Review on Agriculture and Rural Development 2022 vol. 11 (1-2) ISSN 2677-0792
DOI: 10.14232/rard.2022.1-2.181-185

ALLELOPATHIC EFFECT OF FIVE INVASIVE PLANTS ON SEED GERMINATION AND GROWTH OF WILD MUSTARD

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ABSTARCT

Presently, chemical control is the most used method for plant protection. However, it is not an approach that is environmentally sustainable. Alternative IPM methods include biological control such as Allelopathy can be a good alternative in plant protection.
Allelopathy is defined as a direct or indirect interaction, whereby allelochemicals released by one organism influence the physiological processes of other neighboring organisms.
Laboratory experiments were conducted to investigate the allelopathic effect of five weeds, *Eriochloa villosa* (ERBVI), *Panicum miliaceum* (PANMI), *Cannabis sativa* (CNISA), *Sorghum halepense* (SORHA), *Asclepias syriaca* (ASCSY) on germination and growth of wild mustard (*Sinapis arvensis* L.). These weeds are harmful to field cultivation and their weed control is hard to manage.The extracts from the leaves and stem were used to examine the potential of inhibition of germination, root length, shoot length and full plant growth.
The phenomenon of allelopathy was detected in the examined plants. In the case of plants, the allelopathic effect also increased with increasing concentration. The results show that extracts of Johnson grass had the most significant inhibition effect of growth and seed germination.

Keywords: allelopathic effect, invasive plants, weeds, seed germination, plant growth

INTRODUCTION

Allelopathy is defined as the interaction between plants and microorganisms by a variety of compounds usually referred as allelochemicals or allelopathic compounds. Allelochemicals released by one organism influence the physiological processes of other neighboring organisms (RICE, 1984; KONG and HU, 2001; ZENG, 2008; SOLTYS ET AL., 2013). The term allelopathy is originated from the Greek word «Allelon» meaning «each other» and «pathos» meaning «suffering». It was coined by plant physiologist, Hans Molisch (WILLIS, 2007; DUKE, 2010; BHADORIA, 2011). Integrated disease management can be defined as a sustainable approach towards controlling disease by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risk. Although biological control remains the most vital approach. Under field conditions, allelochemicals have a noticeable effect on integrated disease management (SARAF ET AL., 2014). The chemical substances produced by plants influence the growth, survival, development, and reproduction of other organisms (CHENG and CHENG, 2015). They participate in the defense of plants against microbial attack, herbivore predation, and/or competition with other plants. Allelochemicals could be leads for new pesticide discovery (KONG ET AL., 2019). Allelochemicals influence plant growth by disrupting different stages of respiration, such as electron transfer in mitochondria, oxidative phosphorylation, CO_2 generation, and ATP enzymatic activity. These chemicals have the ability to impede the supply of oxygen, which prevents the oxidation of NADH, inhibits the enzymatic activity of ATP synthesis, reduces the formation of ATP in the mitochondria, disrupts phosphorylation oxidative activity of plants and ultimately inhibit respiration. On the other hand, they can stimulate the release of CO_2, which promotes respiration (CRUZ-ORTEGA ET AL., 1988). Root exudation is a major pathway for the release of allelochemicals. Once released into the soil, allelochemicals interact with organic and inorganic soil phases and soil microorganisms. These interactions determine the bioavailability and phytotoxic level of allelochemicals (SCAVO ET AL., 2019). Several allelochemicals alter nutrient uptake in plant roots or induce water stress by inhibiting long-term water use. They inhibit Na^+/K^+- ATP-ase activities involved in ion uptake and transport at the cell plasma membrane, which suppresses cellular uptake of K^+, Na^+ or other ions (Cheng and Cheng, 2015).

The aim of this study was to determine the allelopathic effect of the biomass of *Eriochloa villosa* (ERBVI), *Panicum miliaceum* (PANMI), *Cannabis sativa* (CNISA), *Sorghum halepense* (SORHA) and *Asclepias syriaca* (ASCSY) on the germination and growth of Wild mustard (*Sinapis arvensis* L.). Water extracts were prepared in a laboratory assay at 1%, 5% and 10% concentrations and it determined in experiments conducted in Petri dish bioassays under laboratory conditions.

MATERIALs AND METHODS

The research was conducted in the laboratories of the University of Debrecen, Faculty of Agricultural, Food Sciences and Environment Management, Plant Protection Institute.

Sinapis arvensis L. is the test plant.

Collection of the invasive plants is the first step of this research, were done in 16/10/2021.

Before testing, the fresh plant samples were stored in a freezer. Before drying, the collected sample was cut into pieces. It was dried for 24 hours at 60°C.

Extracts from invasive plants was taken from the leaves and stem. 4g and 8g from samples was measured and 100ml of distilled water were added to the samples. We soaked it for 24 hours (in the dark) using a shaker.

Seeds were placed on a layer of filter paper in a Petri dish (20 seeds/dish) with 10ml of the extract. The Petri dishes were placed in the laboratory at natural light and 20±2°C for 2 days.

The experiments were repeated 3 times.

The germination rate was calculated according to the following formula:

$$(\text{Germination }\%) = (\text{Germinated seed}/\text{Total seed}) \times 100$$

The success of germination was characterized by the percentage of germinated seeds (Germination %) (n=20).

The effect of the extracts with different concentrations (4 - and 8 g/100 ml) and controls was compared by non-parametric Kruskall-Wallis test. If we find significant differences and in case of comparison of different organs (steam and leaf) the groups were compared with Mann-Whitney U-test. The statistical analysis was carried out with SPSS 28 program.

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RESULTS

Effects on the inhibition of germination of *Sinapis arvensis* L.

As shown Table 1, extracts of Johnson grass had the most significant inhibition effect on seed germination followed by Hemp and Common millet.
The allelopathic effect increased with increasing of concentration, in this case 10% of extract concentration gave the best result.
Common millet and Woolly cup-grass affect similarly seed germination of Wild mustard.

Effects on the inhibition of root growth of *Sinapis arvensis* L.

Results on Table 2 show that extracts of Johnson grass had the most significant effect on the inhibition of root growth, followed by *Asclepias syriaca* and *Eriochloa villosa*.
Panicum miliaceum and *Cannabis sativa* have approximately the same inhibition effect on root growth.
The best results shown with 10% concentration.

Effects on the inhibition of shoot growth of *Sinapis arvensis* L.

Table 3 shows that *Asclepias syriaca* has the most important effect on the inhibition of shoot growth followed by *Sorghum halepense* and *Eriochloa villosa*.
Panicum miliaceum has significantly the same effect as *Cannabis sativa*.

Effects on the inhibition on the growth of the full plant

Sorghum halepense has the most important inhibition effect on the growth of full plant followed by "*Asclepias syriaca*" and *Eriochloa villosa*.

Table 1: Germination percentage under control, 1%, 5% and 10% CONC

	Control	1% CONC	5% CONC	10% CONC
ERBVI	99.67 [c]	91.33 [b]	93.33 [b]	85.33 [a]
PANMI	99.67 [b]	72.67 [a]	70.00 [a]	70.00 [a]
CNISA	99.67 [c]	46.67 [a]	52.67 [b]	43.33 [a]
SORHA	99.67 [d]	88.67 [c]	82.00 [b]	32.67 [a]
ASCSY	99.67 [c]	88.67 [a]	80.00 [b]	45.33 [a]

Table 2: Shoot length under control, 1%, 5% and 10% CONC

	Control	1% CONC	5% CONC	10% CONC
ERBVI	20.20 [d]	9.57 [b]	13.21 [c]	2.11 [a]
PANMI	20.20 [b]	11.03 [a]	13.27 [a]	11.04 [a]
CNISA	20.20 [c]	18.91 [a]	18.35 [b]	10.40 [a]
SORHA	20.20 [c]	13.21 [b]	11.90 [b]	0.75 [a]
ASCSY	20.20 [c]	18.80 [c]	11.60 [b]	0.13 [a]

Table 3: Root length under control, 1%, 5% and 10% CONC

	Control	1% CONC	5% CONC	10% CONC
ERBVI	39.09 [d]	11.82 [b]	18.63 [c]	5.31 [a]
PANMI	39.09 [d]	16.61 [b]	19.03 [c]	12.43 [a]
CNISA	39.09 [c]	36.66 [c]	24.55 [b]	11.57 [a]
SORHA	39.09 [d]	26.35 [c]	15.39 [b]	2.59 [a]
ASCSY	39.09 [c]	13.47 [b]	18.60 [b]	3.65 [a]

Table 4: Full plant under control, 1%, 5% and 10% CONC

	Control	1% CONC	5% CONC	10% CONC
ERBVI	59.29 [c]	22.39 [b]	31.84 [b]	7.42 [a]
PANMI	59.29 [c]	27.64 [ab]	32.31 [b]	23.47 [a]
CNISA	59.29 [d]	55.57 [c]	42.89 [b]	21.97 [a]
SORHA	59.29 [d]	39.56 [c]	27.29 [d]	3.35 [a]
ASCSY	59.29 [c]	32.27 [b]	30.20 [b]	3.78 [a]

Note: small letters show the statistical differences based on Mann-Whitney U- test ($p<0,05$)
ERBVI: *Eriochloa villosa,* PANMI: *Panicum miliaceum,* CNISA: *Cannabis sativa,* SORHA: *Sorghum halepense,* ASCSY: *Asclepias syriaca*

DISCUSSION

Allelopathy is the direct or indirect deleterious effect of one plant upon another through the production of chemical inhibitors released into the environment. Our research show that extracts of Johnson grass had the most significant inhibition effect of growth (shoot and root growth) followed by Common milkweed, Woolly cup-grass, Hemp and Common millet. Furthermore, the extracts of Johnson grass had the most significant effect of germination followed by *Cannabis sativa, Asclepias syriaca, Panicum miliaceum and Eriochloa villosa.* The higher concentrations showed usually the best effect.

ACKNOWLEDGEMENTS

This paper and the research behind would not have been possible without the exceptional support of our professor Arnold Szilágyi. His enthusiasm, knowledge and exacting attention to every detail have been an inspiration and kept our work on track from the beginning of the research to the final draft of this paper.

REFERENCES

Bhadoria, P. B. S. (2011). Allelopathy: a natural way towards weed management. *American Journal of Experimental Agriculture, 1*(1), 7-20

Cheng, F., Cheng, Z. (2015): Research Progress on the use of Plant Allelopathy in Agriculture and the Physiological and Ecological Mechanisms of Allelopathy. Frontiers in Plant Science 6:1020 DOI: 10.3389/fpls.2015.01020

Cruz-Ortega, R., Anaya, A., L., Ramos, L. (1988): Effects of allelopathic compounds of corn pollen on respiration and cell division of watermelon, J. Chem. Ecol. 14, 71–86. DOI: 10.1007/BF0102253

Duke, S., O. (2010): Allelopathy: current status of research and future of the discipline: a commentary. Allelopathy J. 25: 17–30.

Kong, C., H., Hu, F. (2001): Allelopathy and its Application. Beijing: Chinese agricultural press.

Kong, C., H., Xuan, T., D., Khanh, T., D., Tran, H., D., Trung, N., T. (2019): Allelochemicals and Signaling Chemicals in plants. Molecules 24, 2737 doi: 10.3390/molecules24152737

Rice, E., L. (1984): Allelopathy, 2nd edition. New York: Academic Press.

Saraf, M., Pandya, U., Thakkar, A. (2014): Role of allelochemicals in plant growth promoting rhizobacteria for biocontrol of phytopathogens. 169 Microbiological Research. 18-29. DOI: 10.1016/j.micres.2013.08.009.

Scavo, A., Abbate, C., Mauromicale, G. (2019): Plant allelochemicals: agronomic, nutritional and ecological relevance in the soil system. Plant and Soil volume 442, pages23–48.

Soltys, D., Krasuska, U., Bogatek, R., Gniazdowska, A. (2013): Allelochemicals as Bioherbicides-Present and Perspectives'. DOI: 10.5772/56185.

Willis, R., J. (2007): The history of allelopathy. Dordrecht:Springer. DOI: 10.1007/978-1-4020-4093-1

Zeng, R. (2008): “Allelopathy in Chinese ancient and modern agriculture,” in Allelopathy in Sustainable Agriculture and Forestry, eds R. Zeng, A. Mallik and S. Luo (New York: Springer New York Press), 39–59. DOI: 10.1007/978-0-387-77337-7_3