PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol 12(1): 1-6
https://doi.org/10.14719/pst.3017

HORIZON
e-Publishing Group
HePG

RESEARCH ARTICLE

Antifungal activity of ethanol and methanol extracts from *Ageratum conyzoides* L. against *Fusarium oxysporum*

Tran Thi Thu Phuong[1,2,3], Nguyen Ba Khanh Trinh[4], Nguyen Dinh Thao Ngan[4] & Nguyen Thi Nhu Quynh[1*]

[1] Bioactive Compounds Department, Institute of Tropical Biology, Ho Chi Minh City 700 000, Vietnam
[2]Faculty of Biology and Biotechnology, University of Science, Ho Chi Minh City 700 000, Vietnam
[3]Vietnam National University, Ho Chi Minh City 700 000, Vietnam
[4]Department,Nong Lam University, Ho Chi Minh City 700 000, Vietnam

*Email: quynhntn.itb@gmail.com

OPEN ACCESS

ARTICLE HISTORY

Received: 15 October 2023
Accepted: 04 August 2024

Available online
Version 1.0 : 04 February 2025
Version 2.0 : 07 February 2025

Check for updates

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Copyright: © The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited (https://creativecommons.org/licenses/by/4.0/)

CITE THIS ARTICLE

Phuong TTT, Trinh NBK, Ngan NDT, Quynh NTN. Antifungal activity of ethanol and methanol extracts from *Ageratum conyzoides* L. against *Fusarium oxysporum*. Plant Science Today. 2025; 12(1): 1-6. https://doi.org/10.14719/pst.3017

Abstract

Billygoat weed (*Ageratum conyzoides* L.) is generally distributed in tropical and subtropical regions. This herb not only has activity against a range of crop pests and pathogens but also boasts a rich history of traditional medicinal use across various countries worldwide. Studies of *Ageratum conyzoides* have provided evidence of the presence of a wide variety of phytochemicals that are capable of demonstrating its pesticidal, antimicrobial properties. Therefore, this study aimed to investigate the impact of various extracts from the billygoat weed on the antifungal activity against *Fusarium oxysporum*, a fungus that causes diseases for many crops. The billygoat weed powder was extracted with 2 solvents, ethanol and methanol at 4 concentrations (30 %, 50 %, 70 % and 90 %) and the antifungal activity of the extracts was determined by measuring the inhibition of fungal growth diameter at different extract concentrations (0 %, 1 %, 2 %, 4 % and 8 %). The results demonstrate that the E90 and M90 extracts, at a concentration of 8 %, exhibit better antifungal activity compared to the other extracts at the same concentration, with inhibition rates of 87.21 % and 89.77 % respectively. Moreover, when conducting a 2-factor ANOVA analysis, there was an interaction between solvent strength and extract solution concentration on the growth of *Fusarium oxysporum*. Hence, *Ageratum conyzoides* has the potential to be applied in the control of some harmful fungi on plants, oriented as biological pesticides.

Keywords

Ageratum conyzoides; antifungal; billygoat weed; ethanol; *Fusarium oxysporum*; methanol extract

Introduction

Fungal diseases pose a significant global threat, impacting not only humans but also the growth and storage of vegetation. *Fusarium oxysporum* is a fungal species that inflicts diseases on numerous crop types, targeting all parts of plants, particularly their roots (1, 2). This result in symptoms such as vascular wilting, root rot, stem rot, fruit rot and seed damage. *F. oxysporum* is commonly present in soil, existing as chlamydospores or mycelia on plant residues and organic matter. Fusarium wilt, a prevalent disease caused by this fungus, affects a wide range of crops, including bananas, tomatoes, onions and cucumbers, leading to substantial losses in both yield and quality (3, 4). They render foodstuffs unsuitable for consumption by reducing their nutritional value and, at times, releasing harmful mycotoxins (5). Certain

mold metabolites present in food can have lasting health impacts on both humans and animals, leading to immune deficiencies and potentially inducing cancer. Effective and long-term management of this devastating disease presents a significant challenge (6, 7). Currently, the most widely employed control methods involve using chemical treatments to directly eradicate disease-causing pathogens in the soil. Although this approach has advantages in terms of speed, cost-effectiveness, simplicity and efficiency, its prolonged use can lead to the depletion of microbial diversity in the soil, adversely affecting the environment and food safety (8). Agricultural practices such as crop rotation and soil amendments require considerable time and effort, making them unsuitable for large-scale operations (9). In comparison to other preventive approaches, there is an urgent need for biologically derived products that efficiently hinder fungal growth while preserving environmental friendliness and safety for humans and warm-blooded animals (10, 11). This requirement is vital for the development of a sustainable and secure agriculture sector.

Researchers have long been drawn to new active ingredients, particularly those derived from herbs, for their noteworthy biological activities. These activities include insecticidal and antimicrobial properties, making them both safe and environmentally friendly (12, 13). Herbal fungicides, in particular, offer diverse mechanisms of action, broad-spectrum activities and limited resistance development and show promise as alternatives to synthetic fungicides (14, 15). *Ageratum conyzoides*, commonly known as goat weed, is an aromatic herb that belongs to the Asteraceae family and thrives in tropical and subtropical regions (16). It has been extensively studied for its diverse secondary metabolites, which encompass flavonoids, alkaloids, saponins, polyphenols, coumarins, precocene, eugenols, essential oils, alkaloids, tannins, sulfur, chromenes, benzofurans and terpenoids (monoterpenes and sesquiterpenes) (16). Beyond their medicinal properties, these secondary metabolites have drawn attention to their potential impact on agriculture, such as their antimicrobial activity against plant pathogens (17, 18) and their potential in pest control (19, 20). Despite its potential applications in agriculture, there remains a dearth of research on *A. conyzoides* in the field of plant protection. This study aimed to bridge this knowledge gap by examining the inhibitory activity of different *A. conyzoides* extracts against *F. oxysporum*, a fungal pathogen, through in vitro evaluation. This research seeks to expand our understanding of the potential benefits and applications of *A. conyzoides* in agriculture.

Materials and Methods

Collection and preparation of plant materials for extraction

Billygoat weed (*Ageratum conyzoides* L.) was collected in Da Huoai - Lam Dong province, Vietnam. The aerial parts were washed with tap water to remove the adhering dust particles, oven-dried at 50 °C to a constant weight and crispy texture to aid grinding to powder using a blender and stored in a sterile air-tight labeled container until required.

Pathogen and culture

The *F. oxysporum* strain was provided by the Department of Transformational Biotechnology, Institute of Tropical Biology. Fungal strain isolated from diseased pepper in Dak Nong, Vietnam. Then, the strain was maintained on potato dextrose agar (PDA) in the dark at 25 °C.

Preparation for ethanolic extraction

Billygoat weed powder (30 g) was weighed and extracted with ethanol at 4 different concentrations (30 %, 50 %, 70 % and 90 %) using an ultrasonic bath at 50 °C for 3 h. The plant powder to ethanol was maintained at a ratio of 1:17. The mixture was filtered and all the liquid extracts were combined. The solvent was removed using a rotary evaporator under low pressure (100-160 mBar) at 60 °C and a speed of 100 rpm. This process produces four concentrated extracts, each labeled as E30, E50, E70 and E90. They are stored at 4 °C (5).

Preparation for methanolic extraction

Billygoat weed powder (30 g) was weighed and extracted with methanol at 4 different concentrations (30 %, 50 %, 70 % and 90 %) using ultrasonic waves for 3 h. The plant powder to methanol was maintained at a ratio of 1:17. The mixture was filtered and all the liquid extracts were combined. The solvent was removed using a rotary evaporator under low pressure (100-160 mBar) at 60 °C and a speed of 100 rpm. This process produces 4 concentrated extracts, each labeled as M30, M50, M70 and M90. They are stored at 4 °C (19).

Assessing inhibition of F. oxysporum fungal colony growth diameter

The study assessed the effects of the extracts on the growth of *F. oxysporum* based on morphology and colony diameter (21). The procedure included pouring 20 mL of PDA medium with various extracts (E30, E50, E70, E90, M30, M50, M70 and M90 at 1 %, 2 %, 4 % and 8 % concentrations) into 9 cm sterile petri dishes. Control plates consisted of PDA only. Each concentration is tested on 3 plates. Using a sterile hook, a fungal hypha from a 7 days old *F. oxysporum* cultured at room temperature and placed in the center of each petri dish. The petri dishes were incubated in the dark at room temperature in a completely randomized design. The fungal growth diameter (FGD) was measured after 3 days of cultivation.

Statistical analysis

The experiment was repeated three times. The data was analyzed using ANOVA in Minitab 21 software and the mean values were tested using the Tukey test at a significance level of 95 %.

Results and Discussion

Based on the growth rate of *F. oxysporum* mycelium diameter, the antifungal activity of the extracts from

A. conyzoides was determined. In this study, we found that both ethanol and methanol extracts in this study had a positive impact on reducing the growth and development of the fungus.

The effect of ethanol extract on the antifungal activity of F. oxysporum

The impact of ethanol extracts on fungal growth after 3 days of incubation was investigated. The results demonstrated that all extract solutions effectively inhibited the development of *F. oxysporum*. Remarkably, E90 displayed superior antifungal properties compared to other extracts, exhibiting the smallest mean colony diameter of 8 % (5.33 mm) when compared to both the control (41.67 mm).

In 2020, secondary compounds in *A. conyzoides*, such as phenols, alkaloids, flavonoids, sterols, tannins, glycosides, coumarins, saponins and anthraquinones were identified (22). Some of these compounds have demonstrated antifungal activity against certain fungi, for example, phenolic compounds against *Fusarium solani* (23) and flavonoids against *Fusarium moniliforme* (24). Based on the scientific evidence, the antifungal potential of *A. conyzoides* ethanol extracts against *F. oxysporum* may be attributed to the presence of these secondary compounds in this plant species.

The results of the survey on the impact of extract concentration show that there is an influence on the growth of fungi with a p-value < 0.05. The higher the extract concentration, the better the inhibitory effect on fungi. For instance, when using a 1 % E70 extract supplement, the observed FGD measured 27,67 mm, surpassing the measurement at an 8 % extract concentration (8,33 mm) (Table 1, Fig. 1). Similar outcomes were observed for the E30, E50 and E90 formulations.

This experiment was designed with 2 factors: one being the ethanol concentration for extracting the active substance and the other being the concentration of the extract added to the culture medium to assess the effects of these factors on the growth of *F. oxysporum*'s mycelium diameter. The experimental results, analyzed using the 2-factor ANOVA test, revealed a significant interaction effect (p-value <0.05) between the ethanol concentrations and the extract concentrations. This interaction suggests that both factors have a combined effect on the growth of *F. oxysporum*.

The effect of methanol extract on the antifungal activity of F. oxysporum

Table 1. The effect of ethanol extracts at different concentrations on the growth of *F. oxysporum* colonies after 3 days

Fungal growth diameter (mm)					
Extract concentration (%)	**Solvent concentration**				**The average extract concentration**
	E30	**E50**	**E70**	**E90**	
0 %	41,67^{a}	41,67^{a}	41,67^{a}	41,67^{a}	41,67 ^{A}
1 %	32,33^{bcd}	37,33^{ab}	27,67^{cdef}	26,33^{def}	31,00 ^{B}
2 %	30,00^{cde}	34,33^{bc}	25,33^{def}	21,33^{fg}	27,75 ^{C}
4 %	24,67^{efg}	25,33^{def}	14,00^{hi}	9,33^{ij}	18,33 ^{D}
8 %	18,00^{gh}	25,33^{def}	8,33^{ij}	5,33^{j}	14,25 ^{E}
The average solvent concentration	29,33 ^{B}	32,80 ^{A}	23,47 ^{C}	20,80 ^{D}	
P (solvent concentration)	< 0,05				
P (extract concentration)	< 0,05				
P (interaction)	< 0,05				

The average values with lowercase letters following each other have no statistical significance (95 %). The average values in the same column with uppercase letters following each other have no statistical significance (95 %). The average values in the same row with uppercase letters following each other have no statistical significance (95 %).

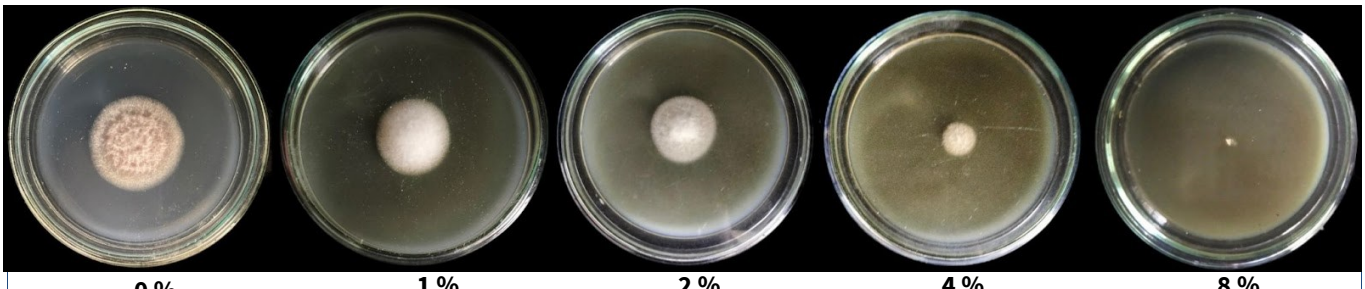


Fig. 1. *Fusarium oxysporum*'s morphology was cultivated on PDA medium supplemented with 90 % ethanol extract (E90 at different concentrations after 3 days. The medium becomes darker in color due to the addition of extracts from low to high concentrations.

Methanol extracts were also evaluated for their impact on fungal growth on agar plates after 3 days of incubation. All extract solutions demonstrated the ability to inhibit the development of *F. oxysporum*, with M90 extract showing better antifungal properties compared to the other extracts. It exhibited the lowest mean inhibition zone diameter (4.33 mm) at the same extract concentration in comparison to the control (42.33 mm). This difference was statistically significant with a p-value of < 0.05 (Table 2).

The active compounds in the methanol extract of *A. conyzoides* were analyzed using the GC-MS method, revealing the presence of 8 compounds, among which precocene II was the main compound, accounting for 59.5 % of the total (25). It inhibits the production of trichothecene by *Fusarium graminearum*, the pathogen responsible for leaf blight and trichothecene contamination in cereals (17, 27). Moreover, Caryophyllene, accounting for 7.6 % of the composition, demonstrated rapid and effective inhibition against fungi like *F. solani* (26).

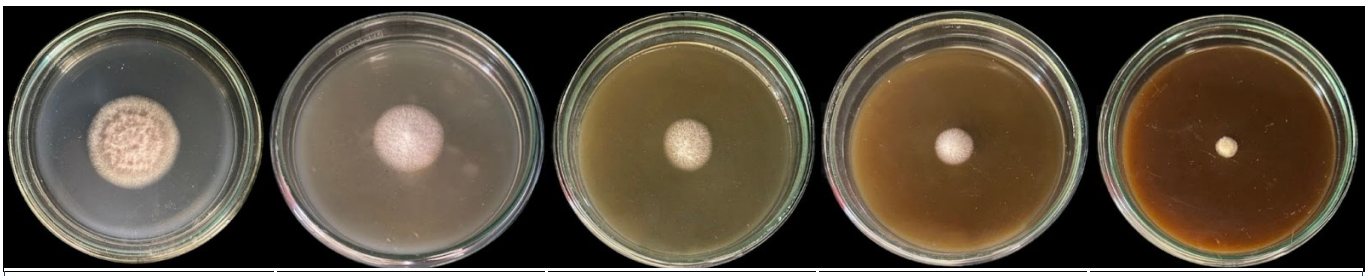
Based on a significance level of p < 0.05, it can be concluded that there is a notable difference in the concentrations of the extract solution. Higher concentrations result in greater inhibition and impact the antifungal activity. Without the addition of the M70 extract, the antifungal activity showed a robust development at 42.33 mm, which decreased to 7.67 mm as the concentration increased to 8 %. As the concentration of the concentrated extract solution increased, the diameter of *F. oxysporum* decreased, and the morphology of the fungal colonies underwent noticeable changes under the influence of this antifungal agent. Without the extract, the fungal mycelium exhibited vigorous growth characterized by fluffy and thick white and pinkish strands. However, in the presence of the extract, the fungal colonies became smoother and appeared brighter white. For instance, Fig. 2 demonstrates that the fungal colonies cultured on a medium containing the extract appeared brighter white and had finer mycelium compared to the control.

The *in vitro* antifungal activity of the methanol extracts from different parts of *A. conyzoides*, including flowers, leaves and stems, against *F. oxysporum* was tested at different concentrations (4 %, 6 %, 8 % and 10 %) over a 6 days cultivation period. The results showed that all plant extracts from different parts were able to inhibit the fungal growth of *F. oxysporum*, with the maximum inhibition observed in the 10 % flower extract with an inhibitory effect of 28.20 %. The leaf extract followed with a 22.4 % reduc-

Table 2. The effect of methanol extracts at different concentrations on the growth of *F. oxysporum* colonies after 3 days

Extract concentration (%)	Fungal growth diameter (mm)				
	Extract concentration (%)				The average of extract concentration
	M30	M50	M70	M90	
0 %	42,33 ^{a}	42,33 ^{a}	42,33 ^{a}	42,33 ^{a}	42,33 ^{A}
1 %	34,33 ^{b}	28,67 ^{cde}	29,67 ^{bcde}	30,33 ^{bcde}	30,75 ^{B}
2 %	31,00 ^{bcd}	16,00 ^{g}	21,00 ^{f}	27,67 ^{de}	23,92 ^{C}
4 %	33,33 ^{bc}	12,67 ^{g}	14,33 ^{g}	12,67 ^{g}	18,25 ^{D}
8 %	26,00 ^{e}	12,00 ^{g}	7,67 ^{hi}	4,33 ^{i}	12,50 ^{E}
The average solvent concentration	33,40 ^{A}	22,33 ^{B}	23,00 ^{B}	23,47 ^{B}	
P (solvent concentration)	< 0,05				
P (extract concentration)	< 0,05				
P (interaction)	< 0,05				

The average values with lowercase letters following each other have no statistical significance (95 %). The average values in the same column with uppercase letters following each other have no statistical significance (95 %). The average values in the same row with uppercase letters following each other have no statistical significance (95 %).



0 % **1 %** **2 %** **4 %** **8 %**

Fig. 2. *F. oxysporum* morphology was cultivated on PDA medium supplemented with 70 % methanol extract (E90) at different concentrations after 3 days. The medium becomes darker in color due to the addition of extracts from low to high concentrations.

tion at 8 % concentration, while the stem extract had the least effect of 13 % reduction at 10 % concentration (28).

When examining the interaction between methanol solvent concentration and extract concentration using a 2-factor ANOVA test, the p-value (interaction) was found to be <0.05. Therefore, both solvent concentration factors for extracting the active compound and additional extract concentration in the medium have an interaction effect on the growth of *F. oxysporum* in the agar medium.

In summary, the efficiency of extracting *F. oxysporum* antifungal compounds is positively influenced by the concentration of extractants and solvents. Solvent concentrations of 90 % ethanol and methanol are suitable for extracting antifungal compounds from *A. conyzoides* powder. The reason is that different solvents produce different natural compounds and therefore, their antibacterial abilities differ (29, 30). Additionally, when different natural compounds are present in the same high extractive type, they interact with each other in a synergistic manner (23, 31), resulting in higher antimicrobial activity.

Conclusion

The obtained results show that the extracts obtained from 90 % ethanol and 90 % methanol solvents have the most effective inhibition on *F. oxysporum* compared to other solvents at low concentrations. The higher the concentration of the extract, the higher the inhibitory effect on the fungus. This means that the extract concentration is directly proportional to the ability to suppress the fungus's growth. Hence, ethanol or methanol can be employed for bioactive compound extraction from the *A. conyzoides* plant, providing a potential biocide application against *F. oxysporum* in agricultural crops.

Acknowledgements

First of all, we would like to express our sincere gratitude to the Vietnam Academy of Science and Technology for funding this research through the project CSCL16.01/2024-2025. We also thank the Institute of Tropical Biology for providing us with equipment and laboratory facilities to conduct the necessary experiments. Besides, we would like to thank M.S. Vo Thi Kieu Thanh, who works at the Department of Bioconversion Technology, for providing us with the *Fusarium oxysporum* strain in this experiment. We are grateful to the scientists, researchers and colleagues who contributed valuable opinions and knowledge to this research.

Authors' contributions

TTTP participated in designing the study, supported all experiments and performed the statistical analysis, processing and writing of the paper. NBKT carried out experiments on antifungal activity and collected data. NDTN carried out methods of extracting active ingredients. NTNQ supported in collecting samples, guidance, editing and reviewing papers.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

References

1. Khan SN, Riaz T, Javaid A. Preceding crops affect the growth and mycorrhizal colonization of Gladiolus (*Gladiolus grandiflorus* sect. Blandus) cv. Aarti under biotic stress of *Fusarium oxysporum* f. sp. *gladioli* (Massey) Snyd. and Hans. Philippine Agricultural Scientist. 2010;93(2):135-41.
2. Rauf S, Javaid A. Antifungal activity of different extracts of *Chenopodium album* against *Fusarium oxysporum* f. sp. *cepae* the cause of onion basal rot. International Journal of Agriculture and Biology. 2013;15(2):367-71.
3. Chahal R, Nanda A, Akkol EK, Sobarzo-Sánchez E, Arya A, Kaushik D. et al. *Ageratum conyzoides* L. and its secondary metabolites in the management of different fungal pathogens. Molecules (Basel). 2021;26(10):2933.https://doi.org/10.3390/molecules26102933
4. Akhtar R, Javaid A, Qureshi MZ. Bioactive constituents of shoot extracts of *Sisymbrium irio* against *Fusarium oxysporum* f. sp. *cepae.* Planta Daninha. 38:e020200961. https://doi.org/10.1016/j.fct.2013.07.047
5. Wuyep PA, Musa HD, Ezmokwe GCN, Nyam DD, SilaGyang MD. Phytochemicals from *Ageratum conyzoides* L. extracts and their antifungal activity against virulent *Aspergillus* spp. Journal of Academia and Industrial Research; 2017;6(3):32-39.
6. Marin S, Ramos AJ, Cano-Sancho G, Sanchis V. Mycotoxins: Occurrence, toxicology and exposure assessment. Food Chemical Toxicology. 2013;60:218-37. https://doi.org/10.1016/j.fct.2013.07.047
7. Kaushik G. Effect of processing on mycotoxin content in grains. Critical Reviews in Food Science and Nutrition. 2015;55:1672-83. https://doi.org/10.1080/10408398.2012.701254
8. Nicolopoulou-Stamati P, Maipas S, Kotampasi C, Stamatis P, Hens L. Chemical pesticides and human health: The urgent need for a new concept in agriculture. Frontiers in Public Health. 2016;4:148. https://doi.org/10.3389/fpubh.2016.00148
9. Nair A, Delate K. Composting, crop rotation and cover crop practices in organic vegetable production. Organic Farming for Sustainable Agriculture. 2016;231-57. https://doi.org/10.1007/978-3-319-26803-3_11
10. Naqvi SF, Khan IH, Javaid A. Detection of compounds and efficacy of n-butanol stem extract of *Chenopodium murale* L. against *Fusarium oxysporum* f. sp. *lycopesici*. Bangladesh Journal of Botany. 2022;51(4):663-68. https://doi.org/10.3329/bjb.v51i4.63483
11. Jabeen N, Javaid A, Ahmed E. Antifungal activity and phytochemical profile of chloroform soluble fraction of *Datura metel* fruit. Journal of Animal and Plant Sciences. 2022;32(4):1085-91. https://doi.org/10.36899/JAPS.2022.4.0512
12. Hamza A, Manzoor M, Anees M, Javaid A, Tariq MR, Firdosi MFH, et al. Bioefficacy of some botanical extracts against brinjal fruit and shoot borer [*Leucinodes orbonalis* (Guenee); Lepidoptera, Pyrallidae]. Plant Protection. 2023;7(2):263-72. https://doi.org/10.33804/pp.007.02.4728
13. Javaid A, Ali A, Khan IH, Ferdosi MFH. Leaves of *Chenopodium*

album as source of natural fungicides against *Sclerotium rolfsii*. Arabian Journal of Chemistry. 2023;16(5):104677. https://doi.org/10.1016/j.arabjc.2023.104677

14. Khan IH, Javaid A. Antifungal activity of *n*-butanol stem extract of quinoa against *Macrophomina phaseolina.* Pakistan Journal of Botany. 2022;54(4):1507-10. https://doi.org/10.30848/PJB2022-4(7)
15. Ferdosi MFH, Ahmed H, Khan IH, Javaid A. Fungicidal potential of flower extract of *Cassia fistula* against *Macrophomina phaseolina* and *Sclerotium rolfsii.* Journal of Animal and Plant Sciences. 2022;32(4):1028-34. https://doi.org/10.36899/JAPS.2022.4.0506
16. Okunadade AL. *Ageratum conyzoides* L. (Asteraceae). Fitoterapia. 2002;73:1-16. https://doi.org/10.1016/S0367-326X(01)00364-1
17. Adetutu A, Morgan WA, Corcoran O, Chimezie F. Antibacterial activity and *in vitro* cytotoxicity of extracts and fractions of *Parkia biglobosa* (Jacq.) Benth. stem bark and *Ageratum conyzoides* Linn. Environmental Toxicology Pharmacology. 2012;34(2):478-83. doi:10.1016/j.etap.2012.06.008. https://doi.org/10.1016/j.etap.2012.06.008
18. Odeleye OP, Oluyege JO, Aregbesola OA, Odeleye PO. Evaluation of preliminary phytochemical and antibacterial activity of *Ageratum conyzoides* (L.) on some clinical bacterial isolates. International Journal of Engineering Science. 2014;3:1-5.
19. Yuliani, Rahayu Yuni. The potency of *Ageratum conyzoides* as biopesticide. Atlantis Press; 2021. https://doi.org/10.2991/absr.k.210408.069
20. Erida G, Ichsan CN, Syamsuddin, Kurniawanc T, Khan IH, Javaid A. Potential of secondary metabolites of *Ageratum conyzoides* L. in weed management: A review. Allelopathy Journal. 2023;58(1):23-40. https://doi.org/10.26651/allelo.j/2023-58-1-1417
21. Al-Hetar MY, Zainal AMA, Sariah M, Wong MY. Antifungal activity of chitosan against *Fusarium oxysporum* f. sp. *cubense*. Journal of Applied Polymer Science. 2010;120:2434-97. https://doi.org/10.1002/app.33455
22. Kapeua Ndacnou M, Pantaleon A, Saha Tchinda J, Ngonkeu Mangapche EL, Keumedjio F, Begoude Boyoguemo D. Phytochemical study and anti-oomycete activity of *Ageratum conyzoides* L. Industrial Crops and Products. 2020;153:112589. https://doi.org/10.1016/j.indcrop.2020.112589
23. Bajwa R, Akhtar N, Javaid A. Antifungal activity of allelopathic plants extracts I. Effect of aqueous extract of three allelopathic asteraceous species on growth of *Aspergilli*. Pakistan Journal of Biological Sciences. 2001;4(5):503-07.https://doi.org/10.3923/pjbs.2001.503.507
24. Ilboudo O, Bonzi S, Tapsoba I, Somda I, Bonzi-Coulibaly YL. *In vitro* antifungal activity of flavonoid diglycosides of *Mentha piperita* and their oxime derivatives against two cereals fungi. Comptes Rendus Chimie. 2016;19:1-7. https://doi.org/10.1016/j.crci.2015.11.023
25. Ferdosi M, Javaid A, Khan I, Ferdosi M, Munir A. Bioactive components in methanolic flower extract of *Ageratum conyzoides*. Pakistan Journal of Weed Science Research. 2021;27(2):181-90. doi:10.28941/pjwsr.v27i2.954. https://doi.org/10.28941/pjwsr.v27i2.954
26. Yaguchi A, Yoshinari T, Tsuyuki R, Takahashi H, Nakajima T, Sugita-Konishi Y, et al. Isolation and identification of precocenes and piperitone from essential oils as specific inhibitors of trichothecene production by *Fusarium graminearum*. Journal of Agricultural and Food Chemistry. 2009;57:846-51. doi:10.1021/jf803403j. https://doi.org/10.1021/jf802813h
27. Furukawa T, Sakamoto N, Suzuki M, Kimura M, Nagasawa H, Sakuda S. Precocene II, a trichothecene production inhibitor, binds to voltage-dependent anion channel and increases the superoxide level in mitochondria of *Fusarium graminearum*. PLoS One. 2015;10(8):e0135031. https://doi.org/10.1371/journal.pone.0135031
28. Hazirah MN, Hamizah O, Natasya WW. Antifungal activity of *Ageratum conyzoides* extract against *Fusarium oxysporum* in *Musa* spp. In: Proceedings of the 5th International Conference on Sustainable Agriculture and Environment; 2023 Mar 22-24: Kuala Lumpur, Malaysia. IOP Publishing; 2023:1182(1):012074. https://doi.org/10.1088/1755-1315/1182/1/012074
29. Okokon JE, Odomana CS, Imabong E, Obot J, Udobang JA. Antiplasmodial and antidiabetic effect of *Eleusine indica*. International Journal of Drug Development and Research. 2010;10(3):493-500.
30. Morah FNI, Otuk ME. Antimicrobial and anthelmintic activity of *Eleusine indica*. Acta Scientiae et Intellectus. 2015;1:28-32.
31. Tiwari U, Cummins E. Fruit and vegetables. In: Tiwari BK, Brunton NP, Brennan CS, editors. Handbook of Plant Food Phytochemicals: Sources, Stability and Extraction. John Wiley and Sons; 2013:105-37. https://doi.org/10.1002/9781118464717.ch5