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Landscapes and floral resources –important components for insect biodiversity and biological control

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Insects are wonderful creatures in nature and are admired for the multitude of functions they possess. The benefits derived from insects are enormous and the gains are directly related to their diversity. Biodiversity by and large leads to community stabilization, ably supporting all forms of life on this earth. Insect biodiversity per se is of utmost importance for all the vital functionalities of various ecosystems. Landscapes in general and floral resources contribute to the biodiversity and conservation of functional insect groups. The insects though, comprise both harmful and beneficial groups, the diversity of either of the groups is economically important, and understanding their dynamics aids in managing ‘insects with insects’.

In an era where agricultural land is shrinking day by day and experiencing a decline in the net cultivable area, there is a greater demand for higher agricultural production and productivity coupled with reduction of crop losses, which take place due to various factors. Reducing crop loss contributes to net production and food security. In this direction, sustainable crop

protection measures play a crucial role in enhancing productivity and profitability. In the recent past, the deleterious effects posed by chemical pesticides necessitated the exploration of alternate plant protection strategies, especially biological control which is ecologically feasible, environmentally compatible, and economically viable. In this direction, conservation biological control is gaining momentum where biocontrol agents *viz.*, parasitoids and predators, the natural enemies of insect pests, are being conserved and augmented for controlling the insect pests (Barbosa, 1998). It is one of the sustainable approaches that alleviate chemical pesticide usage in managing crop pests (Begg *et al.*, 2017). These bioagents are valuable natural resources that need to be conserved to keep the pestiferous insects below the economic threshold level. The ecosystem services rendered by natural enemies in suppressing the insect pest population are invaluable and estimated at a value of \$4.5 billion on this service annually in the United States alone (Losey and Vaughan, 2006).

Conservation biological control is where natural enemies are integrated into crop ecosystems for the purpose of natural pest management, aiding in the sustainability of agricultural production, and conservation of natural resources that fit into the sustainable development goals set by the United Nations Organization. Conservation biological control is the fourth method of biological control in addition to classical, augmentative and inundative biological control. The abundance and diversity of biocontrol agents are directly proportional to the conservation measures that include plant and habitat diversification along with enhanced landscape complexity (Begg *et al.*, 2017). The agricultural crop ecosystems receiving high doses of chemical pesticides are posing a threat to the natural enemy diversity and survival. The insect pests being 'r' strategists and natural enemies being 'K' strategists, a small factor contributing to the rapid buildup of parasitoid and predator populations, will limit the insect pest abundance in the crop ecosystem.

The designing of landscapes and the type of floral plants chosen matters a lot in promoting the insect parasitoids and predators as the insects have their own preferences towards floral resources. Though the natural enemies are entomophagous, preying upon insects, a certain part of their life depends on floral resources. Therefore, the survival rate of the insects' natural enemies will be enhanced with floral

diversification. Maintaining diverse flowering plants will nurture a wide range of beneficial insects, be it pollinators or insect biocontrol agents, where the adult insects rely on pollen and nectar as their diet. The manipulation of agricultural landscapes for the conservation of natural enemies has been widely practiced and reported in Western Europe and North America while other parts of the world are comparatively slower in adoption.

The landscape management for conservation of insect biocontrol agents includes plant diversification and non-crop vegetation conservation supplemented with artificial foods (Penalver-Cruz, 2019). The areas surrounding the agricultural crops must be planted with diverse flowering plants and maintain the natural habitats to attract and conserve natural enemies. This conservation biological control goes well with nature-based solutions, which are being given top priority by the International Union for Conservation of Nature (IUCN) and working towards the sustainable management and restoration of ecosystems for the well-being of all. In this direction, the replenishment of natural resources through clever management is the need of the hour. Protection and conservation of nature including conserving all life forms on this earth ultimately requires us to remain in harmony with nature.

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