Role of Phenolic Compounds in Allelopathic Activity

Iman Radha Jasim¹, Hala Muzher Yaqub¹, Fatem Khaleel Ibrahim²

¹Department of Biology, College of Science, Mosul University, Mosul, Iraq.
²Department of Environmental Science, College of Environmental Science and Technology, University of Mosul, Iraq

*Corresponding Author: imsbio73@uomosul.edu.iq

Abstract:

Phenolic compounds are vital plant allelochemical groups in the ecology, multiple parts of plants contain a variety of phenolic compounds these natural compounds help plants defend themselves against predatory plants. Plants' acetic acid and shikimic metabolic pathways produce phenolic chemicals. Additionally, these compounds exhibit a wide variety of structural forms. In many commercial processes, phenolic compounds are utilized to create chemicals including insecticides, explosives, medicines, and colors. Phenolic chemicals are widely used as herbicides for crop protection in an allelopathic approach, insecticides, and fungicides. They are also employed in the bleaching stage of paper production. The major goal of this evaluation is to draw attention to the ability of phenolic chemicals to allelopathic, which can offer us solutions to a variety of ecological issues, particularly those related to the conservation of the environmentally friendly development of forests, farms, with other alternatives to current synthetic pesticides include bioactive plant secondary metabolites by releasing phytotoxic substances from plant cells.

Keywords: phenolic compound, secondary compounds, allelopathy.
INTRODUCTION:

Allelopathic interactions are caused in different crops or plants via phenolics. It is necessarily important to identify the phenolic compounds and confirm their presence and persistence in the environment throughout time in amounts sufficient to damage plant species, to show the function of phenolic in allelopathy. Any allelopathic substance needs to have its major mode of action determined. Only when a thorough biotic and abiotic variable that influences phenolic toxicity is known can the allelopathic effects of phenolic be acknowledged [1]. Due to the long-term cultivation of the same plant species on the same site, phenolic compounds are one of the main categories of phytotoxic chemicals that induce soil sickness. Decomposed plant residues are their source. A young apple orchard with replant disease was found abundant in phenolic compounds [2]. The main cause of replanting issues in managed tree ecosystems is autotoxicity.

Plant phenolic may be a significant factor in allelopathy, according to the [3] Ageratum conyzoides contain p-coumaric, gallic, ferulic, and p-hydroxybenzoic all reported to exhibit
phytotoxic properties [4]. The natural evergreen broad-leaf trees did not exhibit any effects from the high soil phenolic levels when compared to leaves, bulbs' aqueous extract and volatile chemicals were far stronger inhibitors of germination and seedling development, seedlings of tested plants' ability to germinate and thrive was hindered by the soil under the *Allium ursinum* that contained phenolic. both unbound as well as free forms of p-coumaric, ferulic, p-hydroxybenzoic, and vanillic acids found within allelopathic materials in solutions of leaves and buds. Furthermore, *Lantana camara* contains phenolic compounds with substantial allelopathic activity, including nopinene, eucalyptol, D-limonene, and triterpenoids called Lantadenes A and B [5]. These findings imply that *A. ursinum* affects the growth and germination of seeds in other herbaceous plants in the plant community by releasing volatile chemicals into the soil. Twenty-five substances were extracted and identified from the root exudates of rice, phenolic acids with the allelopathic potential of caffeic, p-coumaric, syringic, ferulic, and sinapic are some of the substances already present in oilseed radish [6, 7].

![Fig. 1: Total publications in allele chemicals since 2007 [ 8 ]](image)

**Chemical composition**

Phenolics are composed of an aromatic hydrocarbon group and a straight hydroxyl group (-OH) relates to a benzene ring to form phenolic substances a class of chemicals that are essential and naturally occurring allelochemicals of plants within the environment [9]. The pentose-phosphate route is often where phenolic chemicals are produced. In the acetic acid and shikimic process of metabolism, condensation reactions between 4-phosphate erythrose and phosphoenolpyruvic acid, and 7-phosphate altoheptulose result in the production of phenolic chemicals [10].

Web Site: https://isnra.net/index.php/kjps  E. mail: kjps@uoalkitab.edu.iq
• **Phenolic effect on agriculture**

Allelochemicals such as vanillin and p-hydroxybenzoic, p-coumaric, ferulic, and caffeic in *Bidens pilosa*, covered by bioassays. Several substances in cover plant biomass, those of a phenolic character and produced through the malonic and shikimic acid pathways for plants, have allelopathic effects by decomposing residues that have been deposited on the soil surface. Secondary compounds are released due to plants towards the atmosphere. The method differs depending on the type of plant, kind of soil, and phenological stage [11, 12]. For instance, during the breakdown of its phytomass, rye releases a few substances with an allelopathic effect [13], plants primarily create phenolic compounds for the goals of growth, development, and defense. These aromatic benzene ring molecules play an important role in the interactions between the biotic and abiotic stressors on the plant. They are an essential part of a plant's secondary metabolites and necessary for a variety of physiologic and mechanical functions.
Extracts of *Peganum harmala* leaf included Gallic acid, vanillic acid, 4-hydroxybenzoic acid, 3,4-dihydroxybenzoic acid, caffeic acid, syringic acid, and ferulic acid. In comparison to stem or root extracts, leaf extracts had a higher total phenolic acid concentration [14].

Buckwheat's ability to control weed growth is attributed to a few phenolic acids and flavonoids [15]. Additionally, tomato and maize tissues had more phenolic compounds than buckwheat extracts [16], showing analyze the primary phenolic substances with the potential to cause harm can be found in rye and oilseed radish shoots. The detrimental effects of such plants on weeds should be exploited for increasing crop production. Crop plants and natural vegetation containing phenols with detrimental effects should be screened for their capacity to suppress weeds. When describing the same species in the same experimental location [16], furthermore, it was discovered that higher levels of cinnamic acid in rye are related to lignification, the procedure that comes after plant leaching, volatilization, and dry matter degradation by soil microbes.

[17] In the phonological stage of plants, there may be interactions between bacteria, substances with an allelopathic potential, the nature of the soil, food for plants, pH, climate, and other factors. an impact on the phytotoxicity of those substances. It was also noted that the complete amount of phenols in a liquid extract of oilseed radish remains from a plant's stems and leaves was higher [18]. The main allelochemicals found in *T. procumbens* were phenolic compounds, which is similar to a recent study by [19] Vanillin was shown to be the main allelochemical in the current study's detection of phenolic acids in *Tridax procumbens*, with benzoic, ferulic, and ellagic. Vanillin, a phytotoxic substance, was also discovered in numerous other plants, including *Oryza sativa* [20].

![High performance liquid chromatography used to identify phenolic acids in T. procumbens](image-url)
Cinnamic and benzoic acids, flavonoids, and terpenes are among the most allelochemicals and are phytotoxic. Allelochemicals harm the development of companion and succeeding crops in a few agroecosystems [21].

2. Physiological and Ecological Mechanisms:

Phenolic allelochemicals have been found both in naturally occurring and controlled environments, where have been shown to create a variety of ecological including losses in crop productivity due to soil disease, failures in natural forest regeneration, and difficulties with the orchard replanting. The biosynthesis and buildup of phenolic compounds are the results of well-controlled processes. The routes for phenolic compounds have evolved throughout time in several plant families, especially when these chemicals take on specific favorable activities [22].

2.1. Impacts on the Membrane Permeability and Regulations on Plant Nutrient Uptake

Plant tissue either slowly grows or dies due to the phenolic allelochemicals effect on cell membrane permeability, prevented from taking nutrients from their environment and have an impact on their regular growth [23], demonstrated a correlation between increases in membrane permeability and decreases in phenyl-β-glucosyltransferase (PGT) activity and phenol glycosylation via Benzoic acid and cinnamic acid in cucumber (Cucumis sativus).

2.2. Impacts on the Photosynthesis and Respiration of Plants

The main effects on photosynthesis have been a decrease in the amount of chlorophyll and photosynthesis. Cucumber seedlings were raised in benzoic and cinnamic acid derivative-containing solutions in the study [24], demonstrating that intercellular CO₂ concentration stomatal conductance and leaf transpiration were all reduced. In seedlings, chlorogenic acid increased stomatal while ferulic acid decreased photosynthetic rate and stomatal, low, and intermediate chlorogenic acid concentrations reduced transpiration rate [25].

2.3. Impacts on the length, division, and structure of the cell

The ability of phenolic allelochemicals to impact the development and growth of plants by preventing the division of cells, elongation of the roots, and cell ultra-structure [26], discovered that coumarin decreased cellular activity and the quantity of Golgi bodies, increased cortex cell thickness, and slowed roots expansion of lettuce (Lactuca sativa L.) seedlings, Benzoic acid decreased the elongation of Eutrema wasabi roots after a 7-day treatment. Organelle structures were significantly harmed, and the root cells were organized erratically. Vanillic, caffeic, ferulic, coumaric, and chlorogenic acids are bioactive substances found in medicinal plants that have inhibitory activity [27]. The reaction of seedlings of Rhododendron delavayi demonstrated...
that biomass accumulation was restricted by three types of phenols—ferulic acid, chlorogenic acid, and protocatechuic acid a rise in total Chl, Chl a, and Chl b, and carotenoid concentrations were stimulated. Stomatal opening, the ratio of stomatal openings, stomatal length, and stomatal width were all considerably suppressed by low doses of ferulic acid.

2.4. Impact on the Function and Activities of Different Enzymes

Thanks to the cell membrane of a plant, phenolic allelochemicals enter and alter the function and activity of specific enzymes. At 0.1 mM, caffeine also increased reactive oxygen species (ROS) generation and significantly altered the activities of POD, which decreased rhizogenesis and inhibited root growth of mung bean. According to the findings of other investigations, ferulic acid treatment for 6 days decreased the maize (Zea mays L.) root's length and weight at the start of seedlings [21]. Additionally, there was a considerable decrease in the activity of hydrolase, maltase, phospholipase, and protease.

2.5. Impacts on Plant Endogenous Hormone Synthesis

DNA and RNA integrity may be compromised by any phenolic [29], phenolic compounds almost emerge as a mixture and not as a single component. Therefore, it is likely that no one chemical ever contributed to allelopathy in the case of phenolic substances [30].

3. Conclusions

These individual plant phenolic compounds affect several environmental species in opposing ways. It is also known that they have an impact on other plant metabolic processes. These phenolic substances take part in both the above- and below-ground defensive mechanisms of plants. They are created as root exudates and have an impact on the variety of the soil and the nearby plants. An overview of the functions of plant phenolic compounds as signaling, pigment, antibacterial, and defense agents in the plant kingdom is given in the current article.

4. References


