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ALLELOPATHY IN AGRICULTURE

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Allelopathy is a biological phenomenon by which an organism produces one or more biochemical that influences the germination, growth, survival, and reproduction of other organisms. Allelochemicals, which are the secondary metabolites of plant, algae, bacteria and fungi, are responsible for allelopathy. The crop having allelopathic property can be used for nutrient management, weed control, disease, pest management and abiotic stress management in field crops. The allelochemicals also enhance and regulates crop growth. Allelochemicals produced by microorganisms, insects, higher animals and plants could provide new strategies for maintaining and increasing forest and agricultural production in the future. The application of allelopathic substances in the crop field reduces the utilization of agrochemicals, which have a detrimental effect on the environment and human life.

Allelopathy in weed management

Allelochemicals have the potential to be used as a herbicide. Allelopathy may help in weed management through the inhibition of weed seed germination and seedling growth. Weed-suppressing ability in several crops is either due to the exudation of allelochemical compounds released from living plant parts or from decomposing residue. As these are free from all the problems associated with present herbicides, they could be used directly as herbicides, and their chemistry can also be used to develop new herbicides. A lot of secondary compounds are produced by plants and microorganisms, and many of these are phytotoxic to weeds, thus having the potential to be used as herbicides. Glufosinate –AM, a synthetic analogue of bialaphos (microbial toxin/allelochemical is found in bacterium *Streptomyces hygroscopicus*) is extensively used for weed control in cropped and non-cropped situations. AAL toxin is a metabolite produced by *Alternaria alternate* f.sp. *Lycopersici* used as a natural herbicide. Many crops have been reported with their alleged

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allelopathic effect. For *e.g*., Barley produces phenolic compounds and two alkaloids *viz*., gramine and hordenine. Gramine inhibited the growth of chickweed, even in small concentrations. In *Sinapis alba*, root length and vigour of root tips decreased due to both hordenine and gramine. Radicle tips exposed to hordenine and gramine of *Sinapis alba* showed damage to cell walls, increase in both size and number of vacuoles, autophagy, and disorganization of organelles. Rye residues have been used to control weeds in fruit orchards (Narwal and Haouala, 2013)

Allelopathy and crop nutrition

Allelochemicals play a significant role in plant nutrition. These allelochemicals released into the rhizosphere, produced by plant, algae, bacteria and fungi, regulate solubilization, mobilization, release and chelation of mineral nutrients. Allelopathy can help to improve Nitrogen use efficiency (NUE). To improve N use efficiency (NUE) in agricultural systems, the nitrification rate in soil should be decreased, which is an important strategy to minimize N losses. Allelopathy offers an attractive and natural option to decrease nitrification for improving NUE in agricultural systems (Jabran *et al.* 2013)

Allelopathy in insect pest management

Extensive use of synthetic insecticides usually have a negative effect on the environment, human and animal health, and most critically, develops resistance against insects. Scientists are therefore turning towards the discovery and use of natural insect suppressants. Azadirachtin, an allelochemical from neem plant, effectively inhibit insect cicadellid, whitefly and *Ashbya gossypii.* Neem seed oil is reported to exhibit antifeedant properties against nymph and adult strawberry aphids. Eucalyptus contains a volatile oil which severely effects post-embryonic development and adult emergence of rice moth when sprayed during the larval period of rice moth. Common rue plant contains allelochemicals, coumarin and flavonoids, which have the potentiality to suppress Mediterranean fruit fly and mosquitoes. Ethanol produced from California pepper tree's leaf extract imparts insecticidal effect on elm leaf beetle. *Ambrosia trifida, Ageratum conyzoides,* and *Lantana camara* have allelopathic activity against insect and other pests (Farooq *et al.* 2011)

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Allelopathy in disease management

Plant disease is a serious issue causing damage to many crops. The soil-born pathogen causes substantial losses to crop production as it disturbs the crop stand and lowers the quality of production. Although cultural practices such as burning infected plant debris and using resistant cultivar have long been used, diseases still cause abundant losses in crop yields. Chemical disease control is not very effective and also very harmful to the environment. Another approach for the suppression of plant-pathogen is by using allelopathic crops in different ways. For reducing disease intensity, an allelopathic crop can be intercropped with the main crop, which creates a microclimate congenial for disease suppression. Intercropping of tomato with Chinese chive (*Allium tuberosum*) inhibit the multiplication of bacterial wilt (*Pseudomonus solanacearum*) without any negative effect on tomato. Marigold, when intercropped with tomato, suppress early blight of tomato caused by *Alternaria solani*. Neem leaves or neem cake applied to soil have a long term effect on the management of root node nematodes. Dried cabbage (Brassica oleracea L. var. capitata) incorporated into the soil significantly reduced the yellow cabbage pathogen (F. oxysporum sp. conglutinan) population and produced near disease-free cabbage plants. Methanethiol, dimethyl sulfide and dimethyl disulfide from the residues were suggested to have contributed to disease suppression (Ramirez Villapudua and Munneche1988).

Allelochemical as growth regulator

In modern agriculture, the role of plant growth regulators is very important. These are the substances which are known to control the plant's physiological and biochemical processes at low concentration. The growth-promoting effects of allelopathy can be used in different ways. Foliar application of plants extracts which having promotive effects can be beneficial for other crops. At higher concentration, the allelochemicals have an inhibitory effect, and at low concentration, the allelochemicals have a promotive effect, *i.e.* concentration of allelochemicals is inversely related to the promotive effect of the plant. Moringa water extracts contain a growth hormone *i.e*. Zeatin, which is the source of cytokinin, has been widely used for growth promotion in agronomic and horticultural crops. It increases yields by 25%-30% for a number of crops such as soyabean, maize and coffee. So, the juice from fresh Moringa leaves can be used to produce an effective plant growth hormone. (Maishanu *et al.* 2017)

Allelochemicals in abiotic stress management

The abiotic stresses, increase in daily mean temperature, changed patterns of precipitation, increase in episodes of drought, and floods may pose threats to crop production and food security in the future. Plants have evolved several mechanisms to cope with abiotic stresses. Production and release of secondary metabolites among organisms induce tolerance mechanism against abiotic stresses in ecosystems. Production of allelochemicals at higher rates induces resistance in plants against stresses and helps them grow vigorously under such conditions. The production of allelochemicals is influenced by the age of the plant, type of stress, the intensity of stress and surroundings. For example, when drought-resistant plants are exposed to drought condition, cyanogenic glucoside synthesis is enhanced. Biosynthesis of ferulic acid is increased under drought condition in wheat. Cucumber, when exposed to dry conditions, produces more phenolics and flavonoids. Similarly, temperature fluctuations also cause a change in the production rate of allelochemicals. Plants have to make necessary metabolic and structural adjustments to cope with the stress conditions. Stress-induced changes in plant metabolism and development can often be attributed to altered patterns of gene expression. In response to stress, some genes are expressed more intensively, whereas others are repressed. The protein products of stress-induced genes, named stress proteins, are helping plants to survive under stress conditions and minimizing the effectiveness of the stress agents. (Pedrol *et al*. 2006)

Conclusion

The term ‘allelopathy’ is mainly viewed negatively, but if correctly managed, this phenomenon may be exploited for enhancing crop productivity. There are a number of reports indicating the improvement in crop production due to allelopathic interactions. This manipulation can be achieved through weed, disease, pest and nutrient management *etc*. For sustainable agriculture, allelopathy has achieved great success in weed management. The utilization of allelopathic crop combined with reduced doses of herbicides can be a promising strategy for sustainable weed management, enhancing environmental health. The allelopathic potential of the crop can be exploited directly by using allelopathic interactions or indirectly by utilizing allelochemicals as a biopesticide.

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