AgriCos e-Newsletter
ISSN: 2582-7049
Volume: 02 Issue: 08 August 2021 Article No: 01

Plant to Plant Communication and Self-Defence against Insect Pest

Dharmendra Singh Lagoriya[1] and Sangeeta Bhandari[2]

[1]PhD Research Scholar, Department of Agricultural Biotechnology, Assam Agricultural University, Jorhat-13, Assam

[2]Project Fellow, Agro-Technology and Rural Development Division, CSIR-Northeast Institute of Science, and Technology, Jorhat-06, Assam

SUMMARY

Plants have developed a multitude of defence responses to ward-off from herbivory insects. Plants act actively against herbivory in both damaged and non-damaged tissues. The plant-to-plant communication allows specific neighbors to warned of likely incoming stress (defence priming). Defence priming employs signals, cues and elicitors that can either be secondary metabolite or volatile organic compounds (VOCs) or any Damage Associated Molecular Pattern (DAPM). Compared to naive plants, systemin-primed plants are significantly more resistant to herbivorous pests as well as primed plants attract more parasitoids and showed an increased response to wounding. These systemine like small peptides play an important role in intraspecific plant-to-plant communication and considered fundamental signal molecules in many plant processes.

INTRODUCTION

Plants cannot run away from danger as most animals can, so they have developed their own weapons and armour in order to protect themselves. As we all known that the plants are also alive and they perform activities like other animals. They grow, eat, move, reproduce and respire. They execute all the living being activites lited below. Let me introduce to you MRS-GREN.

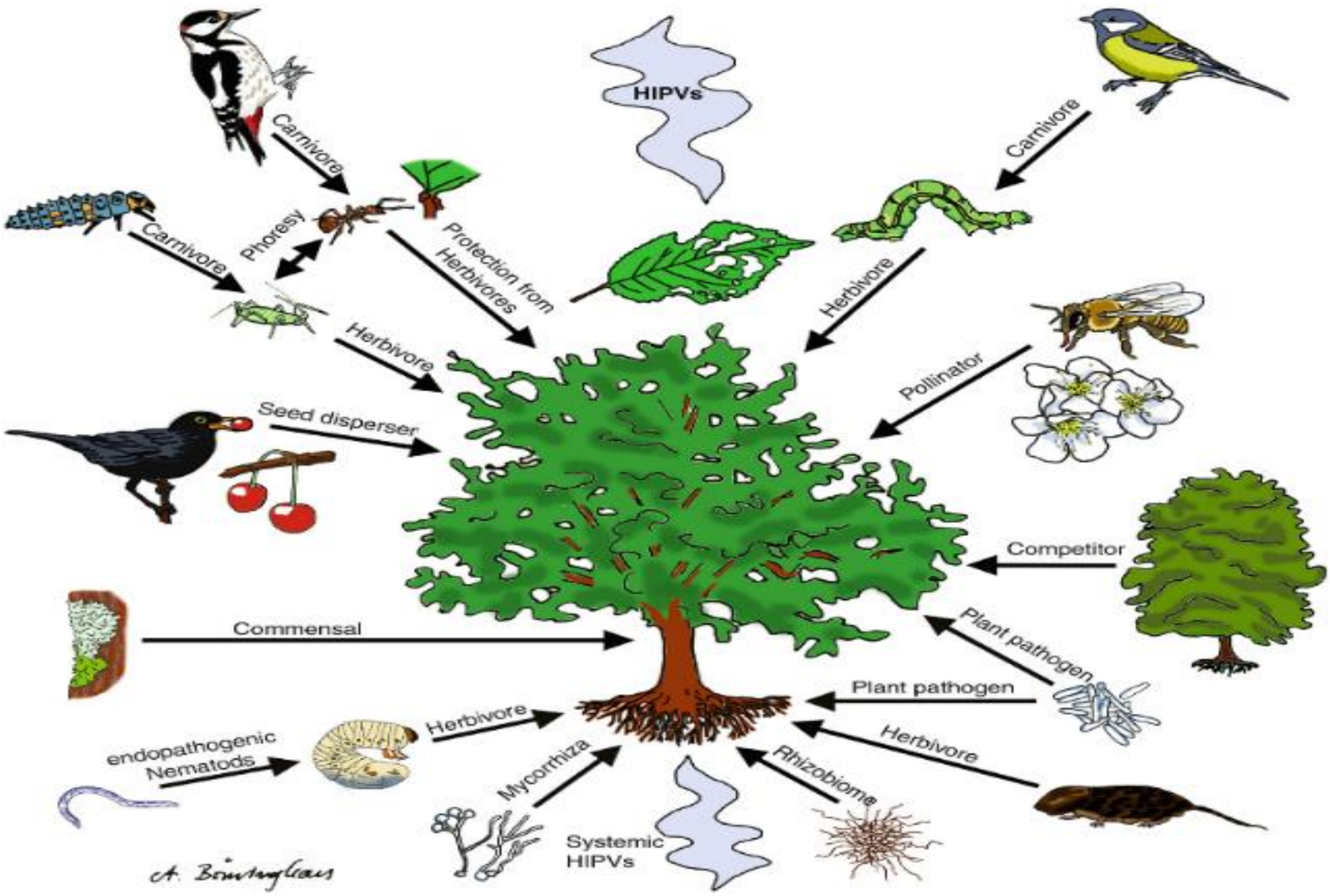
MRS-GREN; It is just a combined word from the different properties of plants that make them alive.

Let discuss them one by one.

- **M-Movement- Do plants have movement?**
  Yes! The plant does have movement. They move their leave, branches even the well know and interesting phenomena of seeds germination and flower opening provides a better understanding of their movements.
- **R-Respiration- Do plants respire?**
  Yes! The process of respiration in plants involves using the sugars produced during photosynthesis plus oxygen to produce energy for plant growth. In many ways, respiration is the opposite of photosynthesis.
- **S-Sensitivity- Do plants have sensitivity?**
  Yes! The plant can sense and respond. They can detect and respond to light, gravity, changes in temperature, chemicals and even touch. The plant usually responds to change by gradually altering its growth rate. Their response and movement are slow because they do not possess nerves and muscles like animals.
- **G-Growth- Do plants have growth?**
  Yes! Plants continue to grow and develop throughout their life. They grow through a combination of cell growth and cell division. The plant possesses meristem cells; an undifferentiated cell that can divide and differentiate continuously until the plant live.
- **R-Reproduction- Plants reproduce and produce offspring.**
  Reproduction in plants is very important to people and animals because, by the process of reproduction, they multiply themselves. In-plants reproduction, insects and other pollinators play an extensive role.
- **E-Excretion- Plants excrete their waste.**
  Plants emit their waste products such as CO_2, H_2O and O_2, while water and gaseous waste products release through stomata and lenticels. Many plants store waste in the form of resin and gum. Most of the waste materials excreted from plants are valuable and essential for humans and animals.
- **N-Nutrition- Nutation in Plants**
  Food is essential for all living organisms. The plant can synthesis food for themselves but animals including humans cannot; that's why plants are known as autotrophs. The synthesis of food by photosynthesis occurs in leaves. For the raw material, plants depend on environmental components such as water, minerals from soil and sunlight from the sun. All these properties indicate that plant possesses properties of living being and as alive they interact with the living and non-living components of the environment.

Plants and their surroundings

Plant and the other environmental components are interconnected to each other. Plants response to the environment includes phototropism- growth toward the light, geotropism- toward gravity, thigmotropism- toward touch and hydrotropism - toward the source of water. Plants are necessary for ecosystems. They are food for many animals. Plants use water from the soil, carbon dioxide from the air, and energy from sunlight to make their food. Plants give off oxygen when they make food. Animals need oxygen to breathe, and they give off carbon dioxide. Can you see how plants and animals need each other? Animals and plants depend on each other for other things too. Birds, lizards, and insects build their homes in trees. Deer and small animals sleep and hide in thick brushes. Some plants need animals to spread their seeds.

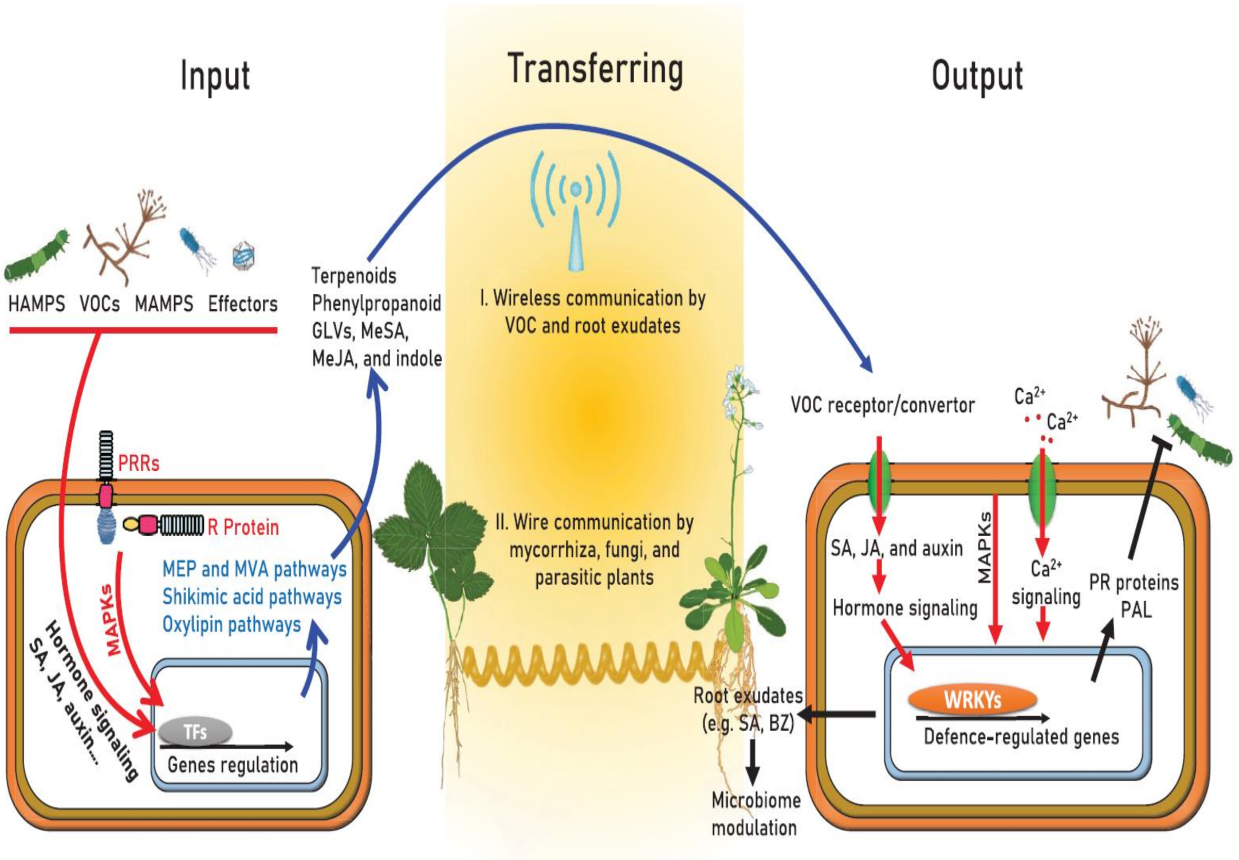


Plant communication with its surrounding Ref. (Schaefer and Rolshausen, 2006).

Plant communication with the living components of the environment

To connect and communicate with the different environmental components plant use signals through its wireless and wired network. The system of wirless and wired communication first hypothesized by Sharifi and Ryu, (2020). Wired communication includes the microbial and plants organ to create the network for the transfer of data from one plant to other plants. This channel are often considered as the pathway of direct communication between and within the plants. Wireless communication involves signal transfer across the space separating two plants just like the signals of wifi. The flow of data between the plant and within the plant involve maily three step such as

- Input signal (extracellular signal perception generates an endogenous signal cascade)
- Transfer of signal (direct connection from signal producer to receiver through mycorrhizal network and parasitic plants, and indirect signal translocation via plant volatile compounds and exudates)
- Output signal (receiver plant responses to biotic and abiotic stresses)



Model of plant-plant communication using signal input-output transfer. Ref. (Sharifi and Ryu, 2020).

Plant communication

Plants can produce diversified secondary metabolites (Schoonhoven, *et al*., 2005). Some of which are released into the air during an attack or egg deposition by herbivores (Dicke *et al*., 2009). These herbivore-induced plant volatiles (HIPVs) mainly comprise terpenoids, fatty acid derivatives, phenylpropanoids and benzenoids that can be emitted either at the site of damage or systemically from undamaged parts of affected plants (Mumm *et al*., 2010). The blends of VOCs (Volatile Organing Compounds) can be complex, comprising hundreds of compounds, some of which are produce by intact or mechanically damaged plants and others of which are synthesized de novo in response to herbivore attack. Signal and cues play a role in the transfer of these compounds and other information of warning conditions within and between the plants.

Signal and cues

Plants convey their information from one plant to another plant using a signalling pathway. Signalling pathways involves the transfer of information within and between plant cells from receptor systems to effectors. Signals can take many forms, including chemical and electrical. Transfer of signals can occur locally within a plant or between different plants, including plants of different species, when they are being attacked or eaten. The response is so fast that within seconds of the attack, the signal has already reached the other leaves, thereby prompting them to begin anticipatory defence responses. Plants perceive their neighbours through different kinds of cues that indicate their proximity, such as light quality, root chemicals, acoustic cues, mechanical stimuli, and airborne volatile organic compounds (VOCs). Cues benefit the receiver exclusively, with the receiver evolving to respond to their presence, much like a predator responds to the rustling sounds of unseen prey. For example, plants use cues, like airborne VOCs, emitted from other plants to upregulate their own defences. Some plants have evolved mechanisms to detect nanomolar concentrations of bacterial quorum sensing compounds produced by pathogenic and symbiotic partners (Hartmann *et al*., 2014). A long-standing hypothesis suggests that cues are precursors to signals (Lehmann *et al*., 2014)

Elicitors

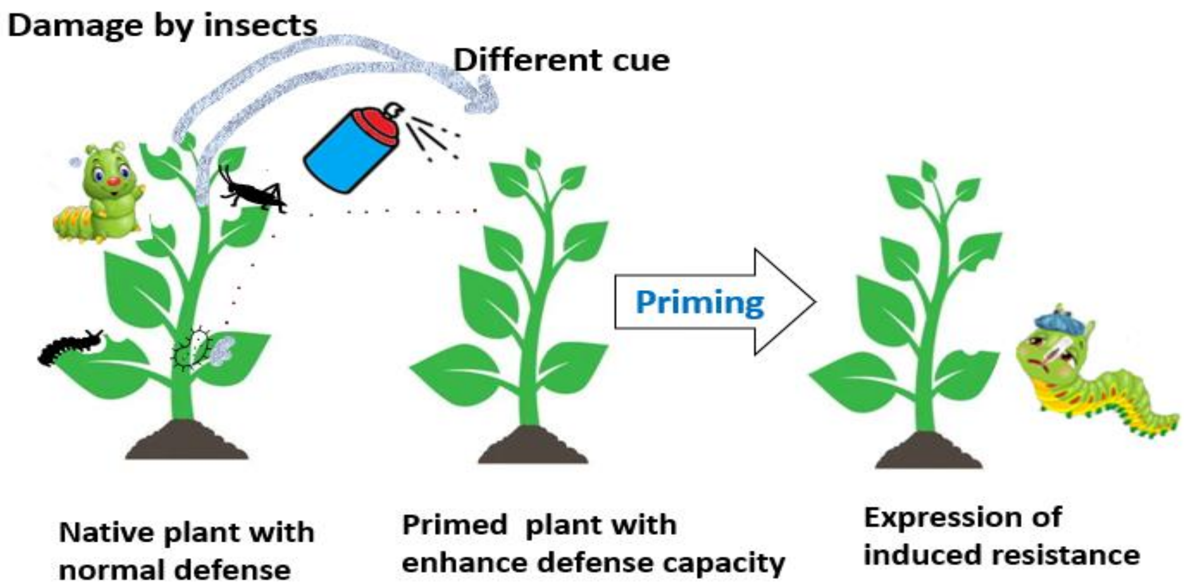
Elicitors are molecules that stimulate several defence responses in plants. Commonly tested chemical elicitors are salicylic acid, methyl salicylate, benzothiadiazole, benzoic acid, chitosan, then forth which affect the assembly of phenolic compounds and activation of a variety of defence-related enzymes in plants. The simplest types of elicitors are plant intracellular products that passively leak into the extracellular space through cellular damage caused by herbivory. Cells contain millimolar levels of ATP which, when released to the apoplast are recognized by undamaged cells via the ATP receptors DORN1/P2K1 (Choi *et al.*, 2014). The characterization of elicitors and plant defence signalling pathways now offers many tools for the development of agrochemicals with plant protection properties and these have been called 'the future of agriculture. Among candidate molecules, elicitors could easily be modified and developed into potent classes of synthetic potentiators of plant defence.

Role of hormone in communication and defence

Upon attack by a necrotrophic pathogen or herbivorous insect; pathogen- or herbivore-derived pathogen-associated molecular patterns (PAMPs) and damage-associated molecular patterns (DAMPs) are recognized, leading to activation of jasmonic acid (JA)-dependent defence responses. Upon attack by a (hemi-) biotrophic pathogen, its PAMPs are recognized, resulting in activation of salicylic acid (SA)-dependent defence responses are activated. These SA- and JA-dependent defence signalling pathways antagonize one another. The induced defence mechanisms have positive effects on the plant's fitness by enhancing resistance through direct activation and priming of defence indirectly recruits some of the beneficial microorganisms. Allocation costs are incurred during activation of the plant's defence mechanisms because valuable resources are used for defence rather than for growth and reproduction. Allocation costs during direct activation of defences are considerably higher than during priming of defences.

Priming mediated defence mechanism:

Priming is a physiological process in which exposure to a stimulus influences the response to a given stimulus, without conscious guidance. It helps unstress plants to be prepared for potential future challenges. (Pastor *et al*., 2014). Priming may be triggered by different cues such as pathogens, insect pests, and molecules of microbial origin, synthetic substances, and abiotic stress. The molecular mechanisms of priming are diverse and involve chromatin modification for faster activation of defence genes and epigenetic memory (Conrath *et al*., 2015). Many studies on priming anti-herbivory defence have primarily focused on Herbivore Induced Plant Volatile (HIPVs), since they are also associated with intra-plant, co-specific and interspecific plant communication (Conrath, 2009).



Priming mediated self-defence mechanism in plants. Ref. (Cornath *et al*., 2006)

Role of Systemin in self-defence

Upon wounding or damage there are many signals release soon after the epidermal damage that plays an important role in the detection of wounding and other early responses. Until 1991 the nature of systematic wound signals was obscure. The mystery of wounding signals become understandable after the identification role of systemin by Pearce *et al* (1991) in the tomato leaves. A small, 18 amino acid peptide systemin enhances transmission of signals from locally damaged leaves to undamaged distal leaves of the plant belonging to the Solanaceae family. Wounding initiates the induction of early signals and the interaction of systemin with its receptor regulates a complex cascade of intracellular events that are all orchestrated to activate PLA2 to release linolenic acid from membranes. That activates the plant self defence system in response to the herbivory attack.

CONCLUSION

Plants express induced systemic resistance to herbivores and pathogens. They can anticipate future enemy attacks by perceiving cues or signals released from damaged neighbours plants. Plants perceive priming signals as a reliable cue to enhance their defences responses and mediated downstream signaling. It will consequently evoke a defence response in surrounding undamaged plants. These signals and causes can be a chemical compound, electoral signal, or herbivory induces plant volatiles (HIPVs). There are different receptor present on the cell that helps them to recognized different types of elicitors. These elicitors help induction of priming undamaged plants. Systemin mediated defence priming have reported in the solanaceous family. The primed plant shows a higher level of defence that were observed transcriptional differences in primed plants provide details about the primed mediated defence response to wound with a significant increase of direct and indirect defence against herbivory. The observed enhancement of plant defence by the priming may allow more efficient use of systemin for the development of pest control strategies based on the manipulation of plant physiology.

REFERENCES

Choi, J., Tanaka, K., Cao, Y., Qi, Y., Qiu, J., Liang, Y., & Stacey, G. (2014). Identification of a plant receptor for extracellular ATP. Science, 343(6168), 290-294.

Conrath, U. (2009). Priming of induced plant defense responses. Advances in botanical research, 51, 361-395.

Conrath, U., Beckers, G. J., Langenbach, C. J., & Jaskiewicz, M. R. (2015). Priming for enhanced defense. Annual review of phytopathology, 53, 97-119.

Dicke, M., Van Loon, J. J., & Soler, R. (2009). Chemical complexity of volatiles from plants induced by multiple attack. Nature Chemical Biology, 5(5), 317-324.

Hartmann, A., Rothballer, M., Hense, B. A., & Schröder, P. (2014). Bacterial quorum sensing compounds are important modulators of microbe-plant interactions. Frontiers in plant science, 5, 131.

Lehmann, K. D., Goldman, B. W., Dworkin, I., Bryson, D. M., & Wagner, A. P. (2014). From cues to signals: evolution of interspecific communication via aposematism and mimicry in a predator-prey system. PloS one, 9(3), e91783.

Mumm, R., & Dicke, M. (2010). Variation in natural plant products and the attraction of bodyguards involved in indirect plant defense. Canadian journal of zoology, 88(7), 628-667.

Pastor, V., Balmer, A., Gamir, J., Flors, V., & Mauch-Mani, B. (2014). Preparing to fight back: generation and storage of priming compounds. Frontiers in plant science, 5, 295.

Pearce, G. (2011). Systemin, hydroxyproline-rich systemin and the induction of protease inhibitors. Current Protein and Peptide Science, 12(5), 399-408.

Schaefer, H. M., & Rolshausen, G. (2006). Plants on red alert: do insects pay attention?. *BioEssays*, *28*(1), 65-71.

Schoonhoven, L. M., Van Loon, B., van Loon, J. J., & Dicke, M. (2005). Insect-plant biology. Oxford University Press on Demand.

Sharifi, R., & Ryu, C. M. (2020). Social networking in crop plants: Wired and wireless cross-plant communications. Plant, Cell & Environment.