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Allelopathy for Sustainable Weed Management in Agro Ecosystem

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Sustainable management of crop production and environment in modern agriculture involves dealing with challenges from climate change, environmental pollution, depletion of natural resources, as well as pressure to cope with dependence on agricultural inputs. Balancing crop productivity with environmental sustainability is one of the main challenges for agriculture worldwide. The emergence of weeds resistant to synthetic herbicides generates huge economic losses, so unconventional weed control strategies, especially those based on ecological principles are very much needed in modern agriculture. Incorporating a natural eco-friendly approach, allelopathy as a tool in an integrated weed control plan by growing specific crops or spraying with extracts containing allelopathic compounds can significantly reduce the use of herbicides. Allelopathy is considered a multi-dimensional phenomenon occurring constantly in natural and anthropogenic ecosystems, by which one organism produces biochemicals that influence the growth, survival, development, and reproduction of other organisms. The deployment of allelopathic cover crops, intercropping, the inclusion of allelopathic plants in crop rotation, and the use of their residues as mulch are important for ecological, sustainable, and integrated weed control systems (Jabran *et al*. 2015). The most significant challenge to sustainable modern crop production is the limited availability of bioherbicides. For current researchers, allelopathic plants can be a source for identifying and isolating new allelopathic substances. After examining their bioactivity under laboratory and field conditions promising compounds can be recommended for novel natural herbicide development for sustainable agriculture (Motmainna *et al*. 2021).

Keywords: Allelopathy, Sustainable weed management, Allelochemicals, Bioherbicides, Crop rotation, Mulching, Intercropping, Plant extracts, Eco-friendly agriculture, Weed suppression

Introduction

Weeds are the most severe and widespread biological constraint to agricultural production systems and cause damage in cropped and non-cropped lands. They compete with crops for natural and applied resources besides being responsible for reducing quantity and quality of agricultural productivity. The world food loss due to weeds about 300 million tonnes *i.e.*, 11.5 per cent of total food production. The emergence of weeds resistant to synthetic herbicides generates huge economic losses, so unconventional weed control strategies, especially those based on

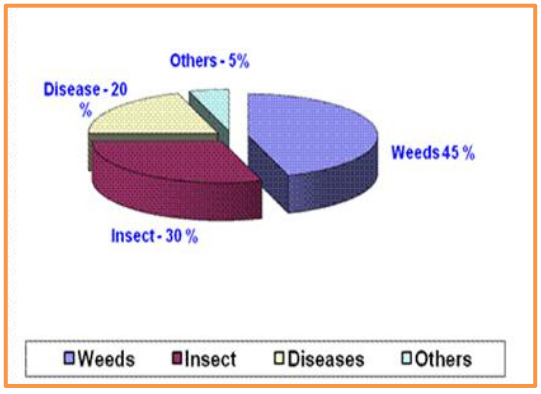


Fig.1. Total annual loss in agriculture produce (%) Source: TNAU AgritechPortal

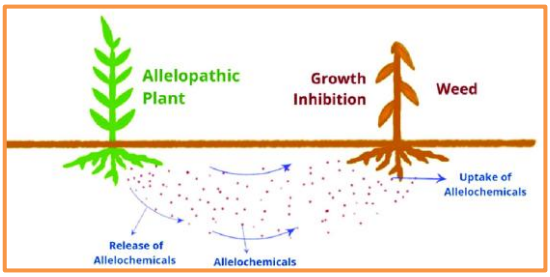
ecological principles, are very much needed in modern agriculture. Incorporating a natural eco-friendly approach- Allelopathy, as a tool in an integrated weed control plan by growing specific crops or spraying fields with extracts containing allelopathic compounds can significantly reduce the use of herbicides. Allelopathy is considered a multi-dimensional phenomenon occurring constantly in natural and anthropogenic ecosystems, by which one organism produces biochemicals that influence the growth, survival. Of the total annual loss in agriculture produce, weeds account for 45%, insect 30%, disease 20% and other pests 5%.

Definition

Allelopathy is any direct or indirect effect by one plant, including micro-organisms, on another through production of chemical compounds that escapes into the environment to influence the growth and development of neighbouring plants (Bahadur *et al*., 2015).

Allelopathy as a Weed Management

- The term allelopathy is from the Greek-derived compounds allelon 'of each other' and pathos 'to suffer' and means the injurious effect of one organism upon the other. The term 'allelopathy' was first used in 1937 by Austrian scientist Hans Molisch.
- Allelopathy is a natural process that can be used in crop production as a tool for biological weed management
- Allelopathic compounds are largely derivative of secondary metabolites identified as such as phenolics, alkaloids, flavonoids, terpenoids, momilactone, hydroxamic acids, brassinosteroids, jasmonates, salicylates, glucosinolates, carbohydrates and amino acids.
- These chemicals are secondary metabolites and are known as Allelo-chemicals.
- Allelochemicals could be utilized to develop new methods to tackle weed resistance to herbicide.



Types of Allelopathy

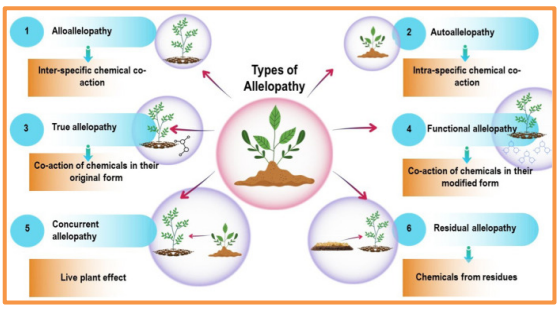
Alloallelopathy: It is inter- specific chemical co-action. Allelochemicals are toxic to other species, other than which release it. E.g. maize (*Zea mays*) is allelopathic for *Chenopodium* and *Amaranthus*

Autoallelopathy: It is intra-specific chemical co-action. Allelochemicals are toxic to same species from which they are released. E.g. wheat (*Triticumaestivum*), alfalfa (*Medicago*sativa), cowpea (*Vignaunguiculata*), rice (*Oryza sativa*), and apple (*Malusdomestica*)

True allelopathy: It refers to the release into the environment of chemical compound that are toxic the form they are produced by the plant.

Functional allelopathy: It refers to the release into the environment of chemical compound that are toxic after chemical modification by microorganisms.

Concurrent/ direct allelopathy: It refers to the instantaneous direct effect of released toxin from the living plant to another growing in vicinity. It is also called 'living plant effect'. E.g. sorghum (*Sorghum bicolor*) suppresses many weeds growing in the vicinity.



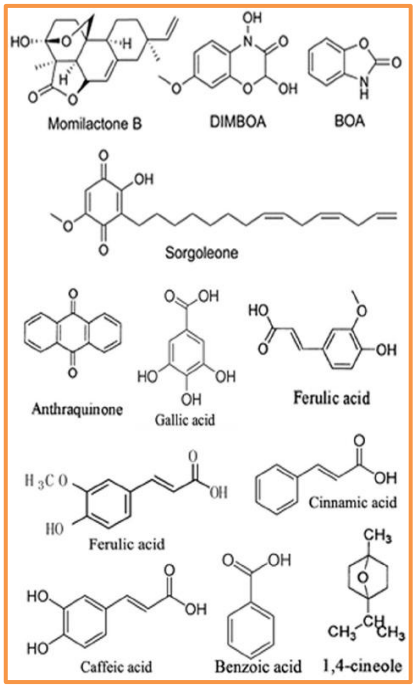
Residual allelopathy: It is the effect obtained on the plants growing in succession from the decaying residues, leaf litters, stem, and roots of the previous plants. E.g. sorghum is allelopathic to wheat and *Phalaris minor* and sweet potato (*Ipomoea batata*) to cowpea.

Allelopathic Compounds

The secondary products could be classified in the following categories.

Rice (1984); Putnam and Tang (1986) divided allelochemicals into various major chemical groups:

- Simple water-soluble organic acids
- Simple unsaturated lactones
- Long-chain fatty acids and polyacetylenes
- Simple phenols
- Naphthoquinone, anthroquinones and complex quinones
- Flavonoids
- Benzoic acid and derivates
- Steroids
- Cinnamic acid and derivates
- Tannins
- Amino acids and polypetides
- Coumarins
- Sulphides and glucosides
- Purines and nucleotides
- Alkaloids and cyanohydrins
- Thiocyanates
- Lactones
- Actogenins



Mode of Allelochemicals Release

In higher plants allelochemicals are released from through:-

- ✓ Vapour- from roots and leaf (from stomata)
- ✓ Stem or leaf leachate
- ✓ Root exudates
- ✓ Decomposition of plant residues
- ✓ Seed extract

Allelopathic Practices Used For Weed Control

The phenomenon of allelopathy may provide a new front in integrated weed control by including them in rotational sequences or intercropping near a cash crop, cover cropping as living or dead mulches, and crop residue incorporation into the soil.

1. Intercropping
2. Crop rotation
3. Mulches

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