Plant communication: an unresolved mystery

Hridya Hemachandran, C. George Priya Doss and Ramamoorthy Siva

Our understanding of plants is limited, as they exhibit various processes like photosynthesis, metabolic biosynthesis, adaptability, defence mechanism, stress tolerance, reproduction, growth, etc. Despite advancement in plant biology research with existing complete genome sequences available for many crops and plants, plant–plant interaction is still an unresolved mystery. Though researchers have been trying to understand plant communication since the last century, the precise mechanisms have not yet been conclusively deduced. Here, we discuss the need for studies on plant communication, which could serve as a resource for betterment of our understanding of the biological system and also in agricultural disease forecasting. Emerging technologies and minds have to be focused to unravel the mystery of plant communication in order to understand the unknown fact.

Plants remain a mystery to humans in numerous ways: for instance, diversification in size from tiny diatoms to mammoth trees, habitation from dry deserts to wet marshlands, autotrophs to heterotrophs and survivability up to 13,000 years like *Quercus palmeri* (Jurupa Oak)[1]. Despite significant advancement in plant biology research, plant–plant interaction is still an unresolved puzzle. Immobility of plants is not to be considered as a disadvantage for communication; in fact, it makes the plants more competent to curb the scorching extrinsic factors for communications within and among their forms[2].

The inexplicable plant conversation was noticed by Darwin, when he initially observed the sensitivity of the insectivorous plant, *Dionaea muscipula* J. Ellis[3]. Further, in the early 1920s, Jagadish Chandra Bose, father of wireless communication, developed the crescograph to study plant response towards stimuli. He observed that the leaves of *Mimosa pudica* L. (touch-me-not plant) retract on constant irritation despite the stimuli response[4]. In 1960, Retallack[5] suggested that plants better through respond to classical music. However, it was in 1983 that the secret of plant communication was revealed by Baldwin and Schultz[6] chemical signals from herbivore maple tree. Chamovitz discussed about deaf genes (myosin) in humans, present in the hair cells of the ear, which when mutated cause loss of hearing. Similarly, four impairment genes encoding myosin were found to be present in *Arabidopsis thaliana* (L.) Heynh., responsible for root hair development, which when mutated, resulted in the lack of root hair production[2]. In 2000, Karban *et al.*[7] demonstrated the role of volatile organic compounds (VOCs) from *Artemesia tridentate* Nutt. (sagebrush) to induce herbivore resistance in wild tobacco. The listening attitude of plants is well discussed by Dicke *et al.*[8]. Further in 2006, Karban proved that the VOCs of sagebush travel up to 60 cm. The eavesdropping attitude of plants for their defence mechanism is well understood from studying damaged plants. Novoplansky demonstrated the eavesdropping nature of neighbouring pea plant roots, when subjected to drought stress[9]. Abscisic acid was found to be involved in plant drought and osmotic stress[10].

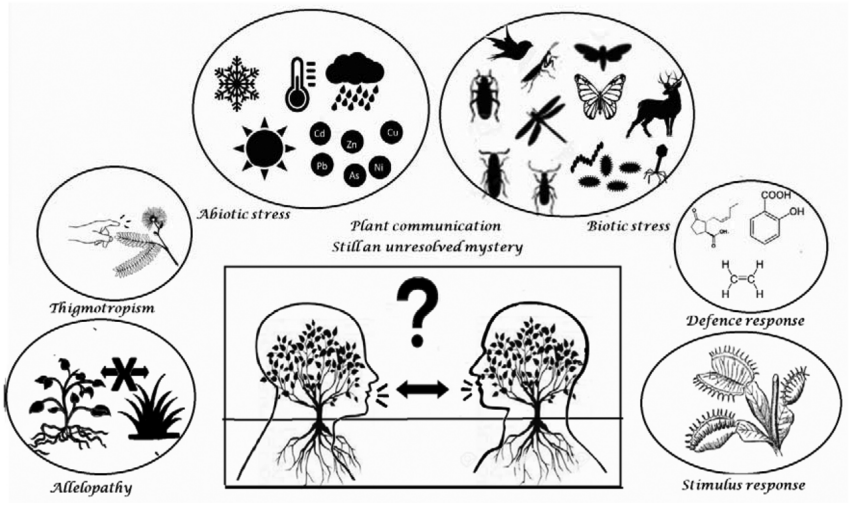

Figure 1. Identified factors and responses in plant communication.

Caveat signal – beware

Like humans, closeness and avoidance are expressed by plants as well. Friendly and peremptory talk was seen in plants, inter- and intra-specifically. Gravitropism, hydrotropism, heliotropism, phototropism and thigmotropism are known to be the stimulating features of plants. Root exudates act as signals; for instance, momilactones in rice roots are suggested to have allelopathic effects. Strigolactones in Orobanchaceae root parasitic plants are shown to attract arbuscular mycorrhizal fungi for phosphorus utilization[11]. The weeds in the field emit volatile compounds during herbivore attack[12]. The abstract cry signs of inter- and intra-plant interaction in response to damage and herbivory are seen in myriad forms such as terpenoids, sulphur, nitrogenous compound, pheromones, kairomones, jasmonate and salicylate[13]. Lima beans upregulate defence genes in response to the odour emitted by spider mite-damaged conspecific plants[8]. Figure 1 depicts our present understanding of the plant communication scenario. Now it is obvious that some communication occurs

in the form of VOCs and other metabolites. Researchers have revealed the molecular mechanism, genes and receptors involved in the communication. However, the mystery remains unresolved till date.

Future prospectives

Chamovitz[2] states, 'Entire life is dependent on plants' and 'life on other planets will be dependent on plants'. He also admits that life does not exist without plants, but we take them for granted[2]. In the last 15 years, the idea that plants are communicating has become much more acceptable, but unresolved. According to Karban, 'It is exciting to unravel all these different realms of plant communication.' Gagliano, an evolutionary ecologist at the University of Western Australia in Perth, describes that sound is faster than chemical signals for plant communication. In support for his statement is the evidence, where the roots of young corn plants grown in water makes clicking sound, and that sound when played back in the same frequency range to the roots, they responded by bending towards the source. The frequencies of sound produced by plants are outside the human hearing range. The importance of ultrasound on plant metabolites production and mechano-sensing studies in plants clearly depicts the plant communication behaviour[14]. During biotic or abiotic stress in plant systemic response of jasmonates, a fluroscent hormone Jas9-VENUS is important as a quantitative biosensor[15]. 'e-nose', a chemical sensor is used to detect VOCs rapidly during pathogen infections[16]. Resolving the enigma of plant communication helps not only in understanding the biological system, but also in agricultural aspects like plant-disease forecasting and stress response. To date, research is in progress for understanding the mechanism of plant communication, and hence there is greater scope in the field of metabolomics through communication, signalling receptors, sensor detectors, acoustics of plant response, gene mining of talking plants, proprioception and yet to be unravelled. Hence more focus on such studies with interdisciplinary science and engineering may fill the lacunae.

Conflict of interest: The authors declare no conflict of interest.

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Hridya Hemachandran, C. George Priya Doss and Ramamoorthy Siva are in the School of Bio Sciences and Technology, VIT University, Vellore 632 014, India.*
**e-mail: siva.ramamoorthy@gmail.com*