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Habitat manipulation for effective biological control

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Habitat manipulation involves altering the cropping system to conserve, augment or enhance the effectiveness of a natural enemy. Habitat manipulation also called as ecological engineering, aims to improve the living conditions for natural enemies within the agro ecosystem, by introducing resources needed for fulfilment of their vital requirements. Growing plants providing food in the form of nectar and pollen, additional non-pest prey, provision of structural diversity (for shelter) and breeding and overwintering sites are key factors. The broad group of natural enemies may include pathogenic fungi, nematodes, insects, mites, birds, amphibians or mammals. Habitat manipulation aims to counter the negative effects caused by agriculture by increasing plant diversity in the agro ecosystem.

Approaches :

Top down control : Here herbivores are suppressed by the natural enemies (Augmentive biological control).

Bottom up control : Manipulation within crop, such as mulching and cover crop that act on pests directly being repellent of toxic (Conservation biological control).

Factors affecting effectiveness of biological control:

Agricultural practices : Modern agro ecosystems are typically low in biodiversity and frequently disturbed by farming practices. Within the field, a few crops and cultivars are most typically grown as monocultures. These fields are often treated with chemical herbicides to control weeds, leaving few flowering plants producing nectar and pollen for natural enemies. Cultural crop practices in the form of mechanical soil treatment, *i.e.* ploughing and harrowing, can disturb the over wintering life stages.

Landscape : The outcome of biological control in a crop is associated with the surrounding landscape. The establishment of larger and easier to manage fields has led to loss of structurally complex elements composed of herbs, shrubs and trees at the field borders. These are important overwintering and nesting sites for many natural enemies. Furthermore, at landscape level the losses of natural and semi natural habitats such as wetlands, meadows and pastures have drastically changed the living conditions for birds, mammals and invertebrates. A more complex landscape can, to a higher extent, provide natural enemies with resources such as overwintering sites, prey/ hosts and plant-derived food and can thereby sustain a greater abundance and species diversity than a simple landscape. Natural enemies can spill over from the complex landscape into the production fields when pest prey is abundant.

Landscape connectivity : The efficacy of biological control in the field is also associated with the ability of natural enemies to disperse in the landscape between different habitat types. Some natural enemies use green corridors, which connect complex and species-rich habitats such as forests with low diversity arable fields, as highways along which they can move more rapidly into arable fields and colonise crop plants attacked by pests. For instance, it was shown in a scientific study that a green corridor consisting of herbs and grasses, which cut through a field of vine stocks, improved predator and parasitoid movement between a natural habitat and the vineyard throughout the growing season, leading to a reduction in the numbers of some pest insects.

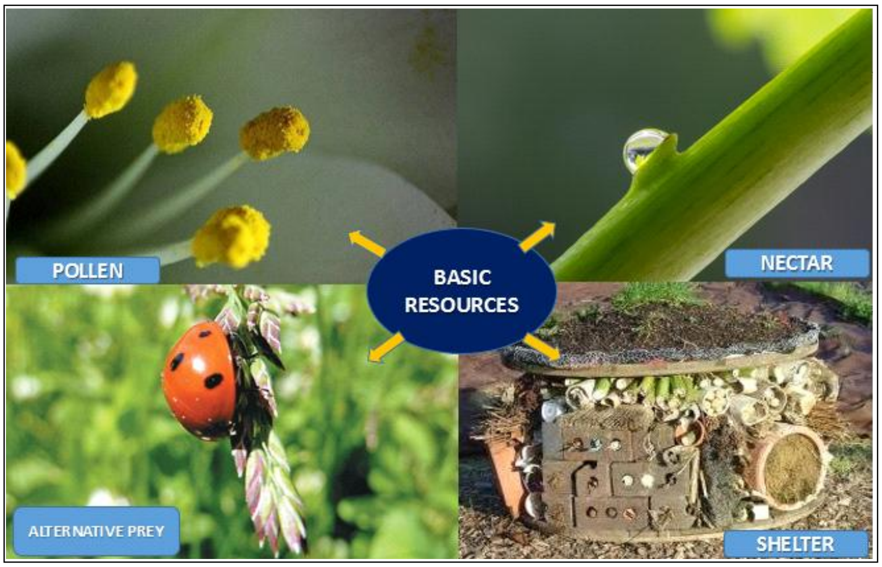
Basic resources needed in habitat manipulation :

Shelter : Provision of shelter habitat in field influence the abundance, diversity and distribution pat- terns of natural enemies. It provide protection from anthropologically operations and disturbances (ploughing and harvesting). They are most important in providing overwintering sites for survival in off seasons. They can also offer suitable sites for breeding. Examples of shelter habitats outside the field can be hedgerows, ditches and field margins. Vegetation in these structures is often a mixture of grass, herbs, bushes and trees created by natural succession. Shelter habitats within the field consist of perennial grass and/or flowering herbs selected to be beneficial for natural enemies.

Nectar : Nectar can either be produced inside flowers, *i.e.* floral nectar, or in glands outside the flowers, *i.e.* extrafloral nectar.

Floral nectar **:** Nectar is energy-rich and is used by natural enemy insects from different orders such as Diptera, Coleoptera and Hymenoptera. It consists of different sugar compounds (mainly sucrose, fructose and glucose) and smaller amounts of other compounds such as amino acids, lipids, alcohols and alkaloids. The composition of nectar differs between plants and various growing conditions.

Extra-floral nectar (EFN) : Total sugar concentration is often higher in EFN than floral nectar. The difference arises from where it is secreted. Extra-floral nectar is produced in glands outside the flower and can be found on leaves, stipules, stems, cotyledons and fruits. It is produced during longer periods than floral nectar and it is easily accessible for most natural enemies and therefore useful for habitat manipulation programmes. However, unlike the nectar produced in flowers, extrafloral nectaries are not advertised with brightly coloured flowers or floral odours, and are therefore more difficult to locate for food-searching natural enemies. Parasitoids and other natural enemies can probably learn to identify cues associated with extra-floral nectaries after successful feeding events. This may facilitate future food foraging for extrafloral nectar.



Alternative prey and host : Most natural enemies can feed on more than one type of prey, *i.e.* they are polyphagous. During periods when the preferred prey is absent, or only found in low numbers, natural enemies can shift to other prey of a suitable size, so called alternative prey. Similarly, parasitoids that can parasitise and develop on more than one specific host species may benefit from having access to alternative hosts. Alternative prey/host can thus be crucial for the survival and reproduction of natural enemies. From a biological control perspective, alternative prey can be a key resource to maintain natural enemies within a production area at times when pest populations are low in the field or before the crop is planted and after it has been harvested. Furthermore, availability of alternative prey in field margins early in the spring can increase the abundance of natural enemies and accelerate their colonisation of the crop field later on, when pest insect populations start to build up.

Pollen : Pollen is a source of proteins and amino acids for many natural enemies. Pollen consists primarily of nitrogenous compounds, mainly proteins, and other less common compounds such as lipids and sterols. The importance of pollen as a food for syrphid flies and lacewings has been well studied. However, lady beetles, predatory hemipteran bugs such as *Orius* spp. and predatory mites also benefit in terms of increased life length and reproduction capacity when feeding on pollen at times when animal prey is scarce. Pollen feeding by parasitoids is less common, although it does occur. Natural enemies often show a preference for pollen from specific plants and not all pollen types are equally well suited as natural enemy food.

Conclusion : During this process pest insects, higher order predators and hyperparasitoids can also utilise food plants introduced into the agro ecosystem. It is therefore important to use selective food plants that are mainly exploited by natural enemies.

Conservation strategies such as mixed plantings and the provision of flowering borders can be more difficult to accommodate in large scale crop production. Before proper planning in a habitat manipulation there is a need to study various tritrophic interactions existing in the ecosystem. Field execution of habitat manipulation concept involves multi-departmental cooperation and research orientation. Finally the most important thing may be reducing the gap between the farmer and the research findings.

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