**Final project report 2021 to SLU Ekoforsk**

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# The importance of insect pollination for field bean yield

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## Sammanfattning

Åkerbönan (*Vicia faba*) är en viktig brytgröda i ekologiskt jordbruk. Kunskap om fördelar, odling och grundläggande ekologi för ekosystemtjänster som pollinering och biologisk bekämpning av insektskadegörare behövs för hållbar odling av åkerböna. Vi ämnade ta reda på effekterna av att anlägga en blomsterremsa och att ställa samhällen med honungsbin vid grödan, på angrepp av skadedjur, pollinering och skörd av åkerböna. Vi undersökte vidare om blomsterremsor förstärker, och om konkurrens från honungsbin undertrycker, vilda humlor i landskapet och över årstider. År 2018 räknade vi pollinerare, naturliga fiender och insekts-skadegörare samt uppskattade skördeökningen med insektspollinering i 17 ekologiska fält med åkerböna i södra Sverige, antingen med eller utan vårsådda annuella blomremsor och med eller utan tillsatta bisamhällen. För att bedöma om blomremsor och honungsbi-samhällen påverkar vilda humlor, undersökte vi antal humlor och honungsbin i linjära livsmiljöer i landskapen runt varje fält med åkerböna samt i varje blomremsa. Våren 2019 återvände vi till varje fält och räknade antal humlor i landskapet runt fältet. Insektspollineringen ökade bönskörden med 27%. Blomremsor ökade inte det totala antalet vilda pollinatörer i fältet med åkerböna under 2018, men blomremsorna lockade till sig och ökade marklevande rovdjur, särskilt spindlar, till åkern, troligen genom att erbjuda en skyddande miljö. Platser med blomremsor, men utan bikupor, tenderade att ha fler humlor 2018 och hade fler drottningar våren 2019. Det fanns färre humlehannar i blomremsor på platser med tillsatta honungsbikupor. Blomremsorna stärkte populationstillväxten för humlor över årstiderna, förmodligen genom att ta bort en resursflaskhals i landskapet. Att tillsätta honungsbisamhällen till landskap med få blomresurser bör undvikas eftersom det raderade de positiva effekterna av blomremsor för de vilda bina.

## Summary

The field bean (*Vicia faba*) is an important break crop in organic farming. Knowledge about benefits, management, and underpinning ecology of ecosystem services such as pollination and biological control of insect pests is needed for sustainable field bean cultivation. We aimed to find out the effects of flower strips, and adding honey bee hives to the crop field on pest attack rates, pollination and yield in field bean. We further assessed whether flower strips enhance, and competition from honey bees suppresses, wild bumble bees in the landscape and across seasons. In 2018, we counted pollinators, natural enemies and insect pests as well as estimated the yield benefit

of insect pollination in 17 organic field bean fields in southern Sweden either with or without sown annual flower strips and with our without added honeybee hives. To assess whether flower strips and adding honey bee hives affect wild bumble bee populations, we surveyed bumble bee and honey bee abundances in linear habitats in the landscapes around each field bean field and in each flower strip. In spring 2019, we surveyed bumble bee queen abundances in the landscape at each site. Insect pollination contributed to 27% bean yield. The annual flower strips did not increase overall wild pollinator densities in field bean fields in 2018, but the flower strips attracted and facilitated ground-dwelling predators, especially spiders, to field bean fields, likely by providing shelter habitat. Sites with a flower strip, but without honey bee hives, tended to hold more bumble bees in 2018, and had more queens in spring of 2019. There were fewer male bumble bees in flower strips to which honey bee hives were added. The flower strips bolstered bumble bee population growth across seasons, probably by relieving a resource bottleneck in the landscape. Adding honey bee hives to landscapes with few floral resources should be avoided as it cancelled the positive effect of flower strips for the wild bees.

## Background

The field bean (*Vicia faba*) is an important break crop that fixates atmospheric nitrogen, thereby providing nitrogen to the crop rotation and improving the soil structure. Field beans have a high yield and protein content, and a protein composition that fits several livestock species. Yield in field beans is enhanced by insect pollination and can be severely reduced by insect pests. Knowledge about benefits, management, and underpinning ecology of ecosystem services such as pollination and biological control of insect pests is needed for sustainable, effective and economically viable field bean cultivation.

Wild bee declines in agricultural landscapes have incentivised farmers to both establish flower strips, and to supplement crop pollination with honey bee hives placed near flowering crops. We aimed to find out the effects of flower strips, and adding honey bee hives to the crop field on pest attack rates, pollination and yield in field bean. We further assess whether flower strips enhance, and competition from honey bees suppresses, wild bumble bees in the landscape and across seasons.

## Methods

### Effects of flower strips and honey bees on field beans

We sampled pollinators, natural enemies and their pests as well as estimated the yield benefit of insect pollination in 17 organic field bean fields in southern Sweden either with or without sown annual flower strips and with our without added honeybee hives. We established spring sown flower strips in spring of 2018 in 9 locations across Skåne. To 4 of these we added a minimum of 10 honey bee hives per field. We also had 8 control fields without a flower strip, adding honey bee hives to 4 of these.

The crossed experimental design allowed us to examine how adding honey bees and/or flower strips

affected: yield and yield components, pests attack of aphids (*Aphis fabae*) and bean beetles (*Bruchus rufimanus*), pest control and pollination, as well as population densities of wild pollinating and predatory and parasitic insects during flowering.

### Effects on bumble bee populations

In summer 2018, we surveyed bumble bee and honey bee abundances in linear habitats in the landscapes around each field bean field. The centre of each landscape (2 km radius) was with or without an annual flower strip, and with or without honey bee hives. We also surveyed bumble bees and honey bees in each flower strip. We followed up these surveys in the following spring of 2019 with an estimation of the number of bumble bee queens found at each site where we surveyed a field bean crop in 2018. This tells us whether the honey bee and flower strip treatments have had any effect on the wild bumble bee populations.

## Results and discussions

### Effects of flower strips and honey bees on field beans

In fields with flower strips, bumble bee densities were redistributed from field edges to interiors but without affecting their overall densities. Flower strips enhanced silver Y moth densities and carabid beetle diversity along the field edge, and overall spider activity density. The supplementation of honeybee hives enhanced honeybee densities, overall ladybird beetle densities, black bean aphid densities along field edges, but deterred silver Y moths and pushed bumblebees towards the field interior. Bean mass per plant was higher in insect pollinated plants compared with bagged, self-pollinated plants. This insect pollination benefit was independent of honeybee hive supplementation and the flower strip treatment suggesting that field bean fields were not deficient in pollinator visits.

Faba bean yields increased with insect pollination by 27 % as a result of more pods per plant and beans per pod. The flower strips did not provide sufficient floral resources to increase overall wild pollinator densities in faba bean fields. Yet, annual flower strips attracted and facilitated ground-dwelling predators, especially spiders, to field bean fields, likely by providing beneficial shelter habitats (Raderschall 2021, Raderschall *et al* submitted).

### Effects on bumble bee populations

We found positive legacy effects of annual flower strips on bumble bee abundance in the subsequent spring. Adding flower strips to agricultural landscapes increased bumble bee queen abundance in following season, but honey bee hives counteracted this effect. Sites with a flower strip but without honey bee hives tended to hold more bumble bees in 2018, and had more queens in spring of 2019. Male bumble bee abundance was lower in landscapes with flower strips to which honey bee hives were added. Landscapes with flower strips, but without honey bee hives, had on average 2.1 times more bumble bees compared with sites without a flower strip in the summer of 2018.

Our relatively small flower strip areas bolstered bumble bee population growth across seasons,

probably by relieving a resource bottleneck. Adding honey bee hives to landscapes with few floral resources should be avoided as it cancelled the positive effect of flower strips (Douhan Sundahl 2019, Raderschall 2021, Bommarco et al submitted).

## Dissemination

The project has been presented in agricultural media (Raderschall & Lundin 2019, Lundin et al 2018) and at a conference (Raderschall et al 2019). The publications formed a major part of Raderschall's PhD-thesis that she successfully defended 16 April 2021 (Raderschall 2021). Two research publications have as yet been produced and are submitted for peer review.

## Research publications

Bommarco R., Lindström S.A.M., Raderschall C.A., Gagic V., Lundin O. Flower strips enhance bumble bee abundance across seasons in landscapes with few honey bee hives. Submitted to Biological Conservation

Raderschall C.A., Lundin O., Lindström S.A.M., Bommarco R. Annual flower strips and honeybee hive supplementation differently affect arthropod guilds and ecosystem services in a mass-flowering crop. Submitted to Agriculture, Ecosystems & Environment

Raderschall C. 2021. Diversified agroecosystems for biodiversity and ecosystem services - ecological intensification of faba bean cropping under land use and climate change. Doctoral thesis 2021:21 Acta Universitatis Agriculturae Sueciae Doctoral Thesis 2021:21

## Other publications

Douhan Sundahl, A. 2020. Bumblebee resource dynamics: A review of foraging and nesting in the agricultural landscape. Independent project in Biology • 15 credits Swedish University of Agricultural Sciences https://stud.epsilon.slu.se/15288/

Raderschall, C. & O. Lundin. 2019. Bin och humlor lyfter skörden av åkerbönor. Lantmannen 7-8: 65.

Lundin, O., C. Raderschall, R. Bommarco & S. Lindström. 2018. Pollinering och växtskydd lyfter skörden i åkerbönor. Arvensis 1: 30-31.

Raderschall, C., O. Lundin, R. Bommarco, S. Lindström. 2019. Diversified farming systems at field- and landscape scales for pollination in faba beans. Oral presentation. 33rd Annual meeting of the Scandinavian association of pollination ecology. Höör, 2019.