International Journal of Entomology Research
ISSN: 2455-4758; Impact Factor: RJIF 5.24
Received: 12-12-2020; Accepted: 27-12-2020; Published: 15-01-2021
www.entomologyjournals.com
Volume 6; Issue 1; 2021; Page No. 27-29

A review on-Volatile-mediated tritrophic interaction

Ujjwal Malik
Department of Zoology, Netaji Maha vidyalaya, Arambagh, Hooghly, West-Bengal, India

Abstract
Volatile Organic Compounds (VOCs) are the most important parameter to establish the tritrophic interaction in between insect, plant and predator or parasitoid. Naturally, insect induced plant volatile attract the natural enemies of that insect. These mixtures of volatiles attract predator as well as parasitoid. In this review, objective is the role of VOCs in tritrophic interactions from an ecological as well as an implemented perspective. Several methods are applicable here. More popular technique is VOCs extraction by HS-SPME and headspace push- pull. Qualitative and quantitative volatiles are analyzed by GC-MS & GC-FID. Most important method is GC-EAD for identifying specific VOCs as well as two-choice arena. Most popular specific compounds are fatty acid derivative, aromatic compounds, aldehydes, alcohols, terpenes, amino acid derivative, sesquiterpenes and a ketone. These compounds play a crucial role for tritrophic interaction. Tritrophic interaction enhance the knowledge of predator and prey interaction also. This overview focuses on the how specific VOCs can interact with insect, plant and natural enemy and thus this specific knowledge can be implemented in pest control by biological control method.

Keywords: vocs; tritrophic-interaction; predator; parasitoid; biological control

Introduction
Volatiles can intermediate with the interaction of plants with pollinators, herbivores and their natural enemies, other plants and micro-organisms. With full of knowledge about these interactions, the underlying mechanisms become increasingly complex. The increasing scientific knowledge can be used to draw a design and apply volatile-based agricultural strategies [1]. Price *et al*., introduced this Tritrophic concept in a well manner. The author narrated details of this Tritrophic interaction. In present scenario terrestrial organism interact at least three interacting trophic levels: plants, herbivores, and natural enemies of herbivores [2]. Predatory soil nematodes hunt for root herbivores with the help of volatile cues from damaged or intact roots of 18 Alpine Festuca grass species & they found that adaptation into harsh, nutrient-limited alpine environments coincided with the production of specific blends of volatiles that is highly attractive for nematodes [3]. In this interaction middle part is plant which can be triggered by herbivore that may be positive effect or negative effect. All these interactions mediated by volatiles compounds [4]. Herbivore induced plant volatile (HIPV) play a crucial role for this insect-plant and natural enemy interaction.

Materials and methods
Several methods are applicable here. More popular technique is VOCs extraction by HS-SPME and headspace push- pull. Qualitative and quantitative volatiles are analyzed by GC-MS & GC-FID. Most important method is GC-EAD for identifying specific VOCs as well as two-choice arena.

Volatile Organic Compounds (VOCs)
Plants release volatile organic compounds that mediating plant-plant interactions aboveground, roots can detect the chemical signals originating from their neighbours, and roots release VOCs involved in biotic interactions Belowground [5]. The certain volatile organic compounds (VOCs) can be considered as Damage-associated molecular patterns (DAMPs). Due to their chemical nature, VOCs are supposed to act not only locally and systemically in the same plant but also between plants. The possibility to use such airborne DAMPs as eco-friendly compounds which stimulate natural defense in agriculture in order to avoid pesticides [6]. Herbivore induced plant volatiles (HIPVs) are specific volatile organic compounds (VOC) that a plant produces in response to herbivory. Some HIPVs are only produced after damage, while others are also produced by intact plants, but in lower quantities. VOCs are low molecular weight compounds mostly belong to terpenoids, alcohol, aldehyde fatty acid and amino acid derivative. They are synthesized by different metabolic pathway [7].

Specific VOCs attractant for natural enemy like predator or parasitoid
After herbivore attack on plant, release volatile organic compounds (VOCs). With the help of this VOCs parasitoid and predator find out their host and prey [8]. Green leaf volatiles (GLVs) and terpenoids released from herbivore-damaged plants were found to be most important in the host identifying of parasitic wasps. Such as parasitic wasp *Opius dissitus* showed response to (*Z*)-3-hexenol [9]. Parasitoid (*Cotesia marginiventris*) responded to these compounds (*E*) -2-hexenal, (*Z*)-3-hexenyl acetate, linalool and geranyl acetate after herbivore damaged [10]. Mixture of specific five compounds (*E*) and (*Z*)–β-ocimene, (*Z*)-3-hexenyl acetate, DMNT, TMTT and methyl salicylate were attracted by mite *Phytoseiulus persimilis* [11]. Predators and parasitoids were attracted by two special compounds *S*-linalool and (*E*)-β-caryophyllene [12]. *Evarcha culicivora* jumping spider attracted to (*E*)-β-caryophyllene, α-humulene and 1,8 cineole and attack to their natural enemy [13].

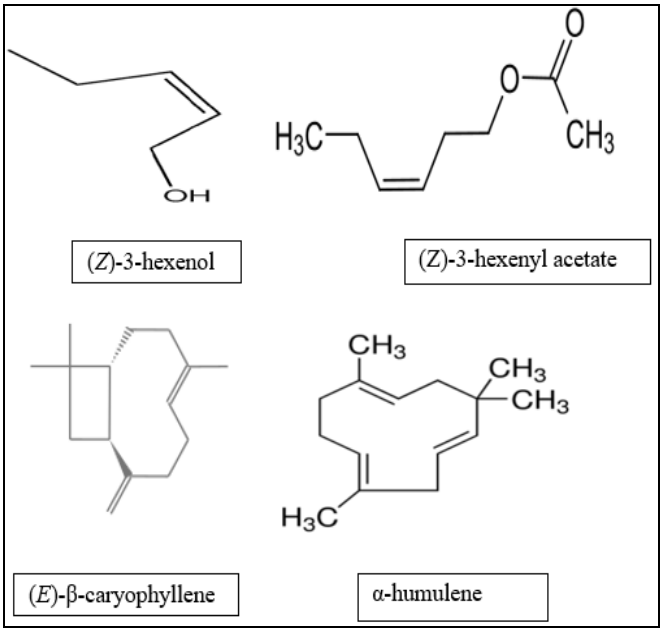

Fig 1: Some of attractant VOCs

Vital role of HIPVs in Plant Defence against Herbivores: Attraction of insect parasitoid and predator by VOCs emitted from damaged plants has been well established. These interactions are specific to a particular insect plant interaction. Such as, *Zea mays* TPS10, is an herbivore-induced volatile compound terpene synthase that forms (*E*)-β-farnesene, (E)-α-bergamotene, and other sesquiterpenes in *Arabidopsis thaliana*, [14] which does not produce significant amounts of volatile terpenes which indicate that a single herbivore-induced gene from *Z. mays* is sufficient to produce this indirect defence. *Cotesia marginiventris*, a parasitoid of *Spodoptera litura* has been reported to be attracted to TPS10- producing *A. thaliana*. Damage by corn rootworm, *Diabrotica virgifera* larvae in maize roots induces the release of (*E*)-β- caryophyllene, which attracts the nematode, *Heterorhabditis megidis* that in turn feed on the larvae of *D. virgifera* [15]. VOCs can mediate both the direct and indirect effect at a time. Volatile release from *Nicotiana attenuate* can deter lepidopteron oviposition and also attract natural enemy [16]. By products of terpenoid pathway monoterpene, sesquiterpene and homoterpene play a crucial role in plant defence system [17].

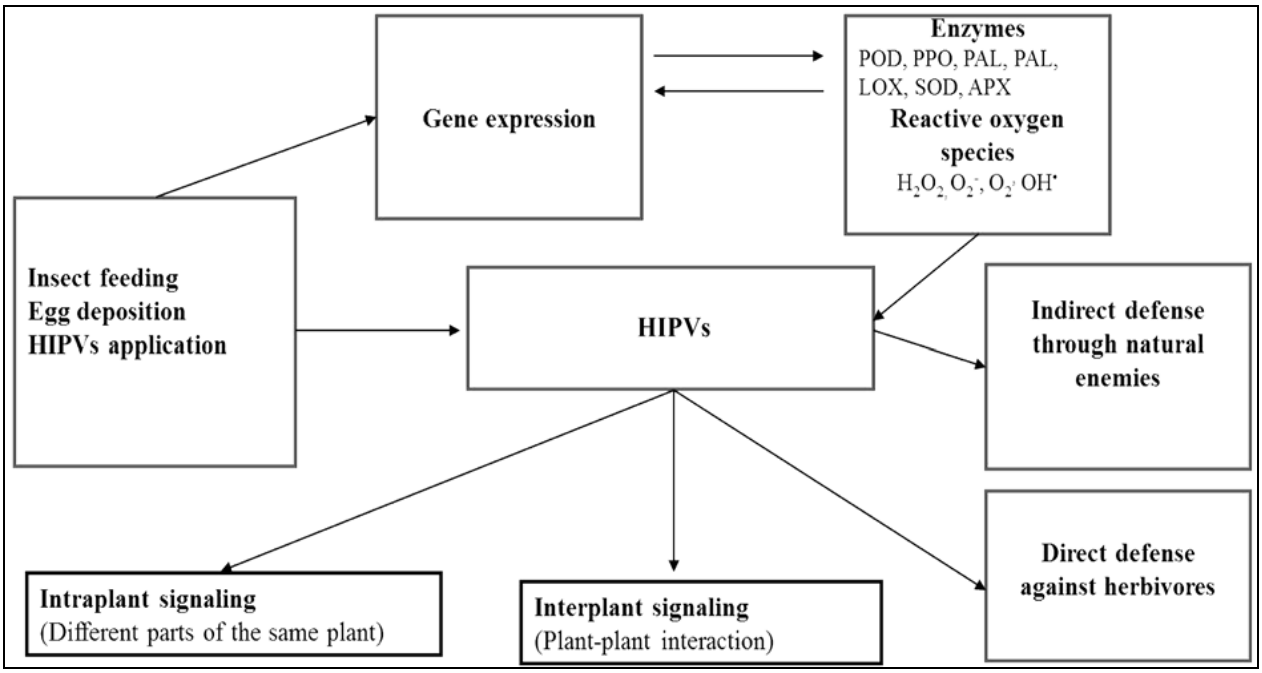

Fig 2: Role of HIPVs in plant defense. HIPVs, Herbivore induced plant volatiles; POD, peroxidase; PPO, polyphenol oxidase; PAL, phenylalanine ammonia lyase; tyrosine alanine ammonia lyase; LOX, lipoxygenase; SOD, super oxide dismutase; APX, ascorbate peroxidase [7].

Application strategy

It has been frequently proposed that the volatile compounds that can mediate tritrophic interactions can be implemented for application in agriculture. Here, we take a closer look at five possible way.

- Volatile compounds that affect arthropod foraging behaviour.
- Apply inducing chemicals that alter the attractiveness of plants behaviour.
- Breed for or otherwise create crops with enhanced volatile emissions.
- Use companion plants that affect the attraction of pests and beneficials.
- Develop odour sensors to monitor for pests and diseases.

These strategies are not mutually exclusive and may be most effective when they are used in combination. These strategies will be more effective for pest control [4].

Concluding remarks and outlook

The VOCs play an important role in host plant-herbivore-natural enemy interactions, and have the potential for biological control & integrated pest management. Understanding of this such interactions mechanism will open up new way out for further studies on primary signalling cascades to the ecological consequences in various eco-systems. Further studies need to be performed to identify the volatile compounds that enhance the olfaction-directed behaviour of insect pests and their natural enemies to formulate strategies for developing varieties

strategy with constitutive and induced resistance to insect pests, and manipulation of such volatiles to attract the natural enemies of the crop pests for enhancing the effectiveness of bio-control agents for pest management [3].

References

1. Kergunteuil Alan, Laureline Humair, Anne-Laure Maire, María Fernanda Moreno-Aguilar, Adrienne Godschalx, Pilar Catalán et al. Tritrophic interactions follow phylogenetic escalation and climatic adaptation. Scientific Reports. 2020; 10:2074. https://doi.org/10.1038/s41598-020-59068-2.
2. Price W Peter, Bouton E Carl, Gross Paul, Mc Pheron A Bruce, Thompson N John, Weis E, *et al*. Arthur. Interactions among three topic levels: Influence of Plants on Interactions between Insect Herbivores and Natural Enemies. Annual Review of Ecology, Evolution, and Systematics. 1980; 11:41-65.
3. Bouwmeester Harro, Robert C Schuurink, Petra M Bleeker, Florian Schiestl. The role of volatiles in plant communication. The plant Journal. 2019; 100(5):892-907.
4. Turlings CJ Ted, Erb Matthias. Tritrophic Interactions Mediated by Herbivore-Induced Plant Volatiles: Mechanisms, Ecological Relevance, and Application Potential. Annual Review of Entomology. 2018; 63:433-52.
5. Benjamin M, Delory Pierre Delaplace, Marie-Laure Fauconnier, Patrick du Jardin. Root-emitted volatile organic compounds: can they mediate belowground plant-plant interactions? Plant and Soil. 2016; 402:1-26.
6. Anja Katharina Meents, Axel Mithöfer. Plant–Plant Communication: Is There a Role for Volatile Damage-Associated Molecular Patterns? Frotiers in plant Sciences, 2020, 11. https://doi.org/10.3389/fpls.2020.583275
7. War Rashid Abdul, Sharma Chand Hari, Paulraj Gabriel Michael, War Mohd Yousf, Ignacimuthu Savarimuthu. Herbivore induced plant volatiles: Their role in plant defense for pest management. Plant Signaling & Behavior. 2011; 6(12):1973-1978.
8. De Moraes CM, Lewis WJ, Pare PW, Alborn HT, Tumlinson JH. Herbivore-infested plants selectively attract parasitoids. Nature. 1998; 393:570-573.
9. Turlings TCJ, Tumlinson JH, Heath RR, Proveaux AT, Doolittle RE. Isolation and identification of allelochemicals that attract the larval parasitoid, *Cotesia marginiventris* (Cresson), to the microhabitat of one of its hosts. Journal of Chemical Ecology. 1991; 17:2235-2251.
10. Wei Jianing, Wang Lizhong, Zhu Junwei, Zhang Sufang, Nandi I Owi, Kang Le et al. Plants Attract Parasitic Wasps to Defend Themselves against Insect Pests by Releasing Hexenol. PLoS ONE. 2007; 2(9):e852.doi: 10.1371/journal.pone.0000852.
11. Michiel van Wijk, Paulien JA. De Bruijn, Maurice W, Sabelis. Predatory Mite Attraction to Herbivore-induced Plant Odors is not a Consequence of Attraction to Individual Herbivore-induced Plant Volatiles. Journal of Chemical Ecology. 2008; 34(6):791-803.
12. Xiao Y, Wang Q, Erb M, Turlings TCJ, Ge L, Hu L, *et al*. Specific herbivore-induced volatiles defend plants and determine insect community composition in the field. Ecology Letters. 2012; 15(10):1130-1139.
13. Nelson J Ximena, Andrew J Pratt, Xavier Cheseto, Baldwyn Torto, Robert R Jackson. Mediation of a plant spider Association by Specific Volatile Compounds. Journal of Chemical Ecology. 2012; 38:1081-1092.
14. Schnee Christiane, Tobias G, Ko llner, Matthias Held, Ted CJ. Turlings, *et al*. The products of a single maize sesquiterpene synthase form a volatile defense signal that attracts natural enemies of maize herbivores. PNAS. 2006; 103(4):1129-1134.
15. Rasmann Sergio, Tobias G Ko¨llner, Jo¨rg Degenhardt, Ivan Hiltpold, Stefan Toepfer *et al*. Recruitment of entomopathogenic nematodes by insect-damaged maize roots. Nature. 2005; 434:732-737.
16. Kessler André, Baldwin T, Ian. Defensive Function of Herbivore-Induced Plant Volatile Emissions in Nature. Science. 2001; 291(5511):2141-2144.
17. Pichersky E, Gershenzon J. The Formation and Function of Plant Volatiles: Perfumes for Pollinator Attraction and Defence. Current Opinion in Plant Biology. 2002; 5:237-243.