Push-Pull Pest Management: An Ecological Strategy for Crop Protection

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An inventive agricultural approach called Push-Pull Pest Management (PPPM) aims to improve pest control while supporting environmentally friendly farming methods. The "pull" component draws the pests' natural enemies, strengthening biological control, while the "push" process applies repellent signals to crops, making them less appealing to pests. In addition to reducing the need for chemical pesticides, this strategy promotes ecosystem health and biodiversity. The incorporation of PPPM into agroecosystems, the function of volatile organic compounds, and the significance of farmer involvement and education are some of its key features. The efficacy of PPPM in many agricultural systems indicates its promise as a workable substitute for environmentally friendly pest control. Overall, PPPM aligns perfectly with the principles of organic agriculture, providing an effective and environmentally friendly solution for pest management.

Push Pull Strategy

It is innovative approach of pest management, based on the stimulo-deterrent diversionary strategy or push–pull system. A "push–pull" strategy is a cropping system in which specifically chosen companion plants are grown in between and around the main crop. These companion plants release semiochemicals that fend off insect pests from the main crop using an intercrop which is the "push" component and concurrently insect pests away from the main crop using a trap crop which is the "pull" component.

The term "push-pull" was first conceived as a strategy for insect pest management by Pyke, Rice, Sabine and Zaluki in Australia in 1987. They investigated the use of repellent and attractive stimuli, deployed in tandem, to manipulate the distribution of *Heliocoverpa* spp. in cotton to reduce reliance on insecticides, to which the moths were becoming resistant.

Principles of the Push-Pull Strategy

The push-pull strategy involves influencing the behaviour of insect pests and their natural enemies by employing cues that make protected crops undesirable to pests (push) while simultaneously attracting them to a different location (pull). This two-pronged approach directs pest migration and affects their distribution and population density.

a) Push: Pests are driven away from the main crop using stimuli that mask the appearance of the host or act as repellents or deterrents.
b) Pull: At the same time, pests are attracted to specific trap crops or traps with highly visible or appealing stimuli, where they can be concentrated and eliminated.

This strategy integrates knowledge of pest ecology, plant-insect interactions, and agroecosystem dynamics to reduce pest pressure without relying on chemical interventions. By combining plants that repel pests with those that attract and trap them, push-pull aims to create a balance between the protection of the primary crop and the enhancement of biodiversity within the agricultural system.

Components of Push Pull System

Push components

i. Visual cues: Alteration of shape, size and colour which lead to development of disturbance in pest population which can be utilized in integrated pest management (IPM)
ii. Non-Host Volatiles: Non host volatiles which disturb the utilization of host plant when intercrop with main crop.
iii. Host Volatiles: The herbivore-induced plant volatiles (HIPVs) are produced by plant when herbivores feed on them. The herbivore-induced plant volatiles (HIPVs) can deter plant utilization by subsequent herbivores as indicators of competition or induced defences.
iv. Repellents: Chemical which repel or push the pest from main crop which can be utilized as push component in this strategy. Frontalin acts as repellent i.e. push the coffee berry borer *Hypothenemus hampei* from coffee.
v. Alarm pheromones: The social insects, including Hymenopterans and gregarious Hemipterans, have developed a diverse blend of chemical compounds that function as

releasers of alarm behaviour. Alarm pheromone released when attacked by the natural enemies, causing avoidance or dispersal behaviour in conspecifics. Many aphid's species release (E)-β-farnesene (Eβf) as alarm pheromone. On main crop application of alarm pheromones which ward off aphids in the field and Eβf also functions as a kairomonal activity to pull natural enemies of aphids.

vi. Antifeedants: Several antifeedants, including azadirachtin (the primary active component of neem, derived from Azadirachta indica), applied as neem seed kernel extract in cotton against H. armigera. However other plants also have antifeedent compounds viz. pongamia, eucalyptus, melia, Annona.

vii. Oviposition deterrents and oviposition deterring pheromones: Oviposition deterrents and oviposition-deterring pheromones (ODPs) are compounds that prevent or reduce egg deposition and so it can be corporate in the push-pull strategies to control species that cause damage through this process or whose imagoes are pestiferous. During egg laying both parasitic and phytophagous insects are known to deposit chemical signals that modify the behaviour of conspecifics who consequently stay away from depositing eggs into host that are oviposited by others. The deterrents isolated from nonhosts plants have deterring oviposition of pests, and of these, frequently evaluated formulation was neem-based formulations and some other plants are also used.

Pull Components

i. Visual stimulants: The visual cues related to the plant growth stage can be important sole method used to attract pests to traps or trap crops, but they can enhance the effectiveness of olfactory stimuli. Sexually mature apple maggots, *Rhagoletis pomonella* attracted towards, red spheres (7.5 cm in diameter) mimicking ripe fruit. These traps, coated with either sticky material or contact insecticides and baited with synthetic host odors, have been used successfully for management of pest.

ii. Host volatiles: For monitoring, mass-trapping, or in attracticide strategies host volatiles used in host allocation of bait traps. HIPVs are often reliable indicators of the presence of hosts or prey to predators and parasitoids and are therefore attractive (pull) to these beneficials. The conophthorin acting as the 'pull' (attractant) for *Hypothenemus hampei*.

iii. Sex and aggregation pheromones: Sex and aggregation pheromones are released by insects which attract conspecifics for mating and optimizing resource use. Both types of pheromones are increasingly important components of IPM, particularly in pest monitoring in crop developmental stages.

iv. Gustatory and oviposition stimulants: Oviposition or gustatory stimulants produced by the trap crops, which help in pull the pest populations from main crop to trap crop area. The gustatory stimulants, such as sucrose solutions, to increase the ingestion of insecticide bait when applied to traps or trap crops. Some of crops attract and supply the food may also help to establish populations of natural enemies and influence their distribution. The hydrolysed proteinaceous baits as a food odour were lingering to catch a broad series of tephritid fruit fly species and are still in use in lure.

Challenges and Limitations

While push-pull pest management holds great promise, it is not without challenges. Some of the common limitations include:

i. Initial Costs and Labor: Establishing a push-pull system requires careful planning, labor, and initial investments in seed materials. The success of the system depends on proper crop spacing, timely planting, and maintenance.

ii. Knowledge and Training: For push-pull strategies to be successful, farmers need to be well-informed about the specific plant combinations and pest dynamics in their region. Extension services and farmer education are critical to the widespread adoption of the system.

iii. Local Adaptation: Not all push-pull systems are universally applicable. Regional

differences in pest species, crop types, and climate require localized research and adaptation to find the most effective push-pull combinations.

Conclusion

The principles of the push-pull strategy are used to minimizing detrimental effect on environment while maximize control efficacy, competency, sustainability and outputs. Although each individual component of the strategy may not be as effective as a broad-spectrum insecticide at reducing pest numbers, the efficacy of push and pull components is increased through tandem deployment. The push and pull components are generally nontoxic and can be useful for the small and marginal farmers by reducing cost of cultivation and indirectly uplift the standard of living. Hence, the strategies are usually integrated with biological control and cultural control for management of pest. Push-pull pest management is a promising ecological strategy for sustainable crop protection. By leveraging natural plant-pest interactions, this system offers an effective alternative to chemical pesticides, promoting biodiversity, improving soil health, and reducing environmental impacts. While it requires careful implementation and farmer education, push-pull technology has the potential to revolutionize pest management in smallholder and large-scale farming systems alike, contributing to the long-term sustainability of agriculture.

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