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Effect of Allelopathy on Crops

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SUMMARY

The phenomenon of one plant having detrimental effect on another through the production and exertion of toxic chemical compounds is called allelopathy. Allelopathy is the indirect harmful effect through exertion of chemical substances. Allelopathy is existent in the natural ecosystem and it occurs widely in the natural plant communities. Allelopathy is possibly a significant factor in maintaining the present balance among the various plant communities. Allelopathic substance was first detected by Davis (1928) in black walnut tree (Juglans nigra) whose foliar leachate containing Juglone was found to damage germination and seedling growth of crops beneath the tree. The production of allelochemicals is affected by biotic factors such as nutrients available, and abiotic factors such as temperature and pH.

INTRODUCTION

Allelopathy is a new and potential area of research. The term allelopathy was coined by Prof. Hans Molisch in 1937 which indicates stimulatory or inhibitory biochemical interactions between the plants including micro-organisms. The allelopathy research started after the end of II World War i.e. near 1950's. During the last 60 years (1937 to 1996), allelopathy research had been conducted in diverse fields, hence, International Allelopathy Society in 1996 broadened its definition, Allelopathy refers to any process involving secondary metabolites produced by plants, microorganisms, viruses and fungi that influence the growth and development of agricultural and biological systems (excluding animals).It has been shown that allelopathy plays a major role in various disciplines of agricultural and biological sciences and could be used for pest (weeds, insects, nematodes, pathogens) management.

Allelopathy

Allelopathy is a biological phenomenon by which an organism produces one or more biochemicals that influence the growth, survival, and reproduction of other organisms. These biochemicals are known as allelochemicals and can have beneficial (positive allelopathy) or detrimental (negative allelopathy) effects on the target organisms.

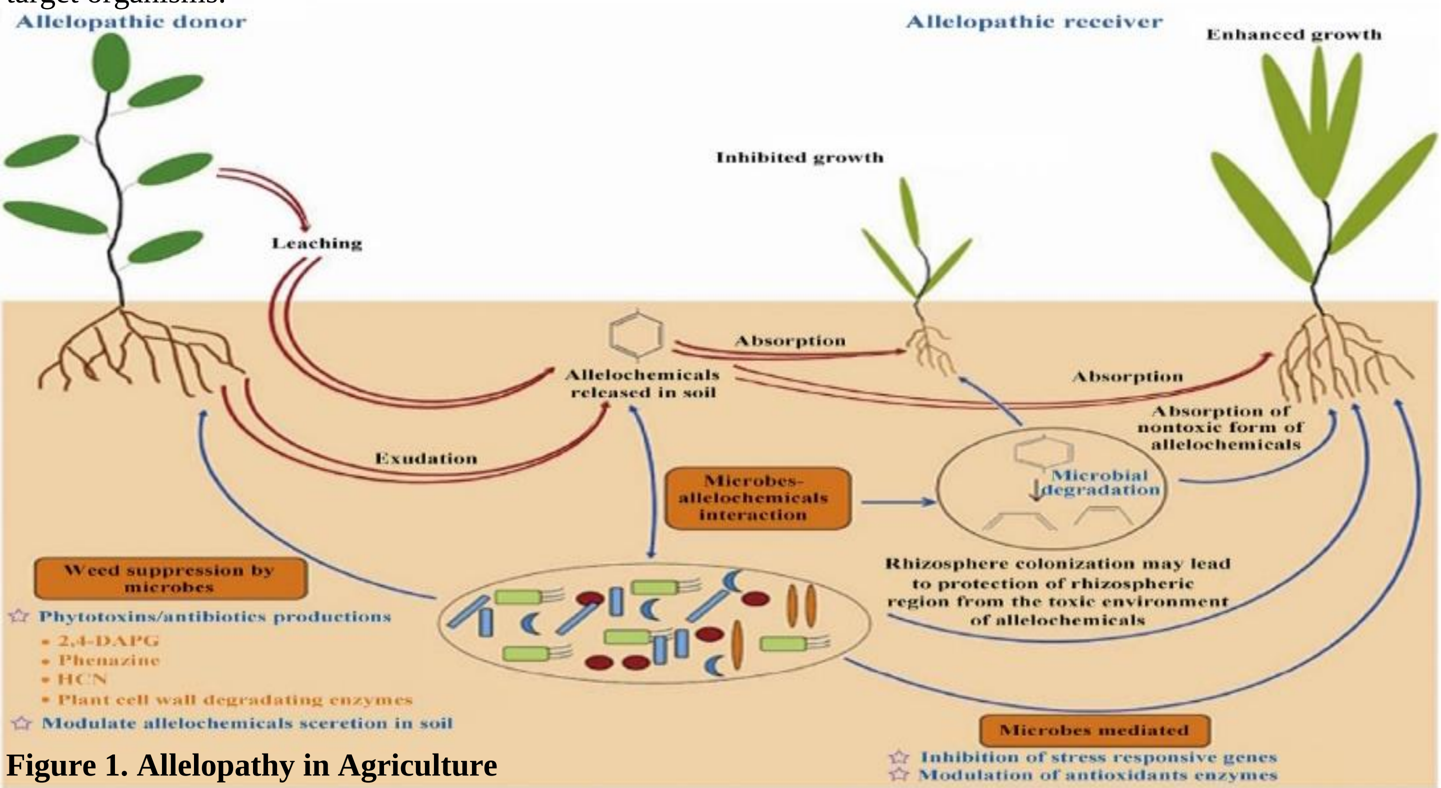

Figure 1. Allelopathy in Agriculture

Allelochemicals are a subset of secondary metabolites, which are not required for metabolism (i.e. growth, development and reproduction) of the allelopathic organism. *Parthenium* daughter plants exhibiting teletoxy to its parent plants is known as autotoxy. The word allelopathy is derived from Greek – allelo, meaning each other and patho, an expression of sufferance of disease. Allelopathy is characteristic of certain plants, algae, bacteria and fungi. Allelopathic interactions are an important factor in determining species distribution and abundance within plant communities, and are also thought to be important in the success of many invasive plants. Allelochemicals are found to be released to environment in appreciable quantities via root exudates, leaf leachates, roots and other degrading plant residues, which include a wide range of phenolic acids such as benzoic and cinnamic acids, alkaloids, terpenoids and others. These compounds are known to modify growth, development of plants, including germination and early seedling growth.

A schematic diagram showing the various roles of microbes in modulating the interaction of allelopathic donor-receiver species. Red arrows with double lines indicate the phenomenon of allelopathy, and blue arrows with single lines indicate the involvement of various microbial processes in reducing/enhancing allelopathic inhibition by soil microorganisms. This figure explains that beneficial rhizobacteria can minimize the phytotoxicity of the allelopathic donor toward the allelopathic receiver by using various rhizospheric processes such as rhizosphere colonization, biofilm formation, and degradation/transformation of toxic allelochemicals or modulation of the defense mechanism in receiver species by inducing the expression of stress responsive genes or the activity of antioxidant enzymes. Furthermore, microbes also can play an important role in the activation of allelochemicals, e.g., through the release of non-toxic glycosides followed by microbial degradation to release the active allelochemicals.

Allelochemicals are released in the form of:

1.Vapour (released from plants as vapour): Some weeds release volatile compounds from their leaves. Plants belonging to labiateae, compositeae yield volatile substances.

2.Leachates (from the foliage): From *Eucalyptus* allelo chemicals are leached out as water toxins from the above ground parts by the action of rain, dew or fog.

3.Exudates from roots: Metabolites are released from *Cirsium arvense* roots in surrounding rhizosphere.

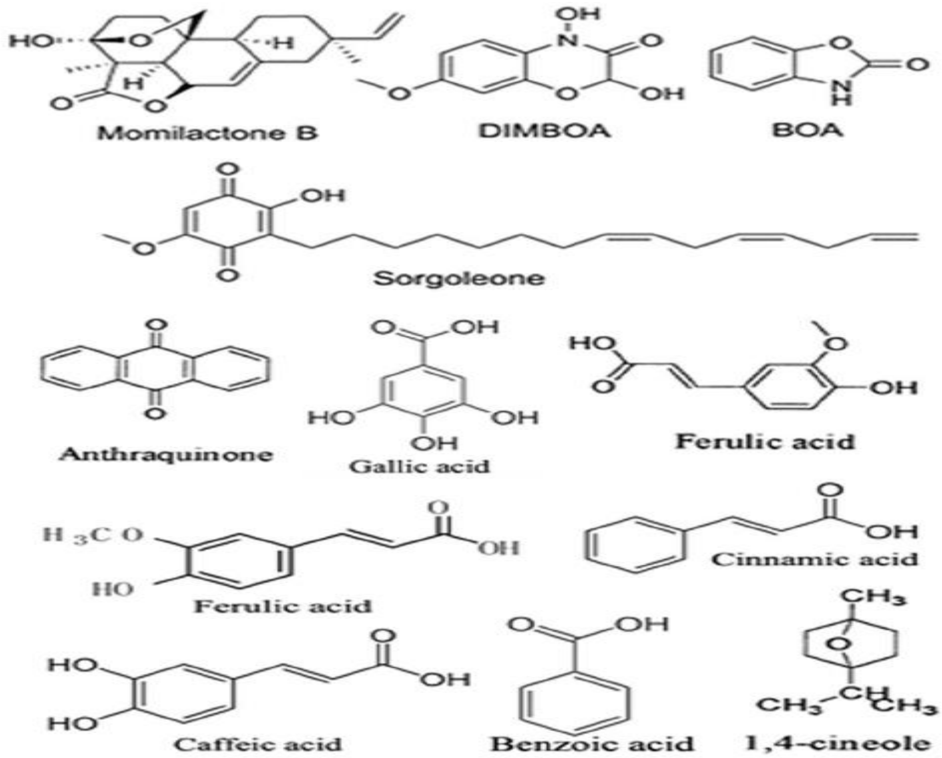

Figure 2. Structures of some of the allelochemicals produced by plants.

Allelochemicals, which are non-nutritive substances mainly produced as plant secondary metabolites or decomposition products of microbes, are the active media of allelopathy. Allelochemicals consist of various chemical families and are classified into the following 14 categories based on chemical similarity: water-soluble organic acids, straight-chain alcohols, aliphatic aldehydes, and ketones; simple unsaturated lactones; long-chain fatty acids and polyacetylenes; benzoquinone, anthraquinone and complex quinones; simple phenols, benzoic acid and its derivatives; cinnamic acid and its derivatives; coumarin; flavonoids; tannins; terpenoids and steroids; amino acids and peptides; alkaloids and cyanohydrins; sulfide and glucosinolates; and purines and nucleosides. Plant growth regulators, including salicylic acid, gibberellic acid and ethylene, are also considered to be allelochemicals. The rapid progress of analysis technology in recent years has made it possible to isolate and identify even minute amounts of Allelochemicals and to perform sophisticated structural analyses of these molecules. The structures of some allelochemicals produced by plants are shown in Figure 2.

Allelopathic effects of weeds on crop plants.

- Root exudates of Canada thistle (*Cirsium sp.*) injured oat plants in the field.
- Root exudates of Euphorbia injured flax. But these compounds are identified as parahydroxy benzoic acid.

Maize

- Leaves & inflorescence of *Parthenium sp.* affect the germination and seedling growth
- Tubers of *Cyperus esculentus* affect the dry matter production
- Quack grass produced toxins through root, leaves and seeds interfered with uptake of nutrients by corn.

Sorghum

- Stem of *Solanum* affects germination and seedling growth
- Leaves and inflorescence of *Parthenium* affect germination and seedling growth Wheat
- Seeds of wild oat affect germination and early seedling growth
- Leaves of *Parthenium* affects general growth
- Tubers of *C. rotundus* affect dry matter production
- Green and dried leaves of *Argemone mexicana* affect germination & seedling growth Sunflower
- Seeds of *Datura* affect germination & growth

Effect of weed on another weed

- Thatch grass (*Imperata cylindrica*) inhibited the emergence and growth of an annual broad leaf weed (*Borreria hispida*).
- Extract of leaf leachate of decaying leaves of *Polygonum* contains flavonoids which are toxic to germination, root and hypocotyls growth of weeds like ***Amaranthus spinosus***
- Inhibitor secreted by decaying rhizomes of *Sorghum halepense* affect the growth of *Digitaria sanguinalis* and *Amaranthus sp*.
- In case of *Parthenium*, daughter plants have allelopathic effect on parent plant.
- This is called AUTOTOXY

Effect of crop on weed

- Root exudates of wheat, oats and peas suppressed *Chenopodium album*. It increased catalase and peroxidase activity of weeds and inhibited their growth.
- Cold water extract of wheat straw reduces growth of *Ipomea* & *Abutilon*.

Stimulatory effect

- Root exudates of corn promoted the germination of *Orbanchae* minor; and *Striga hermonthica*. Kinetin exuded by roots sorghum stimulated the germination of seeds of *stirga asisatica*.
- Strigol – stimulant for witch weed was identified in root exudates from cotton.

CONCLUSION

Allelopathy plays an important role in investigations of appropriate farming systems as well as in the control of weeds, diseases and insects, the alleviation of continuous cropping obstacles, and allelopathic cultivar breeding. Furthermore, allelochemicals can act as environmentally friendly herbicides, fungicides, insecticides and plant growth regulators, and can have great value in sustainable agriculture. With increasing emphasis on organic agriculture and environmental protection, increasing attention has been paid to allelopathy research, and the physiological and ecological mechanisms of allelopathy are gradually being elucidated. It is obvious that allelopathy requires further research for widespread application in agricultural production worldwide.

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