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Multifunctional Bacterial Proteins: Harpins

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SUMMARY

Plant pathogenic bacteria have their own set of weapons to attack plants and cause diseases. They produce some chemical compounds to breach and colonise their host. Secretion systems in bacteria are important tools in the process of pathogenesis, harpins proteins being a part of these secretions systems plays an eminent role in the virulence of bacteria. Harpin proteins are known to have multiple functions in plant bacterial interactions. They have also been reported to be beneficial to plants by inducing defense response in plants and are utilised commercially for inducing plant defense and also for promoting plant growth.

INTRODUCTION

Gram negative bacterial plant pathogens have various weapons to invade plant cells and cause disease in plants, Harpin proteins forms an important part of that armament. Plant pathogenic bacteria have a well build system of secretary proteins and the secretion system which is considered to be responsible for pathogenecity is Type III secretion system (T3SS). Type III secretion system codes for hypersensitive response and pathogenecity genes (hrp genes) (Tampakaki *et al*. 2010). There are nine hrp genes that are highly conserved among pathogenic bacteria, named as hrp-conserved (hrc) genes. The Hrp and Hrc proteins together form the Type III secretion system (Jin and He 2001; Li *et al.* 2002). The Hrp genes encodes two types of protein: effector proteins and extracellular accessory proteins including harpins which are responsible for suppressing plant immunity and thus enabling a pathogen to cause disease in plants.

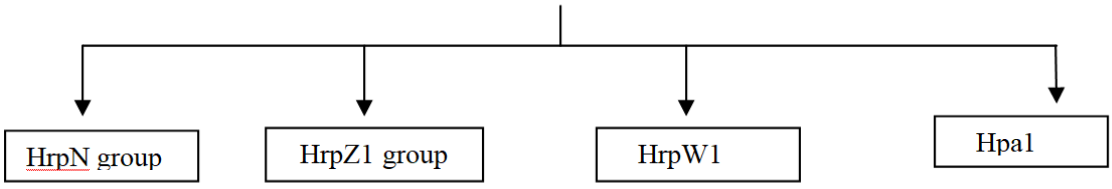
What are Harpin proteins?

Harpins are glycine-rich and heat-stable proteins that are secreted through type III secretion system in gram-negative plant-pathogenic bacteria. They are known to play multiple roles in plant bacterial interactions. They play role in virulence, are involved in translocation of effectors proteins into host cell cytoplasm and are also responsible for inducing defence response in plants against pathogen. Many studies have shown that these proteins are mostly targeted to the extracellular space of plant tissues, unlike bacterial effector proteins that act inside the plant cells. The first harpin of pathogen origin, HrpN of *Erwinia amylovora*, was reported in 1992 as a cell-free elicitor of hypersensitive response (HR). Since then, there has been significant progress to elucidate the mechanism of their virulence functions as translocators or helper proteins of effector proteins at the host plasma membranes.

Table 1: Examples of harpins of different bacterial pathogens

Harpins	Bacterial pathogens
HrpN and HrpW	*Erwinia amylovora*
HrpZ1, HrpW1, HopP1, and HopAK1	*Ralstonia solanacearum*
Hpa1	*Xanthomonas oryzae* pv. *oryzae.*
HpaG	*X. axonopodis* pv. *glycines*
XopA	*X. campestris* pv. *vesicatoria*
HopP1	*Pseudomonas syringae* pv. *tomato*

Harpins can be categorized into four major groups based on their protein similarity and domain structures



General features of Harpin protein

- They carry a relatively high amount of glycine and serine residues.
- They have several regions of α-helices.
- They are acidic in nature, based on their theoretical isoelectric points (except HopAK1 and HpaXm).
- The sizes of harpins from Xanthomonas spp. are comparatively smaller than those from Erwinia and Pseudomonas spp.
- They are heat stable, due to the absence of tertiary structures stabilized by cysteine.

Functions of Harpin proteins

- Harpins act as translocators for effectors into the plant cell:There is significant evidence that harpins act as translocators, facilitating the injection of bacterial effector proteins into plant cells. DspA/E is a critical effector of *E. amylovora* for disease development, and its translocation into host cells is governed by hrpN of *E. amylovora*.
- Harpins are virulence factors of bacterial pathogens: Harpin genes are controlled by Hrp regulatory proteins, and they are functional during infection of plants. HrpN gene in *Dickeya dadantii* plays important role in its virulence to infect African violet leaves.
- Harpins as elicitors have the ability to induce hypersensitive response (HR) and cell death in plant tissues: Various studies on HR elicitation with different harpins revealed that certain regions of harpins are sufficient for HR elicitation. HrpZ1 induces HR-related genes such as Hin1 and activates protein kinases such as AtMPK6 in Arabidopsis and its ortholog.
- They are reported to induce defense responses in plant without hypersensitive response: Foliar application of HrpN in tomato minimised disease caused by *Phytophthora infestans* and *Botrytis cinerea*. Spray treatment with HrpN of *E. amylovora* in Arabidopsis induced expression of the pathogenesis-related (PR) 1 gene and activated systemic acquired resistance.
- Spray treatment of harpins in plants have also shown to stimulate plant growth: Spray treatment of seedlings or soaking the seed of Arabidopsis in solution containing *E. amylovora* HrpN enhanced seedling growth.

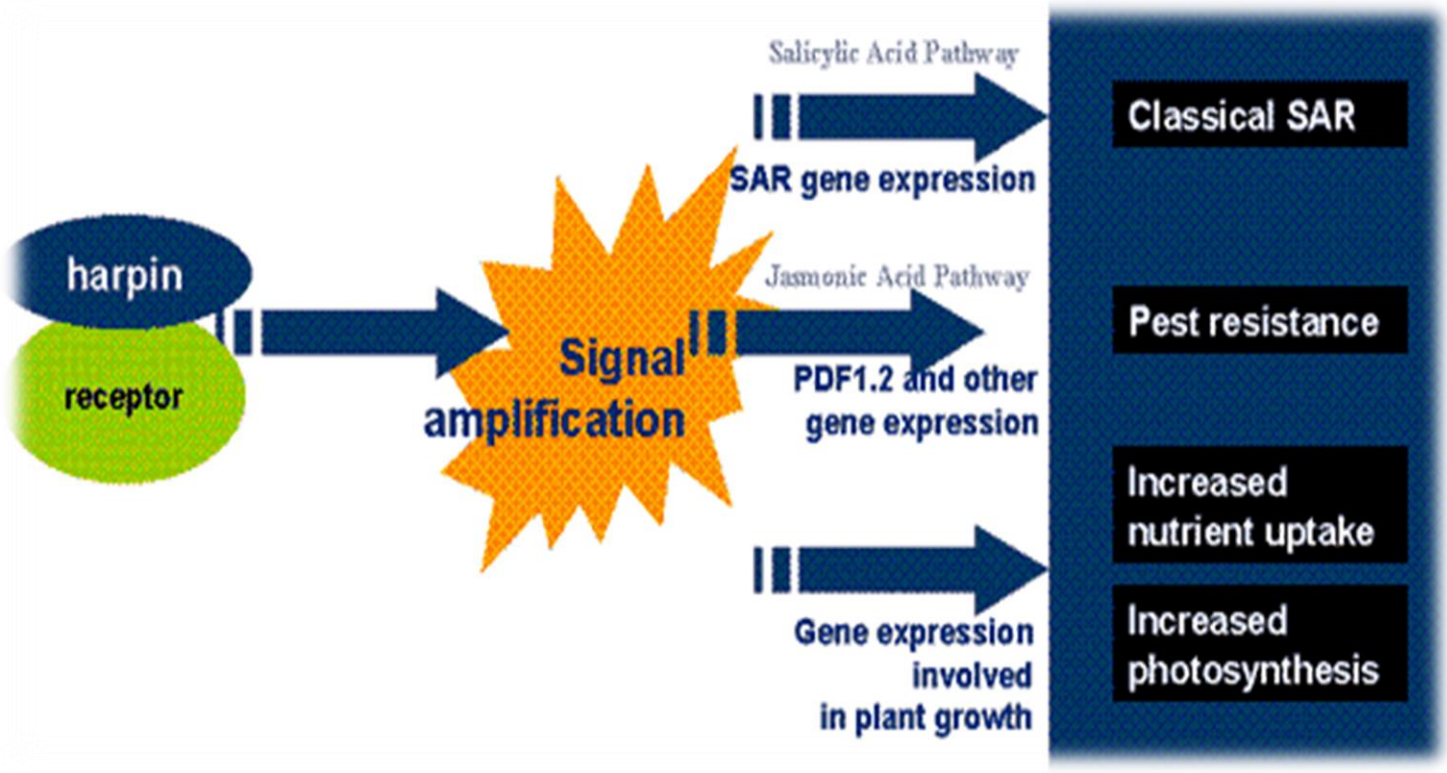


Figure: Role of Harpins in inducing defense in plant

CONCLUSION

Harpins play a vital role in plant-bacterial interaction, and are known to have numerous functions. They not only aid bacterial pathogens to cause disease but also act as elicitors to induce hypersensitive response in plants. Their beneficial traits can be greatly utilised to minimise the disease incidence of bacterial pathogens. They also play a role in promoting plant growth; therefore, some of the commercial formulations of harpins have been released in the market for use. It is rightly said that the solution of the problem lies in the problem itself, as in case of bacterial pathogens, their adverse effect on plants can be minimised by harpins produced by them.

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