Applications of Carbohydrates on Plant Protection and Plant Growth

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Introduction

Carbohydrates are gaining popularity due to their function in plant immunity. Some act as environmental stresses of plant protection, while others function as signaling molecules in the same way that phyto-hormones do. The main kinds of carbohydrates relating to plant immunity, as well as their role and mechanism of action, are described first in this overview. More specifically, the current state of knowledge about the perception of "PAMP, MAMP, and DAMP (Pathogen-, Microbe-, and Damage-Associated Molecular Patterns) type" oligosaccharides is described, as well as examples of brought to trial reactions. The structure/activity interactions of these molecules are given special consideration [1]. Sugars' significance as signaling molecules, particularly in plant-microbe interactions, is extensively discussed. Second, the benefits and drawbacks of using carbohydrate foliar treatments to boost plant immunity the roles of the leaf cuticle and phyllo-sphere microbiota in crop disease prevention are discussed, with a focus on the roles of the leaf cuticle and phyllo-sphere microflora.

Plants have an immune system that helps them to protect themselves against bacteria, oomycetes, and fungi, among other microbes [2]. Activation of defense reactions entails the detection of microorganisms using highly conserved molecular patterns known as PAMPs (Pathogen Associated Molecular Patterns) or MAMPs (Microbe Associated Molecular Patterns) secreted by microorganisms or released from their cell wall by hydrolytic enzymes during interaction with the plant. PAMP-triggered immunity (PTI) is a protective response activated by their perception during pathogen infection. As a result, they are classified as universal elicitors, or substances capable of inducing plant defenses. These generic elicitors can also come from plant cell walls after being hydrolyzed by pathogen cell wall degrading enzymes during plant-microbe interactions, and are referred to as DAMPs (Damage-Associated Molecular Patterns) [3]. General elicitors include carbohydrates, lipids, (glyco) peptides, and (glyco) proteins, among other biochemical types. The "PAMP, MAMP, and DAMP type" carbohydrates, their recognition by plants, and the consequent defense events are discussed in this study.

Photosynthesis-produced carbohydrates are well-known in plants for their crucial roles as forms of energy and carbon skeletons for organic molecules and storage components. Furthermore, a critical role as signaling molecules, analogous to hormones, has emerged and is currently being studied extensively [4]. Sugars are thus considered actors in a complex communication system necessary for the coordination of metabolism with growth, development, and responses to environmental changes and stresses, as they interact with diurnal fluctuations, abiotic and biotic challenges, and hormone signaling. Sugars, mainly the disaccharides sucrose and trehalose, as well as oligosaccharides from the raffinose family and fructose, have a role in the production of ROS by plants in response to abiotic stressors. Enzymatic scavengers (superoxide dismutase, ascorbate peroxidase, glutathione peroxidase) and non-enzymatic metabolites (ascorbate, glutathione, and

tocopherol) are known plant antioxidants. Furthermore, because sugars have scavenging properties, there is rising evidence for their involvement as antioxidants. Sugars could thus be thought of as essential components of a cellular redox network [5]

The question is whether carbohydrates could be useful in reducing plant diseases under field environments, given their functions in plant immunity. Elicitor-induced pathogen resistance is a crop protection technique that is being studied [6]. As a result, pesticides are still widely employed to protect crops from disease, but their indirect impacts on environmental quality, human health, and the selection of resistant strains encourage researchers to explore new tactics in the context of long-term agricultural production. Various carbohydrates are now being researched and tested for their potential as resistance inducers. The limited level of penetration through the cuticle, which limits their perception and the possibility of modification and/or metabolism by phyllo-sphere microbes are two of the strategy's main hurdles [7].

Carbohydrates Involvement in Plant Protection

The smallest carbohydrates, generally referred to as sugars, are mono- and disaccharides such as glucose, sucrose, or trehalose. Oligo- and polysaccharides are naturally occurring complex carbohydrates with biological regulatory activities that are generated by chains of sugar residues interconnected by glyosidic connections. Various structural patterns for oligo- and polysaccharides, such as -glucans, chitin- and chitosan oligomers, oligogalacturonides, alginates, fucans, carrageenan, and ulvans, have been described. Beta-glucans are present in the cell walls of both plants and fungi. One of the most abundant glucans in plants is glucan cellulose [8]. Laminarin, a storage polysaccharide from the brown algae Luminaria digitate, with a degree of polymerization (DP) of 25–33 glucose units and up to three single -glucose branches at position 6 among -1,3 glucans.

After cellulose, chitin is the most common natural polysaccharide. It is a heteropolymer of 1,4-linked N-acetyl glucosamine with various percentages of deacetylate glucosamine rather than a pure photopolymer. Chitin is found in the cuticle of non-vertebrates, such as crustacean shells, insect exoskeletons, and parasitic nematodes, protists, and algae, as well as in the eggs of parasitic nematodes, protists, and algae [9]. Chitosan is a less frequent natural polysaccharide that is a deacetylate derivative of chitin generated by chitin deacetylases. It's particularly common in zygomycete cell walls. Due to the various sugar monomers and types of connections involved in the branched rhamnogalacturonans I and II domains, as well as the variable level of saponification of the homogenization domain, pectin is the most complicated plant cell wall polysaccharide. Oligogalacturonides (OGAs) are linear molecules formed by partial acid hydrolysis or the action of pectinase or pectate lysate on oligomers containing -1,4-linked galacturonosyl residues that are more or less esterified with methyl groups.

PRR receptors accept PAMPs, MAMPs, and DAMPs. Including an examination of the Arabidopsis genome, plants have a far larger number of putative PRRs than mammals. Although PRRs for chitin and OGAs have been revealed, corresponding receptors for other OS, such as -glucans, chitosan, fucan, and others, have yet to be discovered [10]. Plant PRRs are receptor-like kinases (RLKs) or receptor-like proteins with an extracellular domain for ligand recognition that are found at the plasma membrane. The most common PRR forms have leucine rich repeats or lysine motifs, but others may have a C-type lectin or an EGF-like ectodomain. LysM-RLKs and RLPs identify 1,4-linked N-acetylglucosamine units comprising glycan and amino sugars found on microbial surfaces such as fungal chitin and bacterial peptidoglycan, as well as lipochitooligosaccharides released by beneficial microbes [11].

As discussed previously, various OS can promote innate immunity and, in some cases, pathogen resistance in lab situations. This has paved the path for crop protection applications. OS are appealing candidates as resistance inducers in this context

since they are typically non-toxic, environmentally friendly, and may be extracted from renewable sources. Many field trials using OS have been conducted, but only a handful of them have yielded acceptable and repeated outcomes, which is likely why published data are still sparse. The following section of this review includes a non-exhaustive range of experimental data illustrative of OS in crop protection today. In lab analysis, the glucan laminar in was found to diminish the severity of downy mildew and grey mold in grapevine [12]. Unfortunately, vineyard testing produced uneven results, preventing this crop from being used again. Other exchanges appear to be more successful in this case. In fact, numerous sprays of laminar in on strawberries in the field reduced powdery mildew by 70%-80% and reduced leaf spot and grey mold by 50%.

However, there are no published crop protection data for OGAs alone, despite the fact that its eliciting qualities have been extensively researched. Chitosan oligomers were coupled with OGA to stabilize the latter's egg box shape, and the resulting complex was found to be an effective elicitor of defensive reactions in Arabidopsis. In greenhouse situations, repeated spray applications of this mixture triggered defenses in tomatoes, and under strong disease pressure, several spray applications provided 80% protection against cucumber powdery mildew [13]. In a vineyard experiment in Spain, the therapy was also successful against grapevine powdery mildew. Six sprays throughout the course of the growing season, each giving only 35 g/ha of OS, were used in this study to reduce disease severity from 54% in the control plots to 13% in the treated plots. Chemical oligosaccharide resistance is frequently shown to be dosage dependent. During greenhouse protection studies using sulphated laminar in against grape downy mildew, for example, the highest disease reduction rate reached 85% with 5 g. of oligosaccharide, but only 57% with 1.25 g. In field testing with this OS against powdery mildew, this dose-dependent impact was also found.

Carbohydrates are now clearly important in plant immunity. However, due of the high complex of the systems involved, their true significance in plant-microbe interactions is still unknown [14]. Exploring the potential of OS-based induced resistance as a crop protection technique is demonstrated by examples of successful applications. However, there is still a lot of variance in OS therapies. This scenario can be explained by a variety of factors, including a lack of suitable formulation or breakdown by epiphytic microbes. In contrast to pesticides that target pathogens directly, elicitor-induced resistance refers to the plant's perception of the elicitor and subsequent plant response, which is surely influenced by a variety of factors. The impact of numerous elements that can regulate plant response, such as plant developmental stage, host and pathogen genotypes, abiotic stressors, or nutrition parameters, is yet largely or completely unknown and will necessitate additional research. This should assist OS in becoming a part of disease control management, allowing it to work in tandem with other measures to reduce pesticide use [15].

REFERENCES

1. Abbott DW, Boraston AB. Structural biology of pectin degradation by enterobacteriaceae. Microbiol Mol Biol Rev. 2008;72(2):301-316.

   Google Scholar   Cross Ref

2. Akimoto C, Aoyagi H, Dicosmo F, et al. Synergistic effect of active oxygen species and alginate on chitinase production by wasabia japonica cells and its application. J Biosci Bioeng. 2000;89:131-137.

   Google Scholar   Cross Ref

3. Alghisi P, Favaron F. Pectin-degrading enzymes and plant-parasite interactions. Eur J Plant Pathol. 1995;101,:365-375.

   Google Scholar   Cross Ref

4. Allègre M, Héloir MC, Trouvelot S, et al. (2009). Are grapevine stomata involved in the elicitor-induced protection against downy mildew? Mol Plant Microbe Interact. 2009;22(8):977-986.

Google Scholar   Cross Ref

5. Barber MS, Bertram RE, Ride JP. Chitin oligosaccharides elicit lignification in wounded wheat leaves. Physiol Mol Plant Pathol. 1989;34(1):3-12.

Google Scholar   Cross Ref

6. Binet MN, Bourque S, Lebrun-Garcia A, et al. Comparison of the effects of cryptogein and oligogalacturonides on tobacco cells and evidence of different forms of desensitization induced by these elicitors. Plant Sci. 1998;137(1):33-41.   Google Scholar   Cross Ref

7. Borsato LC, Di-Piero RM, Stadnik MJ. Mechanisms of defense elicited by ulvan against uromyces appendiculatus in three bean cultivars. Trop Plant Pathol. 2010;35(5):318-322.

Google Scholar   Cross Ref

8. Cabrera JC, Boland A, Messiaen J, et al. (2008). Egg box conformation of oligogalacturonides: the time-dependent stabiliza- tion of the elicitor-active conformation increases its biological activity. Glycobiology. 2008;18(6):473-482.

Google Scholar   Cross Ref

9. Chandía NP, Matsuhiro B, Mejías E, et al. Alginic acids in Lessonia vadosa: partial hydrolysis and elicitor properties of the polymannuronic acid fraction. J. Appl. Phycol. 2004;16:127-133.

Google Scholar   Cross Ref

10. Davis KR, Darvill AG, Albersheim P. Several biotic and abiotic elicitors act synergistically in the induction of phytoalexin accumulation in soybean. Plant Mol. Biol. 1986;6(1):23-32.

Google Scholar   Cross Ref

11. Dixon RA, Jennings AC, Davies LA, et al. Elicitor-active components from French bean hypocotyls. Physiol. Mol. Plant Pathol. 1989;34(2):99-115.

Google Scholar   Cross Ref

12. Eichert T, Burkhardt J. Quantification of stomatal uptake of ionic solutes using a new model system. J. Exp. Bot. 2001;52(357):771-781.

Google Scholar   Cross Ref

13. Hadwiger LA. Multiple effects of chitosan on plant systems: solid science or hype. Plant Sci. 2013;208:42-49.

Google Scholar   Cross Ref

14. Iriti M, Faoro F. Chitosan as a MAMP, searching for a PRR. Plant Signal. Behav. 2009;4(1):66-68.

Google Scholar   Cross Ref

15. Lahaye M, Robic A. (2007). Structure and functional properties of ulvan, a polysaccharide from green seaweeds. Biomacromolecules. 2007;8(6):1765-1774.

Google Scholar   Cross Ref