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Short Contribution

Effects of biodiversity measures on insects, birds, and vegetation in organic apple orchards in Germany

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Abstract

In a project funded within the framework of the Federal Programme for Biological Diversity, measures to enhance biodiversity in organic orchards were tested in six German regions. On farms across Germany, we established 20 'enhanced plots' in which a standard set of measures was implemented (flowering strips in the alley and at the borders, planting of shrubs at the top of every second tree row). The abundance and biodiversity of various taxonomic groups was then compared between these enhanced plots and paired control plots on the same farm. Additional practical experience with the implementation of such measures was gained in on-farm trials without control plots.

Keywords: biodiversity, flower strips, birds, bugs, grasshoppers, parasitoids, hoverflies

Introduction

In many European agricultural landscapes, species richness and abundance is declining, also of insects and birds that used to be common. To halt these losses, innovative measure are needed that can be integrated into existing production systems. Based on the preparatory work of the subgroup "biodiversity in the orchard" of FOEKO, the organic subproject aims to evaluate and improve measures to enhance biodiversity that can be integrated in the production area. In a participatory process involving organic fruit growers organized in FOEKO in the main fruit growing regions of Germany and in close cooperation with scientists from different disciplines, these measures were evaluated in initially 20 and after 2019 in 16 pilot plots (in one plot there were 2 repetitions). At the end of the project, a catalogue with evaluated measures, which can be integrated into the organic fruit growing system to enhance biodiversity, will be published.

Material and Methods

Starting in July 2016, the on-farm studies were conducted mainly in four regions in Germany: in the southern region with the fruit-growing areas of Lake Constance, Neckar Valley and Baden, the western region comprising Rhineland and Rhine-Hesse, as well as Northern Germany and Saxony. In each region, up to five farms participated in the standard evaluation with two comparable orchards of a minimum size of 1 ha each, or with two plots of the same orchard with a distance between the plots of at least 100 m. In one plot a standard combination of measures to enhance biodiversity was tested, hereafter referred to as "enhanced plot", the other plot served as "untreated control". Additionally, 111 German organic fruit farms participated in the project implementing biodiversity measures without control plots which were used to gain experience and to evaluate the measures on a large scale. The combination of measures included:

- Establishment of perennial flower strips in the alleys
- Establishment of tall perennial flower strips at the border
- Planting of shrubs (*Euonymus europaeus, Viburnum opulus, Ligustrum vulgare*) at the end of each second row

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The **flower strips** in alley had a width of about 0.5 m. They were sown using a certified regional seed mixture of 28 species in the middle of the alleys in autumn 2016 and spring 2017. Additionally, tall flower strips at the borders of the orchards were sown using a mixture of 52 species (Kienzle et al., 2018). *Centaurea cyanus, Matricaria chamomilla, Papaver rhoeas, Sinapis arvensis (wild species), Fagopyrum esculentum* (cultivated species) *and Lepidium sativum* (cultivated species) were added in both types of strips to provide a flowering aspect in the first year and to protect germinating seedlings.

Flower strips in the alleys were mulched 2-3 times per year in an alternating pattern, mulching at any time only every second row, and was timed depending on the height of the vegetation. The edges of the alleys were mulched more frequently. For this purpose, a special mulching machine that can mulch only the edges of the alley was used. The tall border strips were mulched only once in late autumn or in spring. In the orchards, the usual plant protection management in organic apple growing was applied.

Agronomic and biodiversity assessments were carried out in both variants at least four times a year, before or during blossom, in June, July and August. Vegetation was monitored through flowering phenology surveys, which included recordings of the species flowering in the alley centers as well as their flowering frequency. To sample the arthropod fauna, beating tray samples were collected from the tree canopy and sweep net samples were taken from the middle of the tree alley. Malaise traps were set up in one orchard per region twice a year (in mid and late summer) for three days each. Malaise trap, sweep net and beating tray samples were completely evaluated to morphospecies level. In addition, the abundance of wild bees, butterflies, and grashoppers was recorded using transect counts. Nest boxes for birds and wild bees were put out on both the enhanced plots and control plots in 2017. Occupancy of these nest boxes was checked at least once per year. In June before fruit thinning and in autumn before harvest, 1,000 randomly selected fruits per orchard were controlled for damage by insects. All skin injuries that could not be attributed without a doubt to fungal diseases or to russetting, hail, etc. were recorded. Rare or unclear skin defects were documented photographically. This should allow to identify the possible incidence of uncommon insect damage in the plots with weed strips.

Results

Perennial flower strips were successfully established in the alleys of enhanced plots. Compared to the regularly mulched alleys in the control plots, they held a much higher diversity of flowering plants. This plant diversity is similar to that of meadows mowed 2 to 3 times per year. Likewise, tall flower strips on the borders were successfully established. Their plant species composition and structure differed considerably from that of the alley flower strips, thus providing valuable additional resources. **Morphospecies sorting** revealed higher numbers of individuals and morphospecies for beetles and parasitoid wasps in enhanced plots compared to the control. This is true for the years 2018-2020 evaluated to date (2021 pending). Parasitoid wasps are of interest for further identification to species level, as they are important antagonists of common pests, such as stink bugs, aphids, leafminers and leafrollers. Flower strips also attracted **hoverflies**, which are pollinators and their larvae are important antagonists, praying on leaf aphids. Counts and identification of hoverflies caught by malaise traps showed higher numbers of individuals and species in enhanced plots. Generally, the number of **grasshoppers** in the enhanced plots was significantly higher than in the control plots. Moreover, the number of individuals in the biodiversity plots strongly increased from 2017 to 2021 while it remained at a relatively low level in the control plots. However, grasshopper abundance varied strongly between orchards.

Across all regions, the **bird species** that were found most often in the nest boxes were Eurasian tree sparrow (*Passer montanus*), great tit (*Parus major*) and blue tit (*Cyanistes caeruleus*). Between the enhanced plots and control plots, no difference could be detected regarding the occupation of nest boxes by birds. However, in all regions, an increase in the percentage of occupied nest boxes was observed from the first year to the fifth year of the project.
In the **agronomic evaluation**, no relevant effect of the biodiversity measures on fruit damage could be found. Furthermore, the farmers participating in the survey did not give notice of any fruit damage that seemed to correlate with the biodiversity measures. Damage by stink bugs occurred in two trials in Eastern Germany and in one trial at Lake Constance. In Eastern Germany the damage was probably correlated with the occurrence of *Palomena* spec.. In this case, the number of orchards concerned is too low to establish a clear correlation with the biodiversity measures. The enhanced plots generally had a higher abundance and diversity of stink bugs in the grass layer, but a lower abundance and diversity of these (potential) pests in the canopy of fruit trees.

Conclusions

Flower strips were established successfully almost without exception. Based on the evaluation, a definitive recommendation for seed mixtures was given (Krismann et al., 2020). The enhancements increased the biodiversity considerably compared to the control plots, especially the species richness of hoverflies, beetles, parasitoid wasps and grasshoppers. By contrast, birds did not prefer nest boxes in the enhanced plots over the ones in the control plots.

The biodiversity measures did not negatively affect fruit damage during the evaluation period. Still, in specific situations such damages may be observed. An effect of the flower strips on the species number of stink bug populations was observed that has to be studied further as a potential tool for the natural control of these pests.

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