INCREASING DIVERSITY IN AGROECOSYSTEMS

Sue Thomas from the University of Southampton overviews a subject touched on in several past issues of *Pesticide Outlook*. This introduction is followed by two example approaches, one from the USA and one from the UK

The chemical control of insect pests has a number of well-known difficulties. Many chemicals are highly toxic, often persistent, and affect not just the target, but also many other incidental organisms; including invertebrates that provide varying degrees of natural pest regulation. They have also been clearly implicated in the declines of many invertebrate groups such as butterflies, grasshoppers and insects fed on by farmland gamebirds and songbirds. Such birds, also mammals, amphibia and reptiles, have all suffered severe population declines through not only losses in such feeding resources, but also through detrimental effects on reproduction and direct toxicity. Workers applying treatments often fare little better – pesticides are implicated in human health problems and deaths to a disturbing degree world-wide. Additionally, pesticides have the problem of resistance development by the target organism. Regardless of whether the chemical has been formulated to have a highly specific mode of action, to be applicable at progressively lower rates, using precision-application techniques, such resistance will remain limiting.

Within a system of integrated crop management, biological pest control is a useful addition to chemical and other control measures. It may not be quite as fast acting, nor may exterminate all pests, and often has unpredictable success because of weather effects. However, the agents of attack are self-propagating, adaptable to resistant behaviours of the prey species, inexpensive to initiate into action and manage, and have very few side-effects.

One major method of increasing the potential for bio-control within the agroecosystem involves the manipulation of the cultivated environment and/or its surroundings – in particular, the incorporation of greater plant diversity within or near the crop. Intensification of production has often led to the lessening of such diversity. A former view of the conditions required for optimal yields involved absolute 'cleanliness' of the production area, with any incidental insects and plants deemed solely as detrimental. It is now realised that such a system is unsustainable, and the diversity loss that has occurred is unacceptable with regards both long-term benefits to the farmer, and implications for conservation.

Why is increased plant diversity advantageous?

Working against pests

Herbivorous pest species may locate their hosts by responding to volatile chemicals emanating from the plants. If the crop environment is saturated with a variety of such pheromone cues, from the presence of different plants, host location behaviour can be confused, and the pest may be less likely to settle. Even simple visual cues for finding the target plant can be disrupted when there are other species present. Finally, where there are weeds growing, pests may spend less time feeding on the crop plants themselves.

Working for beneficial species

There are many different species of natural enemy of crop pests. In an earlier edition of Pesticide Outlook, J. M. Holland reviewed those that may be found within the arable ecosystem, and described the effects of farming practices on their populations (Holland, 1999). Polyphagous predators including beetles and spiders, aphid-specific hoverflies, ladybirds and lacewings, and parasitoid wasps were considered. In the same edition, K. D. Sunderland examined spiders, one particular group that can be valuable for their contribution towards biological pest control (Sunderland *et al.*, 1999). There is a multitude of literature supporting the view that increased vegetational heterogeneity in and around the cultivated area favours an enhanced assemblage, in terms of abundance and diversity, of these predatory and parasitic organisms (Ellis, 1992; Powell *et al.*, 95; Zangstra & Motooka, 1978).

Natural enemies may not survive if they reduce all their prey to low or zero levels, thus the presence of alternative prey on other plants in the agroecosystem will enable them to survive and facilitate subsequent pest reductions. Weed plants may provide additional physical niches in which beneficials and their alternative prey species can live, supporting densities according to the complexity of the vegetation. Many beneficials have specific habitat requirements for successful survival. They may remain quiescent within plants at times in the year when conditions may be restrictive, *e.g.* over the winter period when crop fields may be barren. They may prefer the higher humidity of weedy areas. Other species require other resources; e.g. parasitoid wasps and hoverflies need flowers in the landscape to acquire pollen and nectar.

Problems

Wild plants may act as reservoirs of crop pests, as well as of some diseases. Pests may also use the extra resources available, especially of flowers. However, the benefits in increasing natural enemies are usually considered to outweigh these disadvantages.

What techniques are available to the farmer?

Trap crops

Trap crops concentrate pests to a small area of the field, where they can then be eradicated. Pesticides can be applied here only; or to limit the chances of resistance developing, this part can be ploughed in or fed to livestock. Earlier-sown crop plants, species particularly attractive to pests, specially located plants, or tall plants grown to filter out approaching flying insects, are options that may be utilised. Inevitably, some area yield loss has to be tolerated.

Intercropping/strip cropping

Two or more crops are cultivated together in parallel strips or closely arranged patches, in the same field. Where a low crop grows under a taller one, weed competition is reduced because of greater ground cover, with reduced soil erosion and water loss. Biocontrol by generalist predators may be more efficient, and host location by pests less effective. Higher labour and management costs, less efficient harvests and yield reductions restrict enthusiasm for incorporation within cereals although it has been used with crops such as sweetcorn, cabbages, beans and courgettes.

Undersowing

A second crop is sown within a first, either at the same time or later, giving two consecutive harvests; e.g. grass leys may be established under spring barley, or clover within Brussels sprouts. Beneficial densities may be greatly enhanced, resulting in aphid declines. Where crops are under-sown with leguminous plants, natural soil fertility may also improve. However, high dicotyledonous weed levels that can develop in under-sown fields can be viewed as unacceptable, and the system is currently little used.

Conservation headlands

The outer six metres of the field receive only selective spraying with narrow-spectrum pesticides, which also reduces drift and deposition into the field boundary or hedge. Greater plant and insect diversity can thus develop in an area of the crop that may less productive anyway because of compaction or shading, and game species will often benefit (Sotherton, 1992; Sotherton & Page, 1999).

Weed strips within the crop

The sowing of several narrow strips of flowering weed plants or grasses at intervals across the cultivated area can increase the abundance of aphid-feeding predatory insects within it (Frank, 1997; Wyss, 1995). Insect diversity may increase the longer the strips are left *in situ*, though such areas may be intrusive to the cultivation and weed control of the whole field.

Field margins and beetle banks

The good management of existing field margin areas and hedgerows, reconstruction of those removed in the past, or the growing of replacement annual or perennial grass and/or flower strips all have the advantage in that they do not interfere with the crop area. They are especially important where field sizes are large. Such schemes effectively increase the amount of habitat available for predators and parasitoids to survive through winter, reproduce in spring, and feed in summer, thus heightening potential biocontrol within crops (Dennis & Fry, 1992; Sotherton, 1995). Weed invasions from such areas are rare, though there are occasional problems with pest enhancement such as slug density increases (West *et al*., 1997; Frank, 1998). Financial incentives for better field margins are good – sowing a simple strip of *Phacelia tanacetifolia* around a field to help hoverflies is little expense for a valuable return, and funding for more complex projects is increasingly available.

Examples of plant diversity enhancement

Ongoing work at a number of research establishments seeks to evaluate the importance of increasing plant diversity in the agroecosystem. The University of Southampton, in conjunction with The Game Conservancy Trust, UK, and collaboration of the University of Washington and Washington State University, US, are two examples, and aspects of their work are outlined in the following articles.

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