Chapter

# Application of Allelopathy in Crop Production

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## Abstract

Need for food production has been increasing greatly in recent years throughout the world. The interest on the supply of quality of food has also increased, but a significant loss of crop production was observed annually, especially the main cereal crops, including rice, wheat and maize, due to the presence of weeds accompanying them in the growing season. Allelopathy has emerged as an alternative approach to solve problem agriculture that including: crop rotations, intercropping, crop residue incorporation and aqueous extracts all that used to explore allelopathy for pest management, enhancement of growth and crop production. As will allelopathic consider as weeds, insect and diseases natural control. Secondary metabolites biosynthesis of at high rates have a great role in provides defense against abiotic stresses. In plant rhizosphere allelochemicals exuded improve nutrient acquisition through the processes of solublization; biological nitrification; chelation and selected retention. In this chapter, application of the allelopathic phenomenon in crop production is discussed and his roller in managing agricultural pests and improving the productivity of agricultural systems. It was found that allelochemicals promote plant growth and production at low concentration; however it can suppress the growth if applied at high concentrations, for that can be used allelopathic compounds for weed control by used high concentrations of plant residues or aqueous extracts of plant.

**Keywords:** allelopathy, weed control, crop production, allelochemicals



## 1. Introduction

Productivity is a good indicator of the conditions suitable, since it reflects directly changes in the quality of soil. The main target of soil management for agriculture is to create favorable conditions for good crop growth, seed germination, plant development, and good harvest. Increased yield of crops associate with good field management practices through increase soil fertility, crop nutrition, weed control, insect and diseases management.

Population increasing in world is a threat to agricultural sustainability and food security for this reason we need to increase crops productive to solve multiple issues in modern agriculture by crop rotations, cover crops, intercropping, mulching, plant residue and aqueous extracts of plant pest management, stress mitigation, and growth enhancement in crop production all these can be due to allelopathic application.

Allelopathy is an important mechanism of plant by the release of plant-produced secondary metabolites or decomposition products of microbes to environment. Allelopathy plays a role main in natural ecosystems, that found many of mechanism to released allelochemicals into the soil rhizosphere that: volatilization, residues decomposition, and root exudation and leaching [1]. Allelochemicals affects is an inhibitory or stimulatory of several roles ecological of these chemicals compound, including plant defense, nutrient chelation, and regulation of soil microorganism, all that depend to concentration of that allelochemicals [2].

In more studies found that allelochemical aqueous extracts application at lower concentrations stimulates germination and growth of many crops and enhancement productivity of crop [3, 4].

Role inhibitory of allelochemicals is well explored that previously was only dimension are known from allelopathy. Directly and indirectly role for allelopathy has been used for weed management by biological control [5]. Aslam et al. [6] presented a contemporary synthesis of the existing data that how allelopathy can be exploited: (a) to biologically control of insects, and disease, (b) enhance of quality of soil by adding decomposition of crop plants residues as nutrients and improvement soil as microbes environment, (c) crop diversification increase by reducing the weeds and pests infestation, (d) to develop biological pesticides from crop plants with a novel mode of action, (e) confer abiotic stresses tolerance (**Table 1**).

Impartment of this study lies in use of allelopathic compounds as a bio stimulants for growth at low concentration, and biological control at high concentration.

Study aims to use allelopathic phenomena in:

1. Biologically control of insects, disease and **weeds**.

2. Enhance of quality of soil by adding decomposition of crop plants residues as nutrients and improvement soil as microbes environment.

3. Increased yield of crops through increase soil fertility, crop nutrition, weed control, insect and diseases management.

| Allelopathic source | Insect-pest/pathogen suppressed | Percent control | Reference |
|---|---|---|---|
| Neem (*Azadirachta indica*) | Corcyra cephalonica | 26.0 | Batish et al. [7] |
| Tomato (*Lycopersicon esculentum*) | Flower thrip (*Taeniothrips sjostedti* Trybom) | 32.0 | Batish et al. [7] |
| Hot pepper (*Capsicum unnuum*) | Pod borer (*Heliothis armigera* Hb.) | 54.0 | Batish et al. [7] |

**Table 1.**
*Insect-pests and disease control through allelopathy.*

## 2. Allelopathy phenomenon and its effect on agricultural production

Through a comprehensive review of many research carried out in the field of allelopathy, we notice that it has doubled several times, by physiologists, plant, soil, weeds and natural product chemists.

Studies mainly on allelopathy involve study extracts effect obtained from various plant parts (stem, root, seeds, and leaves) appear them be the most important source of phytotoxicity compounds in plants [8].

Studies have indicated the presence of many crops that demonstrated the allelopathic effort in other crops that accompany them in the field or track them in agriculture, through the release of allelopathic compounds into the environment through leaching and root excudates, and the decomposition of plant residues by microbiology decomposition as well as by volatilization method [9].

These compounds have inhibitory and stimulating effects on plants and micro-organisms and through their effect on many vital activities, noting that the effects of allelopathic compounds depend on their nature and concentration, as some compounds cause inhibitory effects on seed germination and growth, while other compounds cause stimulating effects.

The results of [10] showed that the plant residues of the sunflower *Helianthus annuus* L. within different growth stages (seedling, elongation, flowering, and maturity) caused a reduction in the germination and growth of wheat varieties *Triticum aestivum* L. and two varieties *Helianthus annuus* L., and that the flowering stage had a clear allelopathic effect of the tested species compared with the rest of the stages.

In another study, the two researchers indicated that adding tomato and rice residues to the soil caused inhibition of growth and some of the yield traits of varieties of wheat growing in soils added to rice residues, while tomato residues caused an increase in these traits.

In crop mixtures, amount of allelochemicals released effects by ecosystems depend on the environmental factors (temperature, water and level of soil nutrient), planting practices and crop species [11].

Continued emergence of additional information about the mechanisms of influence of allelopathic compounds in terms of selectivity, secretion, persistence, and genetic regulation mechanisms pose a constant challenge to plant scientists with the need to develop modern strategies that would enhance the protection of biological diversity [12].

### 2.1 Roles of allelopathy in plant biodiversity and sustainable agriculture

Released allelopathic compounds from plants that might be detrimental or beneficial to the growth of receptor plants. These compounds are involved in the environmental complex of managed or natural ecosystems.

Important role play that allelopathic compounds in the plant diversity determination, dominance, succession, and natural vegetation and productivity of plant in the agroecosystems. One of impartment reason decrease of crop productivity overuse of synthetic herbicide often environmental hazards, nutrient deficiency, an imbalance of soil microorganisms, and causes change in properties of soil physico-chemical [13].

Plant residues released phenolic compounds present in soil are considered to be one of the main factors to allelopathic effects for plants growing .

Advantageous of Intercropping systems are they can provide higher crop yield and diversity with fewer related to pests and weeds than monocultures, systems plant interactions in between crops and weeds and intercropped crop species are still not well understood.

Modern agriculture is dominated by intensive monocultures, which causes the loss of biodiversity and ecological functions [11]. Biodiversity of an ecosystem maintains ecological services such as nutrient cycling, tolerance to pest occurrences and disease outbreaks [14].

Diversification of Agricultural contains agricultural practices that use principles of ecological to increase the productivity and agroecosystems [15]. Number of studies on diversification of agricultural such as agroforestry and intercropping (use of two or more crop species simultaneously) that is type of sustainable agriculture [16].

Positive interactions among plants are defined as the improvement processes of plants to harsh environments and increase resource availabilities to species [17]. If selected well intercropped species can be promoted facilitative interactions [18]. The common types In intercropping systems are mixture are legumes and non-legume species combination due to the capacity of many species of family Leguminosae to biological nitrogen fixation (BNF) in the [19].

It is found that intercropping legumes the microbial communities can alter around the rhizosphere., the bacterial community structure is different in the rhizosphere of faba bean and wheat intercropping from that in wheat monoculture [20]. Microorganisms activities can change the availability of soil nutrient and benefit plants. He et al. [21] have found that rhizobial communities are changes by intercropping maize with chickpea and soybean.

Alrababah et al. [22] found that interactions between crops and trees is necessary for producing crops and conserving forests especially within the threatened Mediterranean forest ecosystems, study explored the allelopathic effects of green and senescent leaf and soil extracts of two agroforestry trees Pinus and Quercus on the germination of wheat, barley, lentil, chickpea, and fababean as the major grain crops of Jordan. Results showed reduced seed germination of all crops.

### 2.2 Allelopathy and weed management

Important role can be allelopathy plays in agro-ecosystems that leading to a wide range of influences and interactions in a biotic communities. Allelopathy can be effects on plants including microorganisms direct or indirect effect, by released of natural products in to environment [1].

Crop allelopathic properties can be make one species more persistent to a native species. Therefore, potentially of these crops may be harmful to both naturalized as well as agricultural settings. While on other side, allelopathic crops provide strong potential for the development of cultivars that are more highly weed suppressive in managed settings [23].

In agro ecosystems, weeds compete with crop plants for resources, which reduce crop yield and deteriorate their quality, The most effective method of weed suppression is biological control which is a natural process, environment-friendly, low cost, and with high public acceptance. Biological methods include the use of insects, fungus, bacteria, allelopathic crops, cover crops, and mulching. Legume crop such as velvet bean can reduce weed biomass by 68% [24].

Allelopathi is a biological phenomenon that affects neighboring plants or that is followed it in agriculture through the production of chemical compounds which is one of the main factors limiting the growth of plants, can benefit from this phenomenon in reducing the growth of the weeds using crops have Allopathic effect, the studies found many crops that possess the effect of allopathic (wheat, sunflower, sorghum, barley, corn) [25].

Use of chemical control is one of the economically costly methods in addition to causing pollution in the environment, that affecting human health and the ecosystem, the continuous use of chemical herbicides creates generations of weeds resistant to those herbicides [26] for that studies have tended to find alternatives that are less expensive and environmentally friendly, as well as not affecting the genetic makeup of weeds. That alternative is the biologic control using the allelopathic compounds released from different parts of the plant, which can inhibit and reduce the growth of some weeds [27]. Biological control of the weeds using allelopathic compounds as herbicides has been widely used as a safe, useful and less costly method.

### 2.3 Allelopathy and insect management

Allelopathy is a naturally occurring ecological phenomenon of interference among organisms that may be employed for managing weeds, insect pests and diseases in field crops. In field crops, However, according to [1] allelopathy is the influence of one plant on the growth of another one, including microorganisms, by the release of chemical compounds into the environment. These chemicals are usually secondary plant metabolites or by products of the principal metabolic pathways in plants.

Many plants have natural defense mechanism against insect pests. They utilize secondary metabolites for this purpose. Neem (*Azadirachta indica*) produces allelochemicals, azadrachtin, salannin and nimbin [28].

## 3. Allelopathy promotion plant growth

Plants Growth promotion by other plants, as well as that of microorganism by plants and other microorganisms, is discussed. Agro system in mixed culture with wheat enhances growth and yield of wheat. Soil amended with shoots of *Solanum nigrum*, enhances the soybean growth and nodulation. Growth and yield of several legumes are enhanced by mixed culture with *Heliotropium peruvianum* [29].

The use of biostimulants, which are defined as substances or materials other than nutrients and pesticides that can be used to regulate the physiological processes in plants to stimulate their growth, Biostimulants promote plant growth and development throughout the crop's life cycle, from the seed stage to mature plants, by improving metabolic efficiency, resulting in increased yield and enhanced crop quality, and facilitating nutrient assimilation, translocation, increasing nutrient use efficiency continues to be a major challenge for world agriculture [30].

Thereby increasing plant tolerance to and recovery from abiotic stresses, allelochemicals are among biostimulants.

In laboratory and field has been reported to inconsistency between plant growth-promoting rhizobacteria effectiveness "PGPR" that stimulate growth of plant and yield.

In field this inconsistency results from PGPR applications can be solved by improved knowledge of interplay between host and introduced PGPR inoculant in rhizosphere under field conditions to reduced chemical fertilizer quantity can application of biofertilizer for maintaining threshold levels of crop productivity [31].

(PGPR) may be encourage plant growth by producing growth regulators; facilitating of nutrient uptake; mineralization accelerating; plant stressreducing; nodulationstimulating, providing nitrogen fixation; mycorrhizal promoting; suppressing plant diseases; and functioning as nematicides and insecticides. There are many PGPR are fluorescent pseudomonads (*Pseudomonas fluorescens*); and other bacteriaare known as well as (Bacillus sp., Azotobacter sp., Acetobacter sp., Azospirillum sp.).

Allelochemicals released by plants have promotory effects at low concentrations [32, 33]. Previous studies have elucidated the positive role of secondary metabolites, hormones and some other natural compounds produced by plants, in plant growth promotion [34].

Allelopathic effect in nutritional and ecological relevance in the soil system.

Relationship between soil characteristics and allelochemicals at two ways
The level of phytotoxicity is affected in soil characteristic, and they are closely

linked to each other and effect on retention, transport and transformation processes of allelochemicals in soil. We need to understand the interactions involved in soil allelopathy and to create new opportunities for a sustainable control of agroecosystems.

Allelopathy has offered a new alternative for the development of eco-friendly agricultural practices, with the dual purpose of enhancing crop productivity and maintaining ecosystem stability [35]. Allelopathy involves the positive or negative effects of a plant (donor), including microorganisms, on neighboring plants (targets) through the release of chemical compounds into the environment by (leaching, volatilization, root exudation, decomposition) **Figure 1**, mostly in the soil. According to [36], it is possible to distinguish between direct plant-plant allelopathic interference (allelopathy in the narrow sense) and indirect allelopathy.

Influence of meteorological, soil and plant factors on the phytotoxicity of allelochemicals in soil [37]. Meteorological and plant factors can be effect in quantity and quality of allelochemicals released from plant (donor). When released to soil system, several of soil factors may be influence retention; transport and transformation processes of allelochemicals in soil and their presence in soil solution in order to be absorbed by other plant (target).

Allelochemicals effects on abiotic and biotic soil processes can effect in other plants. Aldrich [38] described these two kinds of allelopathy as true and functional allelopathy. Allelochemicals that released into soil can (1) effect directly on organisms, (2) can be that degraded or transformed with effect of soil microorganisms, (3) a third species may be induce to produce another compound which interferes with donor plants and (4) cause changes to soil abiotic factors that affect target plants.

It is impossible to separate direct from indirect allelopathic effects in field conditions and to assert that direct allelopathy is solely responsible for an observed phenomenon in the field, because many abiotic and biotic soil factors influence the fate of allelochemicals. Therefore, indirect allelopathic interactions, from an ecological point of view, are probably more important in plant communities than direct ones [36].

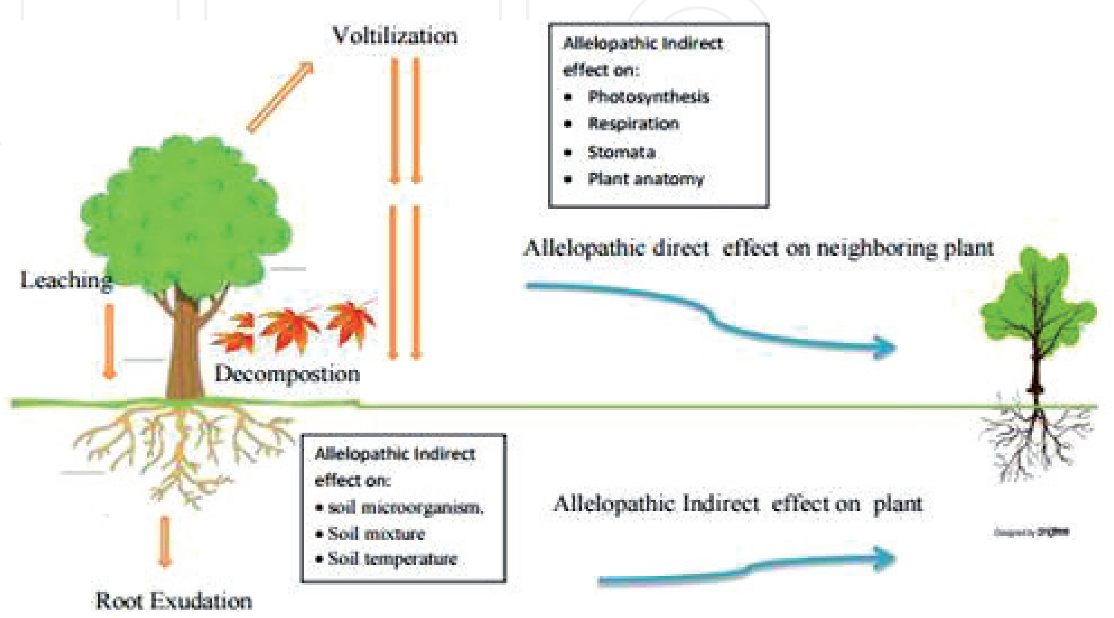


**Figure 1.**
*Methods of released allelopathic compound in to environment.*

## 4. Conclusions

Allelopathy is an important mechanism of plant interference mediated by the additional phytotoxins to the environment; chemicals with allelopathic potential are present in virtually all plants as in most tissues. Under appropriate conditions, these chemicals may be released into the environment, in sufficient quantities to affect neighboring plants allelopathy can affect many aspects of plant ecology, including growth, plant succession, the structure of plant communities, dominance, diversity, and plant productivity.

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