

# ECOLOGICAL ENGINEERING: SUSTAINABLE PEST MANAGEMENT STRATEGY

## Abstract

Ecological engineering is one of the modern concepts for pest management in agri-horti ecosystem which emphasis on the diversification of vegetation on and around the farm in order to modify the ecology of that agro-ecosystem, through habitat manipulation. These interventions like raising of indigenous resources, trap cropping, inter-cropping, beetle bank etc. offer an appropriate environment within the agroecosystem to fulfil the shelter and dietary requirements and helpful in creating a suitable environment for the natural enemies to flourish which in turn helpful in suppressing the pest population. In long run the different practices involved in such diversification or habitat manipulation helps in the conservation of bio-control agents. The ultimate aim of ecological engineering is to provide a sustainable ecosystem for the management of pests without causing any risk to environment and human health. Thus, keeping in view the importance of ecological engineering in maintaining ecological balance, the authors have discussed some of the approaches and their application for sustainable pest management, on-farm management and conservation of biodiversity of natural enemies and sustainable crop production.

**Keywords:** Ecological Engineering, Pest Management Strategy, Agri-Horti Ecosystem, Parasitoids.

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Ecological engineering is the modification of agroecosystems in a way to encourage the survival, reproduction and conservation of predators and parasitoids by applying ecological principles involving habitat management (Increasing the chances of survival for the natural enemies) and habitat manipulation (Declining the chances for pest to survive). Ecological engineering provides sustainable solutions for environment which in turn promotes biodiversity, natural balance, reduces environmental pollution, suppressing pest resistance and resurgence problems. Implementation of ecological engineering requires knowledge and a detailed understanding of existing environmental factors, existing scenario of predators and parasitoids and their interaction with pest population. The ecological engineering via management of habitat offers an appropriate environment within the agroecosystem to fulfil the shelter and dietary requirements like pollen and nectar for adults of natural enemies. Odum used the term “Ecological engineering” first time, described as manipulation of environment by human beings by using less supplements of energy to control the systems in which main energy is still coming from natural sources (Odum, 1962). It focusses on minimizing the mortality of natural enemies by offering additional resources for manipulating the host plant characters to help bio-agents to survive and multiply, which increases the efficacy of their conservation in that particular agroecosystem.

## I. ECOLOGICAL ENGINEERING TECHNIQUES FOR IPM

- 1. Selection of Appropriate Resources:** Habitat management should emphasize for the most appropriate resources which help to sustain the life cycle of natural enemies and also improve and increases their chances of survival without causing any ill effects. Number of frequent visits determine the attractiveness of a particular host plant. Fiedler and Landis (2007). Under the field conditions sugar content increases in the gut of *Diadegma insulare* which in turn improves its survival, longevity and fecundity (Lee and Heimpel, 2008). This study thus provided exceptional indication that the availability of floral resources can help to meet out the sugar need of natural enemies. If these resources are under limit the natural enemies have to meet out the dietary requirement from what is obtainable from the crop and from weed flowers and from the available flora surrounding the field. Relatively higher parasitism rates were recorded from population of rape pollen beetles nearby the field boundaries in comparison to the centre of the simple landscapes (Thies and Tschardtke, 1999). Both the studies show that availability of essential nutrient providing resources in the surroundings has a vital role in the effective management as well as conservation of natural enemies.
- 2. Trap Cropping:** Trap crops are being used to attract or to distract or to capture herbivorous insects which in turn reduces the losses to main crop (Shelton and Badenes-Pérez 2006). As soon as the pests are gathered on trap crops, can be easily managed by application of pesticides only on trap crops or by the destruction of these trap crops sheltering pest population (Pickett et al. 2014 and Reddy 2017). Even though the trap crops have been often used against one particular pest species, may be useful for other pests also. For example, in cotton fields at China, velvetleaf weed (*Abutilon theophrasti* Medicus) works as trap crop for *Bemisia tabaci* Gennadius as well as for *Sylepta derogata* (Lin et al., 2015). Spraying of insecticides on the weed, velvetleaf after sufficient pest accumulation is effective to control them in fields of cotton. The host plant selection by phytophagous insects is influenced by the species of crop and its cultivar and also by plant and pest phenology (Hokkanen 1991). The lure and the spatial coverage of

the trap crop decides its role in effective pest control strategies (Gillespie et al. 2011, Sarkar et al. 2018).

- 3. Inter-Cropping:** Raising two or more diverse crop in the same area is known as inter-cropping. Inter-cropping, it is a key cultural technique applied for pest management by minimising insect pest population and by enhancing ecosystem variety. Strip cropping is also type of inter-cropping in which two or more crops are grown in alternating strips over a field. Inter-cropping acts on phytophagous insects by dividing their population load among main crop and inter-crop, which in turn reduces the pressure of insect pests on main crop. The chemical cues from the intercrop repel or change the insect behaviour reduces the losses caused by pests (González- Chang et al. 2017). Inter-crop also acts as a physical barrier and restricts the movement of pest within the main crop, it also provides floral resources for the associated natural enemies (Smith and McSorley, 2000). Inter-cropping of Celery, *Apium graveolens* L. in fields of cucumber act as repellent and oviposition deterrent for whitefly, *Bemisia tabaci* and declines the population of whitefly on cucumber plants (Tu and Qin 2017).
- 4. Providing Alternate Food Sources:** Free-living adults of parasitoids require nectar and pollen for longevity and reproduction. Hence, providing alternate nectar and pollen producing plants in or nearby the fields increases the abundance of parasitoids. Fava bean, greengram, lentils, marigold and cotton are rich food sources for adult parasitoids. Wildflower strips are the source of pollen, nectar, shelter, improve fitness of natural enemies and their multiplication. The effects on predators and parasitoids include increased longevity, chance of survival, and fecundity. Management of wildflower strips are also helpful in increasing the populations of some indigenous natural enemies by providing essential food elements (Briner 2002).
- 5. Beetle Bank:** Beetle banks in agriculture or horticulture are manged on the raised ground strips of native perennial grasses or plants that provides shelter and food to the indigenous beneficial fauna. Beetle banks not only reduces the use of insecticides and can also serve as habitat for predatory birds, insect pollinators and insect predators (Carabidae , Cicindellidae, Coccinellidae, Formicidae, Sphecidae, Vespidae etc.) and parasitoids (Braconidae, Ichneumonidae, Scelionidae, Trichogrammatidae etc.). An attempt was made in England to provide a suitable habitat for the overwintering population of aphid predators within fields, research scientists sowm perennial grasses like *Dactylis glomerata* and *Holcus lanatus* parallel with the main crop to serve the purpose of Beetle Banks. These banks when run parallel with the rows of main crop leads to achieving higher population of predators (up to 1500 beetles/ Sq. m) within only first two years (Landis et al., 2000). Such landscapes in horticulture ecosystems enhancements at advanced trophic levels which can provide efficient preying sites for owls and raptors (Vickery et al., 2002).
- 6. Chocolate-Box Ecology:** Habitat manipulation by adding floristically diverse flora to enhance pest management has been referred as “Chocolate-Box Ecology”. Floral diversity provides sufficient pollen, nectar and nutrient rich food to natural enemies, this style of habitat manipulation now needs to find out the more frequently available plant species to work out the optimal composition of species or assortment of selection measures to determine most suitable botanical composition (Pfiffner and Wyss, 2004). These measures reflect that the excellence of the diversification (Polaszek et al., 2004)

and involves the selection from native flora for right kind of diversity composition. Extensive strategies are being studied by research persons and employed for the confirmation of the appropriate composition of native diversity which are being deployed for the management of pests in different agriculture and horticulture-based ecosystems via ecological engineering (Gurr et al., 2004).

7. **Push-Pull Strategy:** Push-pull strategies works on the principle of manipulation in behaviour of the pests and their associated natural enemies by incorporation of stimuli that act as a protected resource, unappealing or not suitable or not attractive to the pests (push) while luring them in the direction of favoured and an attractive source (pull) from where the pests are subsequently removed (Cook et al. 2007). Push-pull strategies are based on the principle of using a amalgamation of behaviour by altering the stimuli to manipulate the spread and abundance of pest and/or bio-agents for management of insect pests. These tactics are targeted against the insect pest and try to lower their population on the protected resources or main crop. The pests are repelled away from protected resources (push) and simultaneously attracted towards (pull) attractive stimuli, such as trap crops where they are concentrated, facilitating their population suppression. The approaches involve the collective use of inter-crops and or trap crops, use of most suitable plant species for the farmers and that also exploit and conserve natural enemies. *Chilo partellus*, stem borer of maize can be efficiently managed by using *Melinis minutiflora*, molasses grasses as an inter-crop that attracts insect pests (push factor). *Pennisetum purpureum*, napier grass or *Sorghum vulgare sudanese*, Sudan grass used as trap crops (pull factor) to distract oviposition of *C. partellus* on maize plants (Khan et al., 2001, Khan et al., 2010). Freshly emerged stem borer larvae fail to survive on napier grass because of a sticky exudate produced by it immobilizes the larvae and prevents feeding (Khan et al., 2014). This strategy is found to be very efficient in increasing the diversity of beneficial fauna, partly because of no use of pesticides from very long period to control *C. partellus* (Khan et al., 2014).

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