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Conservation of Natural Enemies in Agricultural Pest Management

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Most species of insects and mites in nature are harmless. Some are even doing important pest management work for us. These useful insects, mites, and spiders are referred to as "natural enemies". The natural enemies of plant pests are considered farmers' friends as they help the farmer to keep pests (and some diseases) under control and prevent them from causing economic damage. Natural enemies mainly include predators and parasitoids. Predators are one type of natural enemy which tend to keep the population of their prey in check. They catch and eat other insects and mites, including pest species. Parasitoids are another type of natural enemy which lay eggs in or on other species of insect (called hosts) and the larval stage kills the host as it feeds on it and develops (DeBach & Rosen, 1991). Natural enemies are subjected to continuous deterioration in populations, especially in modern agricultural systems characterized by complete removal of plants after harvesting as well as by insecticide applications. This complete removal of plants gives rise to the disappearance of natural enemies after each crop season (El-Wakeil, 2017). When farmers go for monocropping *i.e.* all one species of plant, it inevitably disturbs the natural balance. Further, the beneficial effect of predators and parasitoids continue to be disparagingly important. Because of their vital importance in reducing the pest population, there is a need for conservation or enhancing the natural enemies' population in the agroecosystem.

Ways to conserve the natural enemies

Conservation of natural enemies involves reducing factors that interfere with natural enemies or providing resources that natural enemies need in their environment (Dreistadt, 2014). Through several ways such as ecological engineering, judicious use of pesticides and some other tactics, natural enemies can be conserved which are discussed briefly hereunder:

Ecological engineering / Habitat manipulation

Emerging technology to enhance biological control in an agroecosystem by preserving or enhancing plant diversity or providing adequate refugia for pest's natural enemies. Ecological engineering is defined as the design, restoration, or creation of ecosystems/ habitats, with a strong emphasis on ecosystem self-design and self-organization. Habitat management will provide natural enemies with suitable resources that are limiting for species and that do not invoke unwanted side effects. A wide range of approaches are being developed by researchers and adopted by practitioners to ensure that appropriate forms of diversity are deployed for pest management via ecological engineering (Gontijo, 2019). The different approaches are discussed hereunder:

1. Chocolate-Box Ecology: Floristically diverse vegetation is added to provide adequate nectar, pollen and a nutritious diet for natural enemies. Nectar (extra-floral nectar) produced by various plants is a chief food source for adult parasitoids (Rose, 2006).
2. Changing cropping system: Various adult parasitoids and predators profit from sources of nectar and the protection provided by refuges such as hedgerows, cover crops, and weedy borders. Mixed plantings can upsurge the diversity of habitats and can provide alternative food sources and housing to natural enemies.
3. Beetle bank: Offering suitable overwintering habitat within fields by crafting a raised earth bank and sown with perennial grasses is termed beetle banks. It helps natural enemies to survive and get protection from harsh environmental conditions (Saadah & Haryadi, 2021).
4. Microclimate: It is the climate of a very small or restricted area and differs from the climate of the surrounding area. For instance, shelter has been provided by augmenting leaf debris on the orchard floor with peppermint, wrapping the bases of apple trees in vegetable debris held in place with plastic, and placing similar debris around the base of smaller trees or providing on tree refugia of burlap and aluminium in peach.

Judicious use of insecticides

Insecticides are the most toxic pesticide class to predators and parasitoids, followed by herbicides, acaricides and fungicides. Natural enemies are sensitive to the effects of certain pesticides. They tend to reproduce more slowly than pests and will usually take longer to reconstitute their populations after a pesticide application. If the beneficials are destroyed, pests that no longer have rivals may multiply more quickly. This increase in pest population could result in infestations that are shoddier than they would have been had nothing been done at all. There are some strategies which can be adopted to reduce the impact of pesticides on the natural enemies:

1. **Avoiding broadspectrum insecticide**: The use of insecticide with a broad mode of action harms the predators and parasitoids. Pesticides can infect natural enemies either directly (causing mortality) or indirectly (impairing its behaviour or any other sublethal toxicity such as detrimental effects on different developmental stages) (Cloyd, 2012). Spraying with selective insecticides can overcome the negative impact of pesticides on the natural enemies (Bueno, 2017).
2. Time of application: Spraying time also decides the fate of pesticides on the natural enemies. Usually spraying should be done in the early morning hours or late evening hours as the activity of natural enemies and other pollinators will be less.
3. Use of biopesticides: Plant-derived pesticides such as NSKE, Neem oil, *etc*. and entomopathogens such as fungi (*Beaveria* Sp, *Metarhizium* Sp., *etc*), Nematodes (*Stenorhabdus* Sp) are known to have a least significant impact on the natural enemies.

Other approaches

1. Leaving pest residues: While applying pesticides, some area is left untreated so that some pest population is available for the survival and multiplication of natural enemies.
2. EBIPM: Ecologically Based Integrated Pest Management (EPM) is an approach to increase the strength of natural systems to strengthen the natural processes of pest regulation and advance agricultural production.

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