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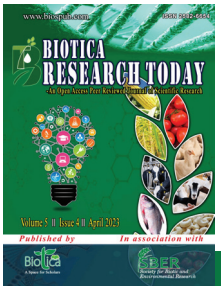

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Benzoxazinoids: A Propitious Biocontrol Agent for a Promising Future

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Abstract

Numerous plants produce benzoxazinoids, primarily DIBOA and DIMBOA or its derivatives, which primarily function as part of the plant's defense mechanisms against a variety of pests, fungi, and weeds and have the potential to supplant synthetic fungicides, weedicides, and pesticides. In general, synthetic chemicals are affordable and efficient, but only in the short run. Target organisms on which they are spread rapidly develop resistance to it. Furthermore, due to their high toxicity and lack of degradability, these synthetic compounds have long been a significant cause of environmental pollution and human diseases. Thus, to keep a green future, this brief review is focused on the various aspects of using benzoxazinoids as a biocontrol agent rather than synthetic chemicals.

Keywords: Biocontrol, Benzoxazinoids, Hydroxamic acid, Sustainable development

Introduction

Weeds, pests, and pathogens in the agroecosystem have always been viewed as a threat to its economic value, because they can colonize the habitat and interact negatively with growing crops by feeding on them, infecting them, or engaging in competitive interference in its habitat, which lowers the crop yields as well as the quality of the crops. Due to these ongoing issues, agriculture, a significant economic sector globally, endures billions of dollars in losses each year. Chemical weedicides, insecticides, and fungicides are already available and in widespread use to combat this. This does offer a temporary fix, but it cannot be sustained over the long run. Long-term usage of such chemicals only results in catastrophic environmental damage which is unintended, but still done all over the world to increase agricultural quality and yield. Scientists around the world have discovered various ways of biological control in agriculture, among them, the usage of benzoxazinoid as a biocontrol agent has been in discussion for more than 5 decades. Benzoxazinoids are cyclic hydroxamic acid compounds that are generally secondary metabolites having 2-hydroxy-2H-1,4-benzoxazine-3 (4H)-one skeleton (Figure 1). It has been discovered more than 60 years ago and since then various chemical aspects, including its role in the allelopathy, pathogen interaction, and the agricultural biocontrol have been in discussion. In plants, Benzaxoinoids are mainly present as glucosides which hydrolyze to aglycones if any tissue gets injured (Niemeyer, 2009). The usage of benzoxazinoids and their derivatives as a biocontrol agent has been widely studied and presented successfully. This concise overview outlines the molecule's chemical properties as well as its applications in agriculture and the environment.

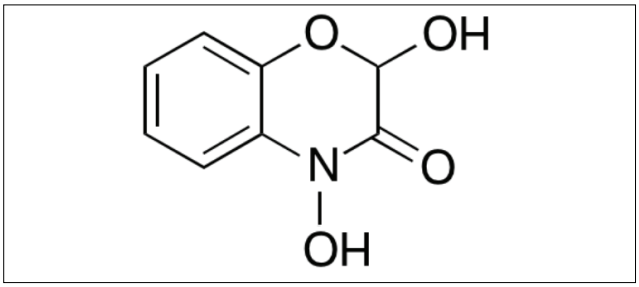

Figure 1: 2-hydroxy-2H-1,4-benzoxazine-3(4H)-ones (DIBOA)

The Molecule: Benzoxazinoids

The abundance of benzoxazinoids, which are cyclic hydroxamic acids, is highest in the Poaceae family of plants, which includes both wild and domesticated plants. There

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have also been reports of benzoxazinoids in the Acanthaceae, Ranunculaceae, Lamiaceae, and Scrophulariaceae families. Although the main study on its biosynthesis and its effectiveness was widely done on Poaceae. The biosynthesis of Benzoxazinoids occurs from precursor indole-3-glycerol phosphate, the same as that of tryptophan. The first step of synthesis occurs at the chloroplast and the rest four stages occur at the endoplasmic reticulum where Cytochrome P450 monooxygenase converts it to DIBOA which is the simplest benzoxazinoid. It then undergoes UDP-glucosyltransferase-mediated DIBOA-Glc conversion (Niemeyer, 2009). Later, DIBOA-Glc undergoes oxidation to become DIMBOA-Glc (Figure 2), another glucoside produced from Benzoxazinoid Hydroxamic acid found in plants. While DIBOA is present in Rye, DIMBOA is most frequently found in wheat and maize, while both can be found simultaneously in these species (especially wheat and maize). In plants, benzoxazinoid concentration varies on tissue ages and environmental and species-to-species factors.

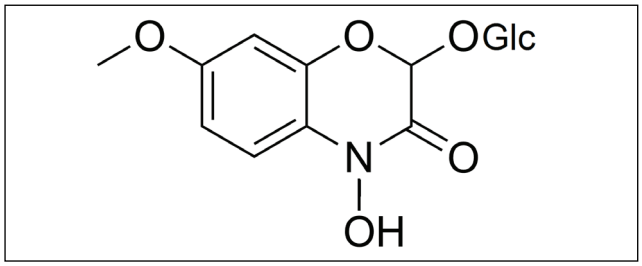


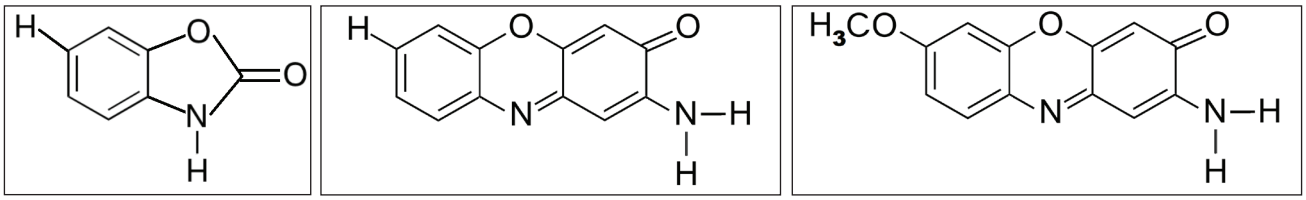
Figure 2: DIMBOA-Glc

Role as an Effective Biocontrol Agent

Since their function in allelopathy, pest control, and pathogen control has been open for debate, benzoxazinoids as a biocontrol drug have drawn a lot of interest. This covers all actions that have been mentioned repeatedly over the years. The ones that are emphasized among them are the following.

1. Role in Allelopathy

Allelopathy is primarily understood as the study of secondary metabolites produced by microbes and plants that influence the formation and growth of organisms in their surroundings. Since the discovery of its stimulatory or inhibiting effects, allelopathy has drawn a lot of attention. A wide range of impacts, including its function as a plant suppressant, has been thoroughly researched. The allelopathic impact of DIBOA on nearby weed species was observed in Rye. DIBOA's phytotoxic impact prevented the growth of that weed species. DIBOA and DIMBOA may change in contact with soil due to the wide variety of soil bacteria and fungi and other compounds present in the soil which are having a role in the ecosystem depending on their bioactivity. Some compounds which are derivatives of DIBOA are BOA, MBOA (Fomsgaard *et al.*, 2004), and APO (Gagliardo and Chilton, 1992), as well as AMPO (Etzerodt *et al.*, 2008). Additionally, this serves as a biocontrol substance for a variety of pathogenic microorganisms (Figure 3).



a) BOA b) APO c) AMPO

Figure 3: Biocontrol substances

2. Role in Pest Defense

Benzoxazinoid-rich plants have demonstrated resistance to a range of insects and their larvae, which depend on such plants for survival. It has been discovered to be useful against lepidopteran pests in a range of cereal products.

3. Role in Defense against Aphids

For the majority of crops, aphids are a prevalent issue because they harm farming areas and reduce crop yields. They can proliferate to high population levels and severely harm crops. Aphids have been discovered to be harmed by benzoxazinoids. According to numerous accounts, aphids' concentration dropped as benzoxazinoids content rose (Niemeyer, 2009).

4. Role in Disease Defense

Benzoxazinoid metabolites have been seen to perform good resistance against various fungal diseases which affect cereal crops. Later it was found that the concentration of benzoxazinoids in host plants also depends on the degree of pathogenicity of the infecting organism.

5. Role in Nematode Resistance

The incorporation of Rye as a cover crop before cotton plantation was found to be resistive against damages made by root-knot nematode *Meloidogyne incognita* (McBride *et al.*, 2000).

Ecological Perspective

The early days of chemical use were marked by various management practices. However, with the discovery of synthetic herbicides, fungicides, and pesticides by the 1930s, old methods gradually ended, and the use of synthetic chemicals increased many folds. With this increase in synthetic chemicals usage, there also an increase in various species of pathogens, weeds, and pests that were resistant to these synthetic chemicals. Eyeing the hazards these chemicals cause to the environment and human health it was evident to find out alternative ways to protect crops against weeds, pests, and pathogens. Several biocontrol methods then came into focus. One of them was the use of benzoxazinoid, which offered sustainable growth

from an economic and environmental viewpoint and was first suggested the way back in the 1960s. Additionally, benzoxazinoids are a secure biocontrol agent as it is an environment friendly with weed suppressing, pests resisting, and pathogen inhibiting potentials.

Conclusion

It has become evident that benzoxazinoids contribute significantly to plants' defense systems against a variety of organisms without harming the environment or long-term human health. But the problem still lies with its low productivity in plants which has been a major issue for extended defense action. That is, as plants get older, their percentage of benzoxazinoids begins to drop. Even juvenile plants harbor enough concentration of benzoxazinoid hydroxamic acids to impart protection against a range of organisms. Therefore, attempts are being made to raise the concentration of benzoxazinoid in plants, particularly during key developmental phases and ideally in tissues that are most vulnerable to pathogen attack. Therefore, several research organizations have thought about developing *Agrobacterium tumefaciens*-mediated transformation to increase the benzoxazinoid production in plants so that crop cultivators could switch more towards environmentally friendly biocontrol agents than unsustainable synthetic chemicals.

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