Mini Review

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Reality and potential of induction of plant immunity against pathogens

Mini review

Plant immunity the ability of plants to neutralize pathogens attack through the activation of its defence systems. During the process of pathogen recognition by plant's cell, a complex cascade of biological processes work in synergism to synthesize the pathogenesis-related proteins and activate the oxidative burst systems.[1] The oxidative burst serves as direct defence mechanism via oxidation of the essential molecules of the pathogen, stimulation of cross-linking between cell wall components, and programmed cell death termed, which is termed hypersensitive response.[2] Death of cell releases its content into the vacuole and reduce the attack so that the neighboring would cells survive.

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Atef MK Nassar
Department of Plant Protection, Damanhour University, Egypt

Correspondence: Atef MK Nassar, Department of Plant Protection, Damanhour University Damanhour, Egypt, Email atef.nassar@dmu.edu.eg

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Activation of those systems could be either systemic or induced (systemic acquired resistance (SAR) or induced systemic resistance (ISR)). SAR can be induced by treatment with an assortment of agents, including necrotizing pathogens and chemicals (e.g. acibenzolar-S-methyl (ASM)), and is mediated by a salicylic acid (SA)-signaling pathway. On the other hand, ISR develops as a result of colonization of plant roots by plant growth-promoting rhizobacteria (PGPR) and is mediated by a jasmonate (JA)- and ethylene (ET)-sensitive pathway.[3]

Induction of plants' immunity could be achieved through treating plants with many agents, including cell wall fragments, plant extracts and synthetic chemicals, which induce resistance to subsequent pathogen attack both locally and systemically.[4] The chemical resistance activators include probenazole and its active metabolite 1,2-benzisothiazole-1,1-dioxide,[5] ASM (Bion and Actigard (Syngenta)), Milsana (*Reynoutria sacalinensis* extract; KHH BioScience), Elexa (chitosan; SafeScience) and Messenger (harpin protein; Plant Health Care). Saccharin, a metabolite of probenazole, induced SAR in rice against *Magnaporthe grisea* and *Xanthomonas oryzae*[6] and *Rhynchosporium commune* on barley.[7]

β-Aminobutyric acid (BABA) induces resistance against many plant pathogens on a wide range of crops.[8] Phosphite is being used to induce putative processes for the management of Phytophthora diseases.[9] Biochar is one of the products of the pyrolysis (the direct thermal decomposition) of biomass in the absence of oxygen[10] has been reported to improve crop performance by increasing nutrient retention,[11] promoting mycorrhizal fungi in the soil,[12] and modifying soil microbial populations and functions.[13] Application of biochar to soil induced systemic resistance to grey mould (*Botrytis cinerea*) on pepper, powdery mildew (*Leveillula taurica*) on tomato, and the broad mite pest (*Polyphagotarsonemus latus*) on pepper.[14] Broad-spectrum control of *Botrytis cinerea, Colletotrichum acutatum* and *Podosphaera aphanis* was noticed on strawberry plants grown in 1 or 3% biochar-amended potting mixture.[15]

Arbuscular mycorrhizal (AM) protected tomato plants against the necrotrophic fungus *Alternaria solani*.[16] Plant growth-promoting rhizobacteria (PGPR), root-associated bacteria in the rhizosphere of many plant species, increased plant growth and suppressed plant diseases by secretion of antibiotics and some PGPR elicited the ISR against a broad range of pathogens.[17] *Penicillium simplicissimum*, a plant growth-promoting fungus that was isolated from the rhizosphere of zoysiagrass (*Zoysia tenuifolia*), has been shown to induce ISR responses in cucumber.[18] *Trichoderma harzianum* T39 primed resistance against downy mildew in grapevine,[19] while *Trichoderma asperellum* SKT-1 induced resistance in Arabidopsis against the bacterial pathogen *Pseudomonas syringae* in tomato through the SA-based signaling pathway.[20] For the priming mechanism to be activated with *B. cinerea*, infection of plants pre-treated with Trichoderma lead to enhanced activation of JA-responsive genes, which boosted a systemic resistance in the plant in a genotype-dependent manner.[21]

Moreover, marine green algae provided numerous elicitors, including β-1,3-glucans (laminarin), β-1,3-sulphated fucans, carrageenans and ulvans.[22] Crude Ulva extracts protected *Medicago truncatula* plants against *Colletotrichum trifolii,*[23] and *Phaseolus vulgaris* against *Colletotrichum lindemuthianum*.[24] Also, ulvans and oligoulvans stimulated the defence responses and activated SAR in tomato against the vascular wilt pathogen *Fusarium oxysporum* f.sp. *lycopersici*.

However, stimulation of induced and/or systemic resistance might activate the plant defences, which enable cells to fight pathogens. Less information is available on the factors that control the ability of induced cells to accumulate the required level of resistance i.e., genotype. Additionally, information about incorporation of induced resistance materials/agents in crop protection programs (IPM) is rare. Therefore, studies on the employment of these factors within IPM programs must be conducted along with the study of effects of pesticides application on those materials/agents. In addition to, the specific mechanism of induction within cells should be investigated on molecular and genetic levels.

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Conflict of interest

The author declares no conflict of interest.

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