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# ALLELOPATHY: A TOOL FOR SUSTAINABLE WEED MANAGEMENT

**Daly George[1*] & Dr. P.V Sindhu[2]**

*[1]Ph.D Scholar & [2]Assistant Professor*

*[1&2]Department of Agronomy, College of Horticulture, Vellanikkara, Kerala Agricultural University*

**Corresponding author: *dalykgeorge@gmail.com***

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## Introduction

Weeds are the largest biotic threat affecting the yield of cultivated plants. According to a study by researchers associated with the Indian Council for Agricultural Research (ICAR), India loses agricultural produce worth over $11 billion to weeds every year; it is above the Centre's budgetary allocation for agriculture for 2017-18. Looking at the global scenario the main contributors of crop loss are again weeds. Weeds cause numerous harms in agro-ecosystems they aggressively compete for water, nutrients and sunlight, resulting in reduced crop yield and poor crop quality. Owing to the high cost and drudgery involved, traditional methods, particularly hand weeding are on the decline. Chemical weed control is a cost effective choice to manage this situation. However, depending only on herbicides for weed management is not advisable, considering the ill effects of continued use of chemicals. Also ban on manufacture, sale and use of popular and currently marketed herbicides and global increase in organic agriculture, urges the need for alternative sustainable weed management strategies. The phenomenon of allelopathy has been suggested as a potential biorational method towards this goal.

## Allelopathy

Allelopathy is any direct or indirect harmful or beneficial effect by one plant (including microorganisms) on another through production of chemical compounds that escape into the environment. The source of allelochemicals in agricultural fields can be weeds, crops or microorganisms.

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**Mode of release of allelochemicals**

Allelochemicals can be produced and accumulate in all plant parts like leaves, roots, stems, rhizomes, flowers, fruits and seeds. These bioactive compounds are released from plants in a number of ways.

1. Volatilization - allelopathic plants release a chemical in its gaseous form through small openings in their leaves into the atmosphere. It is significant under arid or semiarid conditions.
2. Leaching - rainfall, dew or irrigation may leach the chemicals from the aerial parts of plants that are subsequently deposited on other plants or on the soil. Leaching also occur through plant residues.
3. Root exudation - some plants release defensive chemicals in to the soil through their roots. The released compounds are absorbed by roots of nearby plants.
4. Decomposition of plant residues - chemicals contained in residues are simply released upon decomposition, or produced instead by micro-organisms utilizing the residues.

**Examples of allelochemicals**

| **Allelochemicals** | **Natural source** | **Mode of action in receiver plants** |
|---|---|---|
| 1, 8 - Cineole | *Eucalyptus globulus* Labill. | Inhibition of mitosis |
| Sorgoleone | *Sorghum bicolor* L. Moench. | PS II inhibition |
| Artemisinin | *Artemisia annua* L. | Alter peroxidase enzyme activity |
| Sarmentine | *Piper* sp. | Membrane disruptor & PSII inhibitor |
| Juglone | *Juglans nigra* | Inhibition of mitochondrial respiration |
| Tricolorin A | *Ipomoea tricolor* | Retards photosynthesis |

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| | | |
|---|---|---|
| Momilactone | *Oryza sativa L.* | Unknown |
| Benzoxazinones | *Secale cereale* L. | *Alteration of* Mitochondrial function |

**Role of allelopathy in weed management**

The inhibitory aspect of allelopathy has immense potential for weed suppression in sustainable crop production systems. Several aspects of plant physiological and biochemical processes have been proved to be affected by allelochemicals. The phenomenon of allelopathy can be exploited in several ways to control weeds, such as:

- **Use of phytotoxic plant residues as mulch**

Crop residues are potential source for weed control in agro-ecosystems. If we use allelopathic crop residues as mulch in addition to physical effect, it will inhibit germination, growth and survival of neighbouring plants by releasing allelochemicals from decomposing residues.

Example: sorghum residues applied as mulch to the field helps to reduce weed infestation in pulses

- **Cultivation of allelopathic cover crops and intercrops**

Compatible crops are grown together in order to obtain higher net yield and economic benefits. In addition to these benefits, intercropping and cover cropping with potential allelopathic crops can be used as environment friendly and economical weed control strategy.

Example: cover crops such as *Raphanus sativus*, *Fagopyrum esculentum* and *Avena strigosa* showed allelopathic weed suppression

- **Inclusion of allelopathic crops in rotations**

Allelopathic weed control can also be achieved by growing allelopathic plants in a field for a certain period, in order for their roots to exude allelochemicals. The allelochemicals added to the field from the previous allelopathic crop will help to control weeds.

Example: inclusion of a rye crop in a rotation

- **Breeding of allelopathic cultivars**

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Development of cultivars with high allelopathic potential along with high yield is a promising strategy for achieving sustainable weed management and farm productivity.

Example: 'rondo' a rice cultivar developed by the USDA-ARS through mutation breeding exhibited superior weed suppressing ability than many commercial cultivars.

- **Direct application of allelopathic plant extracts or powder**

Plant products in the form of aqueous extracts or dry powders of crops and other plants can be used directly as natural herbicides to suppress the growth and development of weeds in different crops or non-cropped areas.

Example: application of sorghum water extract (sorgaab) and sunflower extracts (sunfaag) suppress weed growth

- **Development of bio herbicides**

Thousands of allelochemicals obtained from plants or microorganisms have diverse and challenged structures, which can be exploited as natural herbicides with safe mode of action and better selectivity to crops.

Example: 'leptospermone' isolated from roots of bottlebrush plant exhibit inhibitory potential on weeds

- **Synthetic derivatives of bioherbicides**

Allelochemicals, which have sufficient herbicidal activity used as herbicides directly to control the weeds, while other products with lower herbicidal activity may be served as chemical templates for development of synthetic herbicides. Synthesis and optimisation of analogous and derivatives of allelochemicals has low toxicity, high herbicidal activity with a wide spectrum of weed control and excellent crop selectivity.

Example: 'mesotrione' developed by the Syngenta Pvt. Ltd.USA is synthetic derivative of allelochemical 'leptospermone' produced by the roots of the bottle brush plant

**Challenges in using the allelopathic approach**

1. The type and amount of allelochemicals released into the environment depend on the combined effects of plant factors and environmental factors.

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2. Synthesis of many allelochemicals is very much expensive, though having excellent herbicidal properties.
3. The half-life of allelochemicals is short, varies from a few hours to a few months.
4. Allelochemicals which are very active under laboratory studies, often lose their activity in field situations.
5. Some allelochemicals are toxic to human beings.

**Conclusion**

As an alternative strategy to conventional herbicides, new methods that encourage the use of natural compounds are necessary to ensure sustainability. Allelopathy in that context is a feasible, eco-friendly and sustainable approach which can reduce the adverse effects of weeds in cropping systems. Allelopathic weed control will play a great role in sustainable agriculture with a safe impact on the environment. However, rigorous and dedicated research is required for its wide utilization at field level.