Development and Validation of Safe, Effective Formulations of Elicitors Capable of Systemic Induced Resistance in Plants

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Plants are constantly fending off biotic and abiotic stress factors that significantly reduce their productivity and overall growth potential. Plant responses to these stressors are complex and involve numerous physiological, molecular, and cellular adaptations. Priming is an adaptive strategy that improves the defensive capacity of plants. This phenomenon is marked by an enhanced activation of induced defense mechanisms. Stimuli from pathogens, beneficial microbes, or arthropods, as well as chemicals and abiotic cues, can trigger the establishment of priming by acting as warning signals. Upon stimulus perception, changes may occur in the plant at the physiological, transcriptional, metabolic, and epigenetic levels. This phase is called the priming phase. Upon subsequent challenge, the plant effectively mounts a faster and/or stronger defense response that defines the post-challenge primed state and results in increased resistance and/or stress tolerance. Priming can be durable and maintained throughout the plant's life cycle and can even be transmitted to subsequent generations, therefore representing a type of plant immunological memory. Just as vaccination can prepare animals to quickly react to a disease, priming can prepare plants to react to future stress and/or pathogen challenges.

Disease and pest control in commercial agriculture is largely based on the use of fungicides, bactericides, and insecticides—chemical compounds toxic to plant invaders, causative agents, or vectors of plant diseases. However, the hazardous effect of these chemicals or their degradation to the environment and human health strongly necessitates the search for a more sustainable means of disease control. In addition, the effectiveness of chemical agents is increasingly degraded by the development of stress tolerance by the target organisms. Clearly, plants have evolved some natural ability to protect themselves from pests and disease. We can refer to this ability as the plant’s innate immune system. Elicitors are compounds which activate the plants immune system. Various biosynthetic pathways are activated in treated plants depending on the compound used. Commonly tested chemical elicitors are salicylic acid, methyl salicylate, benzothiadiazole, benzoic acid, chitosan, and so forth which affect production of phenolic compounds and activation of various defense-related enzymes in plants. Their introduction into agricultural practice could minimize the need for chemical control, thus contributing to the development of sustainable agriculture.

Our emerging understanding of plant signaling pathways associated with priming has led to the discovery of natural and synthetic elicitor compounds that induce similar defense responses in plants upon induced pathogen infection (without the negative impact of an actual pathogen infection). Different types of elicitors have been characterized, including carbohydrate polymers, lipids, glycopeptides, and glycoproteins. In plants, a complex array of defense responses is induced after detection of microorganisms via the recognition of elicitor molecules released during plant-pathogen interaction. Following elicitor perception, the activation of signal transduction pathways generally leads to the production of active oxygen species (AOS), phytoalexin biosynthesis, reinforcement of plant cell wall associated with phenyl propanoid

compounds, deposition of callose, synthesis of defense enzymes, and the accumulation of pathogenesis-related (PR) proteins, some of which possess antimicrobial properties. AOS lead to hypersensitive response (HR) in plants, which is a localized or rapid death of one or few cells at the infection site to delimit the pathogen growth. Following the activation of HR, uninfected distal parts of the plant may develop resistance to further infection, by a phenomenon known as systemic acquired resistance (SAR), which is effective against diverse pathogens, including viruses, bacteria, and fungi.

Zero Gravity Solutions, Inc. (ZGSI) has developed a platform technology to design, produce and monitor safe and effective elicitors for commercial use; thereby allowing the plant to perform at its maximum genetic potential. We have identified chemically defined non-toxic formulations that induce systemic priming in a large variety of plants. We have also identified molecular cues and biomarkers responsible for priming effects.

ZGSI elicitors have demonstrated impressive control in a number of crops infected with bacteria, fungi and viruses. Since the elicitors do not act directly on the pathogens, these results confirm the natural potential of the plant genetics, compared to commercial control agents.

The use of priming elicitors in crop protection and pest management is still in the early stages of use as a new control method, and thus the current experiences come from experimental trials, and not yet from large scale agricultural use. The following is a baseline list of advantages of using elicitor treatments have been reported or can be expected to demonstrate.

(1) Reduced damage from insects, fungi, pests, and herbivores.
(2) Reduced likelihood of resistance or stress tolerance developing (as the plant response is more complex than that of a chemical agent).
(3) Reduced environmental hazard as elicitors affect the plant directly, and their acute toxicity to other organisms is lower than that of pesticides.
(4) Compatible with organic production systems, in many cases.
(5) Able to be combined with other agrochemicals (e.g. elicitors can be applied with the current spraying technology).
(6) Elicitor treatments can be the foundation of more sustainable agricultural systems by helping the grower realize the inherent potential of the plant genetics and minimize the need for excess nutrients and agrochemicals.