خوردگی برگ، پژمردگی و سوختگی در دوره پس از ظهور نشان
داده شد. این نتایج نشان می‌دهد که اکتینومیست‌ها منبع
امیدوارکننده‌ای از عوامل فیتوتوکسیک هستند. بنابراین،
پژوهش‌های بیشتر برای بررسی این مواد برای روشن شدن
ساختار آن‌ها که ممکن است به عنوان عوامل علفکش زیستی
امیدوارکننده باشند، توصیه می‌شود.

واژگان کلیدی: اکتینومیست‌ها، علفکش زیستی، جوانه‌زنی،
متابولیت، گیاه‌سوزی