Ecofarming (e-Magazine)

Agriculture

Ecofarming
e-Magazine for Agriculture and Allied Sciences
http://www.ecofarming.rdagriculture.in
e-ISSN: 2583-0791

Harnessing Plant Volatiles for Effective Insect Pest

1. **Pratik Kachhela**
Department of Entomology, B. A .College of Agriculture, Anand Agricultural University, Anand
Email: pratikkachhela@gmail.com
2. **Patel NB**
AINP on Pesticide Residue, Anand Agricultural University, Anand 388 110
3. **Kaushik Parmar**
Directorate of Extension Education, Anand Agricultural University, Anand
4. **Raghunandan BL**
AINP on Pesticide Residue, Anand Agricultural University, Anand 388 110
5. **Divyesh Lapkamna**
Department of Entomology, B. A .College of Agriculture, Anand Agricultural University, Anand

Received: February, 2024; Accepted: February, 2024; Published: April, 2024

Introduction

Plant volatiles have emerged as potent tools in the field of insect pest management, offering sustainable and eco-friendly alternatives to traditional chemical approaches. This review explores the intricate relationship between plants and insects, focusing on the role of plant volatiles in deterring, attracting, and disrupting the behavior of pest species. Also plant volatiles can be harnessed to mitigate insect pest damage and enhance sustainable agricultural practices.

Chemical Ecology of Plant-Insect Interactions

Understanding the intricate web of chemical signals exchanged between plants and insects is fundamental to leveraging plant volatiles in pest management. Plants release volatile compounds as a form of chemical communication, influencing insect behavior and serving as cues for various ecological interactions. Understanding the chemical diversity of plant volatiles is essential for designing effective pest management strategies.

Attractants and Repellents

- Plant volatiles can function as attractants or repellents, depending on the specific compounds emitted. By identifying and manipulating these compounds, researchers can develop strategies to lure pests away from crops or deter them from settling, providing a non-invasive and environmentally friendly approach to pest control.

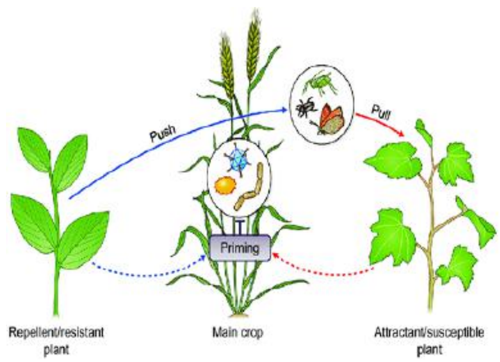


Figure 1 : Repellent and attractant plant near main crop

- In push-and-pull intercropping approaches for plant protection, volatile organic compounds (VOCs) play a crucial role. This strategy, pioneered by Pyke et al. (1987), involves the use of repellent plants that emit VOCs to 'push' insects away from the main crop, along with attractant plants that emit VOCs to 'pull' insects to the field's outer edges. Additionally, Wenig et al. (2019) demonstrated that VOCs can induce resistance against microorganisms in nearby plants. The presence of airborne defense cues from companion plants, as suggested by dashed arrows, may potentially prime the defenses of the main crop against microbial pathogens.

Attractants for Natural Enemies

- In addition to repelling pests, plant volatiles play a pivotal role in attracting natural en emies, such as predators and parasitoids. By releasing specific blends of volatiles, plants can signal the presence of herbivorous insects to their predators, creating a dynamic and natural form of biological control within ecosystems.
- Plants release higher amounts of volatile compounds when subjected to insect feeding, a response initiated by the interaction between elicitors, like volicitin found in the oral secretions of herbivorous insects, and damaged plant tissue. These emitted volatile semiochemicals serve as signals, aiding natural enemies such as parasitoid wasps in locating their herbivorous hosts.

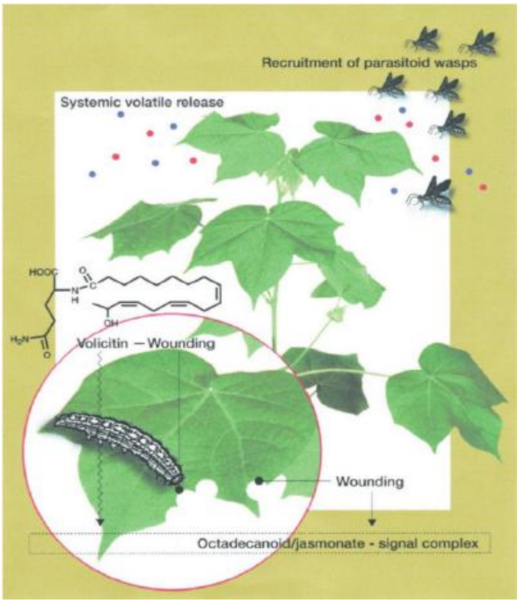


Figure 2 : Attract natural enemies by using plant volatile

Trap Cropping and Companion Planting

Trap Cropping : The trap crop is usually more attractive to pests than the main crop. Pests are drawn to the trap crop, reducing the damage they cause to the main crop.

A trap crop system is typically designed to draw agricultural pests, mainly insects, away from the primary crop. For instance, in fields growing onions (Allium cepa L. (Amaryllidaceae)), populations of Thrips tabaci Lindeman (Thysanoptera: Thripidae), a significant onion pest, can be controlled by implementing buckwheat (Fagopyrum esculentum Moench (Polygonaceae)) as a trap crop. Moreover, a combination of two trap crop species, such as sunflower (Asteraceae) and grain sorghum (Poaceae), can attract insect pests more efficiently, as observed in their ability to divert brown marmorated stink bugs (H. halys) away from bell peppers. Indeed, the sequential planting of additional trap crops can prolong the period during which insect pests find them attractive.

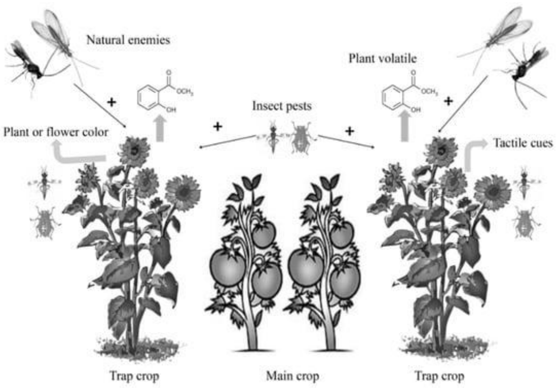


Figure 3 : Marigold or cucumber is frequently employed as a trap crop in tomato cultivation to attract tomato fruit borers (*Helicoverpa armigera*).

Companion Planting : Companion planting involves planting different crops together (intercropping) in a way that provides mutual benefits such as pest control, enhanced nutrient uptake, or improved growth. Pairing onions, particularly cultivating spring onions, alongside carrots is a well-established practice favored by numerous gardeners. The fragrance of onions acts as a deterrent for carrot root flies, protecting the carrots in companion planting. Simultaneously, the aroma of carrots aids in deterring onion flies from the onions, making it a mutually advantageous combination.

Figure 4: Onion and carrot intercropping

Semiochemical-Based Traps and Monitoring

The development of semiochemical-based traps that mimic plant volatiles has shown promise in monitoring and managing insect populations. These traps can be used to detect pest presence, assess population dynamics, and even serve as a targeted control method by selectively attracting and trapping specific pests. Plant volatiles act as semiochemicals, influencing the behavior of both pests and their natural predators. By manipulating these chemical cues, researchers and farmers can develop eco-friendly pest management approaches. Utilizing semiochemicals in traps or lures helps disrupt pest mating patterns and reduce overall population density.

a) **Monitoring :** Rhainds et al. (2016) employed a monitoring approach to assess the abundance of male spruce budworms (*Choristoneura fumiferana* Clemens, Lepidoptera: Tortricidae) in Canada using pheromone-baited traps. Similarly, this method was utilized for evaluating the population of the lesser date moth (Batrachedra amydraula Meyrick, Lepidoptera: Batrachedridae) in studies conducted by Levi-Zada et al. (2018).

b) **Mass trapping :** In recent times, the utilization of this method has proven to be a successful strategy in the control of the Japanese beetle, *Popillia japonica* Newman (Coleoptera: Scarabaeidae), as indicated by Piñero and Dudenhoeffer in 2018.

c) **Attract and kill :** The attract-and-kill strategy involves trapping and concurrently eliminating captured pests. Research on this tactic has focused on its application for extended pest management, addressing issues such as the Egyptian cotton leafworms, codling moths, biting flies, apple maggots, and bark beetles. Additionally, it has been employed in efforts to eradicate invasive species like boll weevils and tephritid fruit flies, as documented in studies by Phillips (1997), Prokopy et al. (2000), Stelinski and Liburd (2001), and El-Sayed et al. (2009).

d) **Mating disruption :** Four mating disruption mechanisms are under consideration:

(i) **Competitive attraction (False trail following) :** where semiochemical substances divert male attention away from wild females by leading them on a false trail.

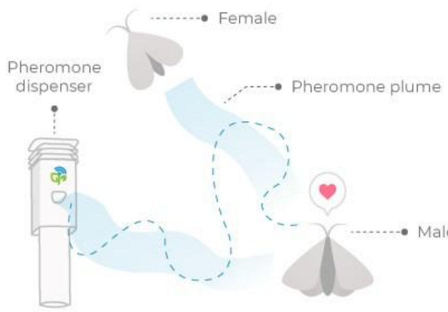


figure 5 : False trail following

(ii) **Confusion of males (camouflage) :** achieved through the saturation of the environment with semiochemical substances, resulting in erratic flight patterns and the failure to locate females, thereby impeding mating.

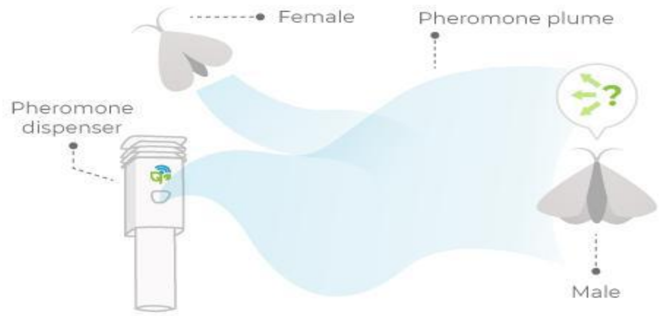
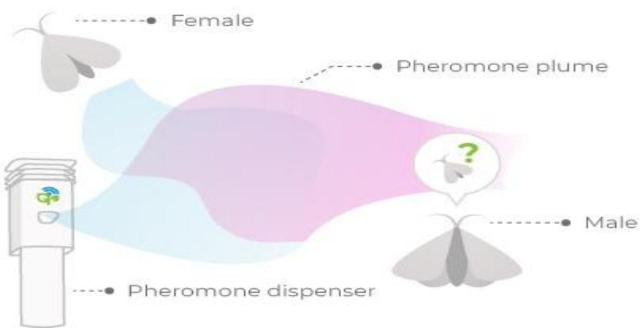


figure 6 : Camouflage

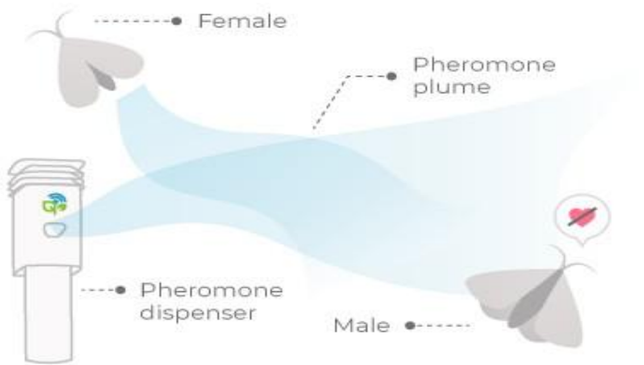


(iii) **Sensory desensitization :** involving the adaptation of the male antennal receptor system or the habituation of the central nervous system due to prolonged exposure to semiochemical substances with continuous high background concentration; and finally,

Figure 7 : Sensory desensitization

(iv) **Disguise (emigration of males prior to mating) :** where males emigrate from an area in response to an excess of pheromones, rendering them unavailable for mating with virgin females. These mechanisms, as outlined by Barclay and Judd (1995) and Mafra-Neto et al. (2014). Contribute to the application of mating disruption as a potential control strategy for lepidopteran pests.

figure 8 : Emigration of males prior to mating



Induced Plant Defences

In response to insect herbivory, plants can release volatiles that signal neighbouring plants to activate their defence mechanisms. This induced resistance can be exploited in pest management strategies, priming crops to better fend off potential threats and reducing the reliance on chemical pesticides.

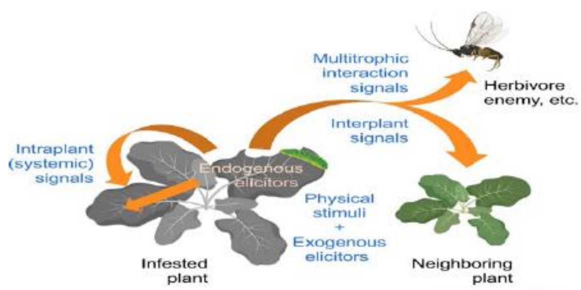


Figure 9 : Systemic signals from infected to healthy plant

Challenges and Future Prospects

Despite the promising advancements in utilizing plant volatiles for insect pest management, challenges remain. Factors such as the specificity of volatile compounds, their stability in diverse environments, and scalability issues need to be addressed. Ongoing research aims to overcome these hurdles, paving the way for the widespread adoption of plant volatile-based strategies in agriculture. Future research should focus on unravelling the intricacies of these interactions and developing practical applications for a wide range of agricultural systems.

Conclusion

Plant volatiles represent a rich source of potential for sustainable insect pest management. Their multifaceted roles in deterring pests, attracting natural enemies, and guiding innovative trapping methods underscore the importance of understanding and harnessing these natural chemical cues. As research progresses, the integration of plant volatiles into holistic pest management strategies holds great promise for fostering environmentally friendly and resilient agricultural systems.

References

1. Vlot, A. C., Sales, J. H., Lenk, M., Bauer, K., Brambilla, A., Sommer, A. & Nayem, S. (2021). Systemic propagation of immunity in plants. *New Phytologist*, *229*(3), 1234-1250.
2. Paré, P. W., & Tumlinson, J. H. (1999). Plant volatiles as a defense against insect herbivores. *Plant physiology*, *121*(2), 325-332.
3. Sarkar, S. C., Wang, E., Wu, S., & Lei, Z. (2018). Application of trap cropping as companion plants for the management of agricultural pests: a review. *Insects*, *9*(4), 128.
4. Reaney, H. (2022). Onion companion planting. *Homes & Gardens.*
5. Tukua, D. (2023). 22 Ways To Combat Garden Pests Naturally. *Farmer's Almanac*
6. Food From My Backyard. (2014).
7. El-Ghany, N. M. A. (2019). Semiochemicals for controlling insect pests. *Journal of Plant Protection Research*, *59*(1).
8. Arimura, G. I. (2021). Making sense of the way plants sense herbivores. *Trends in plant science*, *26*(3), 288-298. (figure 5)
9. Leung J. (2020). Understanding Pheromones and mating disruption. Semios (web access)