Allelopathy based Weed Management: Advances and Challenges

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OPEN ACCESS

Keywords

Agriculture, Weed, Advances, Challenges

How to cite this article:

Badesra, S., Manuja, S., Sharma, G. D., Shivalika, Mali, S. and Kumari, S. 2025. Allelopathy based Weed Management: Advances and Challenges. *Vigyan Varta* 6(4): 231-233.

ABSTRACT

Allelopathy is a natural process where plants release chemicals (allelochemicals) that influence the growth of other plants, offering eco-friendly solutions for weed control and sustainable farming. It helps in weed management, crop productivity, pest control, and ecosystem balance, reducing reliance on synthetic herbicides. Key management strategies include residue incorporation, crop rotation, intercropping, mulching, and cover cropping to enhance soil health and suppress weeds. Future research focuses on identifying and commercializing allelochemicals, improving bioherbicides, and integrating allelopathic traits into crops. Allelopathy presents a promising, sustainable alternative to chemical herbicides, promoting environmentally friendly agriculture.

INTRODUCTION

Allelopathy is a natural biological process wherein plants release biochemical compounds (allelochemicals) that impact neighboring plants' development, survival and reproduction offering a promising avenue for sustainable agriculture. The phytotoxic properties of allelochemicals or biologically active metabolites exuded by higher plants, fungi or microorganisms provide a source of practical solutions for weed control. Allelopathic plants can play a beneficial role

in weed control in several ways like crop rotation, intercropping system, as cover crop, mulching or incorporating plant material with soil, use of plant- based herbicides alone or in combination with synthetic herbicides, use of crude oil extraction and isolation of active compound and synthesis of derivative compounds. Leaf extracts of tree species are a potent source of metabolites and the toxic effects of these are species- specific (Krumsri *et al*. 2020). Natural products based on allelochemicals may replace or reduce the use of synthetic compounds because they are safe for humans, pets and the environment. Allelopathic compounds are a suitable substitute for synthetic herbicides because they do not have residual or toxic effects, however, so far only 3% of the approximately 400,000 known compounds in plants that show allelopathic activity have been recognized as acting as bioherbicides, although more than 2000 plant species (39 families) have strong allelopathic effects (Li *et al*. 2019).

In agriculture and forestry, allelopathy holds significant promise as a sustainable solution for various challenges, including weed management, crop protection, and soil health maintenance. Harnessing plants' allelopathic potential can lead to beneficial outcomes such as weed suppression, enhanced crop productivity, and reduced reliance on synthetic agrochemicals (Bednarz *et al*. 2023; Ain *et al*. 2023).

Objective of allelopathy

Weed management: It is the practice of controlling weeds in agriculture by using allelopathic plants or their compounds as natural herbicides.

Crop Productivity: Increasing crop yields through the engineering or selection of plants with advantageous allelopathic traits.

Pest and Disease Control: In order to lessen the need for synthetic pesticides, allelochemicals are being investigated for their ability to repel bacteria, fungi, and pests.

Sustainable Agriculture: Promoting environmentally friendly farming methods by lowering dependency on chemical inputs is known as sustainable agriculture.

Ecosystem Balance: Understanding biodiversity and succession dynamics through the study of natural plant communities is known as ecosystem balance.

Management of allelopathy

1. **Residue incorporation:** In situ incorporation of crop residues as well as green manuring crops release allelopathic exudates that decline the germination of upcoming weed seeds as well as boost the soil fertility to make the host crop competitive enough against the invasive weeds

2. **Crop rotation:** Crop rotation should be like that allelochemicals released by one crop get enough time to degrade and to not harm the growth, germination or any metabolic activity of succeeding crop eg., Mize- fallow-soybean. Maize releases different allelochemicals like benzoxazinoides, terpenoides etc., which get degraded over the fallow period and will not harm the soybean crop

3. **Intercropping:** Crop selection should be like that during intercropping they should not suppress each other growth and effectively control the weed growth eg., sorghum+ soybean

4. **Straw mulching:** Mulch which releaese allelochemiclas during decomposition should be preffered eg., rye

5. **Cover crop:** Crop showing allelopathy should be used as cover crop eg., *Brassica spp*.

Future thrust

More researches yet to be awaited to analyse plant-plant and plant- microbe interactions, more importantly farmers should be aware of efficient agricultural practices that promote better weed control by using allelopathy, transfer of allelopathic traits to high yielding varities is very crucial with different method of extraction of allelochemicals should also be discovered, identification of biochemicals followed by commercialization should taken into account with development of bioformulation for practical use.

CONCLUSION

By harnessing the natural chemical interactions between plants, allelopathy provides an effective means to suppress unwanted weed growth, reduce the need for harmful synthetic herbicides and enhance the overall health and productivity of crops. The isolation and identification of allelochemicals can lead to new pesticides, which will highlight allelopathy as a way to achieve green pest management. Allelopathy is a dynamic process that is extremely complex. Chemical variables include time-dependent factors and simple effects, and analysis of these is not possible, which means detailed investigations ar always required. The discovery of new modes of action of allelochemicals is crucial to tackle the weed resistance problem. The great changes that allelopathy research has undergone in recent years show the high sensitivity and selectivity that allelochemicals have. This can help to reduce the use of traditional herbicides.

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