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Functional agro biodiversity in Dutch arable farming: results of a three year pilot

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Abstract: A pilot on 400 ha of Dutch arable farms during 2004-2007 perennial grassy field margins and functional annual flower strips were created on potato and wheat fields. Monitoring information on pests and natural enemies was directly communicated to the farmers to support pest management decisions. Due to the increasing numbers of natural enemies and the gradually reducing peak densities of aphids, the farmers could refrain from insecticide applications against aphids in these crops. The pilot has yielded great public awareness on possibilities for functional agro biodiversity in arable crops.

Key words: natural pest control, conservation biological control, field margins, sustainable agriculture, pesticides, agro economy

Introduction

On initiative of the Dutch farmers organization (LTO) and the two ministries responsible for agriculture and environment, a Functional Agro-Biodiversity (FAB) pilot was started in 2004 on four arable farms in the province of Zuid-Holland. The aim was to increase biological diversity, to enhance natural enemies of pests, and ultimately to reduce the use of pesticides. The pilot was intended to deliver knowledge and practical experience on how to enhance this functional biodiversity without compromising the agro economical conditions of the area (Van Alebeek et al., 2006).

To enhance functional biodiversity, the waterboard and other local institutions were asked to improve the quality and management of semi-natural vegetations on dykes, ditches, road sides and hedgerows. At the field level, project farmers created field margin strips with perennial grasses and/or an annual flower mixture. Moreover farmers were advised to restrain the use of insecticides and to preferentially use selective insecticides that have little effect on the main natural enemies. The impact of these measures on natural enemies and pests were studied during 2005, 2006 and 2007 in wheat, potato and Brussels sprouts. The latter vegetable crop required a somewhat different approach and is discussed in a separate paper (Van Rijn et al., this issue).

Functional Agro Biodiversity (FAB)

In this FAB pilot the emphasis was on 'conservation biological control'. Winter habitat and adult food, two resources that are often in short supply for natural enemies in modern, large scale agricultural landscapes were specifically addressed in this large scale field study. As crops are on the field for only a part of the year, natural enemies have to seek refuge in other habitats during the rest of the year. For some lacewings, hoverflies and ladybeetles trees and scrubs are important overwintering sites (Sarthou et al., 2006). The less mobile carabid and staphylinid beetles benefit more from grassy vegetation alongside fields, ditches and canals (Thomas, 2004). Although natural enemies obviously feed on prey during (part of) their life cycle, many species, including parasitoids, hoverflies and lacewings, solely feed on sugar sources or pollen during their adult stage. Field margins can provide these resources, if the right types of flowers are presented (Wäckers et al., 2005).

Material & Methods

Landscape elements
The project area consists of four arable farms (400 ha.). Woody landscape elements take up approx. 5% of the project area including *Salix* spp. vegetation on a river bank, some *Populus* spp. bushes and several smaller mixed bushes and hedgerows consisting of some 10-15 tree and shrub species. The area is crossed by several dykes, which are partly grazed by sheep or cattle, partly infrequently mown. Grass and riparian vegetations on dykes, road verges, along canals and ditches make up approx. 8% of the project area. All arable fields are largely enclosed by ditches with relatively steep ditch banks.

Field margins
Two types of field margin strips were created: perennial and annual strips. In spring 2005 10 km of 3 meter wide perennial field margins were created, largely along ditches and connected to the larger network of landscape elements mentioned above. These margins were sown with a mixture of 18 different grasses and forbs (1:1). Each year in April 4 to 5 km of annual flower strips were sown on 8 or 9 different fields. The species of these strips (see results) were selected for their suitability in providing (floral) food for winged natural enemies and the low risk of supporting pests (Wackers et al., 2005).

Experimental design and monitoring
Each year 3 experimental fields of potato and wheat were selected, if possible with a perennial field margin present. The fields were 400-600 m long and 100-300 m wide. In half of each field annual flower strips were created at one margin and on driving lanes within the field, 75-90 meters apart. In both halves of the fields crop plants were monitored 4-7 times per growing period. Monitoring took place at various distances from the field margin and the annual flowering strips within the field. The numbers of pests and natural enemies were annotated (if possible) per species and life stage. The results were directly communicated with the farmers, to inform their decision making on pest management. Vegetation and flower composition of field margins was determined by quadrate sampling. Flower visiting insects were monitored by direct visual inspection and by sweep net sampling. Ground dwelling predators were sampled by pitfall traps.

Results and conclusions

Vegetation development and natural enemies in field margins

During the project a well balanced mixture of functional plants has been developed for the annual flower strips. It comprises Buckwheat, Coriander, Borage, Cornflower, Fennel and another 4 annual flower species. Sown in early April, it yields field margins lavishly flowering from late May until September. However, the method of sowing and the weather in spring strongly affected weed pressure, flowering time and ground coverage of different species. When the location of annual strips was changed between years, emergence of reseeded plant species sometimes caused weed problems in subsequent crops.

Within the flowering field margins aphidophagous hoverflies were the most abundant natural enemies, followed by lacewings, parasitoids and ladybeetles. The variation in the amount of flowers was clearly correlated with the number of visiting natural enemies.

Carabid beetles are the most numerous ground dwelling predators in pitfall traps, with *Pterostichus melanarius* as the most common species. Staphylinid rove beetles and spiders each take up about one tenth of the total catch. During summer, annual (flower) margins appear to harbour even more ground beetles than perennial (grassy) margins.

Pests and natural enemies in fields

In wheat and potato the main pests were aphids (*Macrosiphum avenae, Metopolophium dirhodum, Rhopalosiphum padi*; or *Aphis nasturtii* and *Macrosiphum euphorbiae*). Aphid numbers typically showed a peak in June or July, with natural enemy peaks trailing by several weeks. Eggs and larvae of hoverflies and lacewings and mummies (parasitized aphids) could be observed shortly after the onset of flowering, with the highest numbers in the fields with annual flower strips. Predatory bugs and ladybeetles were observed in the fields at higher aphid densities only.

Aphid densities along perennial field margins tended to be lower than along flower margins or in the field centres in June, but this tendency reversed in July. In potato fields the peak aphid densities were generally lower in the part with flower margins. Excluding ground predators from enclosures resulted in higher numbers of aphids in spring (both in wheat and in potato fields), demonstrating the importance of ground dwelling predators for aphid control.

Over the three years the peak aphid levels showed a clear decline, whereas natural enemy numbers (especially hoverflies) remained stable or increased. This 3-year increase of the predator-to-prey ratio may result from the measures taken to enhance natural enemies, but unfortunately no monitoring data from other areas are available for comparison.

The low pest levels, and their documentation and communication with the farmers, have resulted in a strong reduction in the application of insecticides. In most years participating farmers applied no or very little insecticides in potato and wheat fields, whereas farmers outside the project commonly used one or two applications per year against aphids.

Socio-economic aspects

The direct benefit of FAB lies in a reduced application of insecticides. The financial benefits are very limited, as the costs of these pesticides are very low (€4-24 per ha) and fungicides still require regular spraying. On the other hand, the 3-meter wide field margins involve costs for seeds (€50-60 per km) and a reduction of production area (net loss in wheat or potato: €250-400 per km). In the absence of product labelling the market value is not affected. For the farmers, field margins are profitable only when compensated by a subsidy, as in the FAB region (*i.e.* €500 per km). Field margins require less labour than a crop, but a FAB strategy requires additional labour for scouting of pests and natural enemies in the field.

Within the Netherlands, the public awareness of FAB and conservation biological control have been stimulated by open days on the participating farms, by special issues of a farmer's magazine and a monthly column by a project farmer in the same magazine. A special issue on agro biodiversity of an entomological magazine is now being used in Dutch agricultural education (Van Rijn et al., 2007).

Discussion

This FAB pilot has yielded practical and scientific information on (1) how to create functional field margins on clay soils, (2) efficient methods of field sampling, (3) the relative importance of different natural enemies for the control of aphids in wheat and potato, and (4) the effects of field margins on natural enemies and aphids in different crops. Secondly, it has shown that FAB measures can be applied on commercial arable farms, and that they result in a reduced need to apply pesticides. Regular monitoring of the pests and natural enemies in the field, and a rapid communication of the results with farmers, are essential for this result. Thirdly, the costs and benefits of FAB measures for the farmer have been assessed. Field margins are economically feasible only when farmers can obtain higher prices for their produce through accreditation schemes or receive compensation from public sources. The communal and environmental services of field margins as part of FAB (e.g. reduction of water pollution, increased biodiversity, recreational value of rural landscapes) may justify such subsidies.

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