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Intricacies of Programmed Cell Death in Plants

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Abstract

The homeostasis in plant cells disrupt during their interaction with phytopathogens which often caused cellular death in case of both resistance and susceptible reactions. The mechanism underlying beneath this process is not clearly deciphered as it is a complex process. However, it has been an established fact that host plants respond in form of programmed cell death (PCD) to their pathogens through the expression of various genes which also involve signal transduction. In this article, we have some of the basic fundamentals of PCD in host plant against different types of pathogens which would help in understanding the process of plant response which in turn will help in developing strategies for tackling plant diseases.

Keywords: Homeostasis, Phytopathogens, Hypersensitive response, Avirulence, SAR

Introduction

The plants possess defence mechanisms against phytopathogens that are majorly divided into two classes *i.e.* constitutive defence mechanisms which exist even before the attack of the phytopathogen and induced defence mechanisms which activate after the attack of the phytopathogen. In recent times, induced defence mechanisms of the plants became a topic of interest of the researchers as to manipulate them in natural conditions thus making plant capable of withstanding the biotic stresses. There are two types of phytopathogen mainly biotrophic and necrotrophic which attack plants. The biotrophic phytopathogen does not elicit a vigorous defence response as their mode of nutrition depends on the living plant host. The plant, however, recognizes this phytopathogen and induce rapid localized cell death in order to stop the flow of nutrients to them and ultimately leading to their death. Thus, the localized death of plant cells is an important mechanism to stop the colonization of biotrophic

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phytopathogens. Programmed cell death is a basic process which occurs in the organisms that function in an array of aspects of development and stress responses. Programmed cell death (PCD) is a tightly regulated process of a few localized cell death in response to various stimuli which in turn confers survival benefits. It is also known as "Apoptosis", which is of Greek origin and means "falling off" (Gilchrist, 1998).

Types of PCDs in Plants

Hypersensitive Response (HR): It is often regarded as the quick demise of the cells around the point of invasion of the phytopathogen(s) through the intermediates of reactive oxygen species (ROS) and ion fluxes, which makes it impossible for the phytopathogen to survive and thus leading to a susceptible reaction for the plants. Apart from this, HR also induces signalling cascades which in turn leads to immunity of the neighbouring cells in addition to the priming of distal cells for biotic challenges.

Senescence: Senescence in plant is defined as the irrevocable process in which the cellular processes get arrested through various mechanisms consisting of shortening of telomere, genotoxic stress, inflammatory cytokines, etc. This leads to culmination of p53 tumour suppressors and/or p16, a cyclin-dependent kinase inhibitor. It is a key cellular process which can be induced and plays a vital role in permanently restricting the propagation of damaged and defective cells.

Plant's resistant response and cell death

When plants are invaded by the phytopathogens, they produce a rapid defence response and very efficiently restrict the growth and development of phytopathogens. Such type of interaction between the plants and its phytopathogen is known as resistant reaction or resistance. This reaction is explained by "Gene-for-Gene Hypothesis" which proposes that the phytopathogen harbours a gene called as avirulence (avr) gene whose product is recognized by the product of a specific gene harbored by the plant known as resistance (R) gene. In the absence of any of these genes in either plant or the phytopathogen leads to a susceptible reaction or susceptibility. The immunity of plant against biotrophic phytopathogen depends on the factor that plant recognize phytopathogen as early as possible and induce a hypersensitive response. The most characterized form of resistance responses against the biotrophic phytopathogens is expeditious and restricted death of infected cells and

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neighbouring cells, respectively. The HR response in plants against one phytopathogen develops immunity to many other phytopathogens to which they are not previously exposed. The immunity gained by plants through this is known as systemic acquired resistance (SAR) and it essentially requires salicylic acid-mediated signal transduction (Mukhtar et al., 2016).

Induction of defence mechanisms and cell death

As the systemic acquired resistance occurs at or after the hypersensitive reaction and on some occasions after a susceptible interaction involving cell death, we can probably say that SAR and cell death are related to each other. However, cell death in plants as due to wounding, freezing, or leaf spot caused by phytopathogen do not elicit SAR. Thus, the relationship between SAR and cell death may naturally be that the latter would occur at the same period as SAR development. The possible situation can be that when a resistive response is elicited, it induces numerous pathways in the plants, of which some are involved in cell death while some are responsible for SAR. So, it can be also said that a single event in the infected leaf may lead to the development of SAR at peripheral ends and also concurrently in a signal that leads to generation of localized cell death (Greenberg, 1997; Greenberg and Nao, 2004).

Conclusion

The death of cells in plants is a response to diverse phytopathogens and is seem to impart various other defence responses, leading to a resistant reaction. The phytopathogen recognition as per the gene-for-gene hypothesis is one of the mechanisms which leads to the triggering of programmed cell death. It is also very likely that numerous other factors may manipulate the pattern of cell death as induction due to abiotic stresses does not lead to systemic acquired resistance development in plants. The emerging interest in plant-phytopathogen interactions may lead to getting new insights about the process and how it can be utilized in the protection of plants against the attack of various phytopathogens.

References

Gilchrist, D. G. (1998). Programmed cell death in plant disease: the purpose and promise of cellular suicide. Annual Review of Phytopathology, 36(1), 393-414.

Greenberg, J. T. (1997). Programmed cell death in plant-pathogeninteractions. Annual Review of Plant Biology, 48(1), 525-545.

Greenberg, J. T., and Yao, N. (2004). The role and regulation of programmed cell death in plant–pathogen interactions. Cellular Microbiology, 6(3), 201-211.

Mukhtar, M. S., McCormack, M. E., Argueso, C. T., and Pajerowska-Mukhtar, K. M. (2016). Pathogen tactics to manipulate plant cell death. Current Biology, 26(13), R608-R619.