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Flying Doctors: Entomovectoring in Crop Protection

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SUMMARY

Modern agriculture demands integration of several ecosystem services for agricultural sustainability and ecosystem functionality. One such aspect is entomo-vectoring technology, which uses managed bees to disseminate biological control agents (BCA) to flowering crops that can boost crop yields by providing non-chemical protection from pests and diseases while enhancing pollination . It is a technique that guards many cross-pollinated crops against pests and diseases. Thus, entomo-vectoring integrates pollination ecology and biological control strategy.

INTRODUCTION

Transferring pollen grains from a flower's anther to its stigma is the essence of pollination. The agents that participate in this pollination process are called pollinators. 80 percent of flowering plant species are designed for animal pollination, primarily by insects, which contribute to 35 percent of global agricultural production and increases the yield of 87 percent of the world's most important food crops. Pollination by insects is termed as Entomophily. More than 3,500 natural species of bees contribute to higher agricultural harvests. Thus, animal pollinators including bees, butterflies, moths, birds, bats, and other insects like beetles are responsible for one out of every three bites of food we consume.

Biological Control

Utilization of living organisms to control pest is biological control. A natural enemy such as a parasite, predator, or disease-causing organism is introduced into the environment of a pest or, if already present, is encouraged to multiply and become more effective in reducing the number of pest organisms. Biological control of potential pest insects can be increased by: 1) conservation of existing natural enemies, 2) introducing new natural enemies and establishing a permanent population, and 3) mass rearing and periodic release of natural enemies, either on a seasonal basis or inundatively.

What renders entomo-vectoring superior to spraying?

Targeted Delivery: The worth of this intriguing technology lies in the fact that the bees do a consistent and targeted delivery of the biocontrol agents right into the flowers which are the principal infection courts for many flower-borne diseases.

Persistent protection throughout the blooming season: This technique protects the crop throughout the flowering period and prevents many post-harvest losses, giving entomovectoring an edge over regular spray application.

Reduction in use of synthetic pesticides: Entomovectoring technology was primarily introduced as a biocontrol approach to limit the use of synthetic pesticides due to concerns about its effects on human health and the environment.

Resistance management: The approach also prohibits insects from becoming resistant to routinely used chemical insecticides.

Ecosystem service: Bees pollinate flowers as they spread biological control agents among them, which is a crucial ecological service for boosting agricultural yields.

Ecological Intensification: Using natural processes to substitute human-produced inputs like pesticides while sustaining or increasing food output per unit area is referred to as ecological intensification. Entomo-vectoring is a suitable illustration in this context.

Self-perpetuating: The self-perpetuating nature of this technology makes it easy for the long-term control of the disease.

Components of Entomo-vectoring

The three basic components to understand the principle are: The disease-causing pathogen, the biological antagonist of the pathogen, and a vector (pollinator species) that disseminates the biocontrol agents into the target site for control of pathogens.

Fig. 1: Bees coated with biocontrol agents

Fig.2: Dispenser system attached to hive

Fig.3: Parts of Dispenser

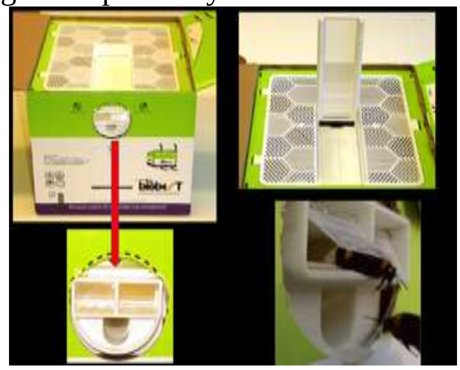

Fig.4: Commercial dispenser systems

The dispenser system and modes of transmission of antagonist

The technique involves multi-trophic interactions in plant-pathogen-vector-antagonist system. The BCA are loaded to the body of the bees as they pass through the dispenser system (20-25cm optimal length) which is of two types: one-way and two-way dispensers. While one-way dispensers have same unit for entry and exit, two-way dispensers offer different paths for the entry and exit and thus is more efficient [3]. Using these dispensers, the biological control agents are disseminated from hive to flowers. This is called primary transmission. The further dissemination of antagonist from one flower to other is called secondary transmission.

Different pollinator species involved in Entomo-vectoring

Selection of a potent vector depends on the type of crop to be pollinated, the pace at which the vector visits the crop, and the vector's ability to deposit Microbial Control Agent at the target. Honey bees (*Apis mellifera*), Bumble bees (*Bombus impatiens, B. terrestris*) and Mason bee (*Osmia cornuta*) are commonly used as efficient vectors.

Fig. 5: Honey bees

Fig. 6: Bumble bees

Fig. 7: Mason bees

Characteristics of antagonist to be used for Entomovectoring

A decent antagonist should be (a) genetically stable, (b) effective at low concentrations, (c) not fastidious in its nutrient requirements, (d) able to survive adverse environmental conditions, (e) resistant to pesticides, (f) non-pathogenic to the host, (g) not detrimental to human health, and (h) preparable in a form that can effectively be stored and disseminated.

Mechanism of Entomovectoring

- As a honey bee leaves her hive, she exits through a specialized dispenser containing the MCA, coating her with a fine powder.
- When she alights on a flower, some of this biological control agent is left behind.
- As she flies through the field, the powder is also deposited on the leaves, such that she returns to the colony "clean" and can unload her gathered pollen and nectar.
- The MCA left on the flowers and leaves may go to work immediately against insects and pathogens.
- It may colonize the flower and act as a prophylactic for the developing fruit and later dissemination

Success stories for Entomovectoring

Fire blight disease, caused by the plant pathogenic bacteria *Erwinia amylovora*, is one of the most economically important diseases in pome fruits. Current applications of biological control-based products with air blast sprayers are unable to target the material applied directly onto the stigmatic surfaces and floral nectarines where initial pathogen build-up and subsequent host colonization begins. Thus, solitary bees (*O. cornuta*) are used as vectors of biocontrol agents (*Bacillus subtilis*) for control of fire blight disease [2].

Grey mould disease of strawberry is usually caused by *Botrytis cinerea*. This is airborne plant pathogen and colonizes the anthers of strawberries. Antagonist *Gliocladium catenulatum* is a parasitic fungus preventing the growth of many plant-pathogenic fungi by parasitism, competition, nutrient depletion. Bumble bee, *B.terrestris* serve as a vector in this case. It was also observed that entomovectoring lengthened the fruits' shelf life [1].

Fig. 9: Fire Blight disease of pome fruits

Fig.10: Grey mould of strawberry

Case studies were performed by Mommaerts and Smagghe in 2011. The treatments were control (no mould control, no pollination), (no mould control and pollination) and (mould control and pollination). Enhanced pollination by honey bees increased the yield by 58%, while combining pollination with bee-vectored biocontrol increased yield by 105% compared to the control group.

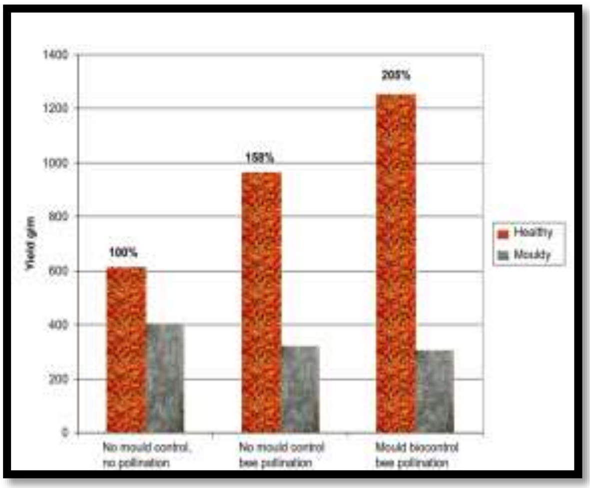

Fig.10: Higher marketable yield in pollination and entomovectoring treatment [1]

Entomovectoring in insect pest management

Entomovectoring can also be employed for insect pest management. For e.g., coleopteran pests of oilseeds were managed by honey bee vectored *Metarhizium anisopliae* (Metchnikoff), *Drosophila suzukii*

Matsumura in cherries and strawberry was managed using *Apis mellifera* Linnaeus vectored *M. brunneum* and *Hypothenemus hampei* Ferrari and *Hemileia vastatrix* (Berkeley and Broome) in coffee were managed using *A. mellifera* vectored *Beauveria bassiana* (Balsamo). Worldwide experiments also proved the rationality of entomovectoring as a revolutionary technology.

CONCLUSION

The modern agriculture will be revolutionized and will become holistic by adopting pollination ecology and biological control-based technology called as entomovectoring. This will expand the utility of pollination technology to include crop production and protection. Entomovectoring is best method for prophylactic measure. Technology will enhance apiculture among farmers. At the same time risk assessment studies with respect to vector and human safety is needed to employ entomovectoring into practical uses. The Efficacy and impact of the entomovectoring technology can be proved by management of hives (size location and properties), vegetation management, and optimization of dispensers and properties of the microbial preparate.

Dr. Peter Kevan, University of Guelph's apivectoring pioneer, calls entomovectoring a "double benefit to agriculture" – that is, crop pollination and crop protection acting together to increase yields and quality. At the same time proper risk assessment studies must be done to ensure vector, environment, and human safety. To sum up entomovectoring, if properly implemented will be a win-win situation for every component of ecosystem.

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