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Impact of land use on pest control in Brassica – a first synthesis

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Impact of land use on pest control in vegetable Brassicas – a first synthesis

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1. Introduction, Knowledge, Objectives

In the framework of the BMBF funded project on horticultural value chains (wega.online.org) a holistic approach for integrated pest management in vegetable Brassica crops was investigated (Ludwig & Meyhöfer, 2014). Three levels of research activities were considered: (1) the potential risks of infestation and benefits of natural control related to specific landscape configurations, (2) reliable and easy monitoring techniques of realised pests on the field for consideration of action thresholds and (3) the application of innovative intervention strategies based on biologicals and pesticides when thresholds are reached. With this first synthesis the potential risks and benefits related to the landscape configuration are summarised. In general the (agricultural) landscape consists of a matrix of different habitats. Among them are permanent habitats (e.g. orchards, pastures, forests, conservation areas and settlement) but mainly annual habitats, i.e. horticultural and agricultural crops. Due to specific crop rotation schemes most of these habitats are characterised by rapid temporal and spatial changes. Nevertheless all types of permanent and annual habitats interact with each other. Annual crops are short lived and might function as stepping stone to build up populations which than move to adjacent habitats, while permanent habitats allow long term population build up which may result in equilibrium population densities. All annual crops have in common that they are re-colonized by pests and natural enemies during each cropping period. Colonisation takes place from source habitats in their surroundings, either annual or permanent. Whether or not pests cause damage on the crop depends on their dispersal behaviour as well as on quality and quantity of source habitats, target habitats and environmental conditions which might favour rapid population development. In concert these processes lead to high local variability in pest pressure and natural enemy impact, which make reliable predictions difficult and contribute to terminated insecticide use. A better understanding of the importance of alternative habitats for both pests and natural enemies as well as factors influencing dispersal are mandatory to improve plant protection strategies. Growers might profit from a reliable assessment of risks and benefits, and are able to focus plant protection efforts on high risk areas. In the long run conservation biological control strategies to increase functional biodiversity might be helpful. To fill that gap we investigated the impact of landscape elements on colonization of Brussels sprouts by important pest species and natural enemies and analysed the effect on pest population development on several cabbage crops throughout several growing seasons.

2. Material and Methods

Nineteen organic vegetable growers in western Germany were selected to investigate interactions between landscape elements and occurrence of pests and natural enemies on cabbage crops over several growing periods. All growers cultivated a wide spectrum of vegetables, but also grew Brussels sprouts and other cabbage crops. Plant protection of cabbage crops was mainly based on coverage with protective nettings to control cabbage root fly, lepidopteran and other pests. To monitor the colonisation by pests and natural enemies standardised Brussels sprouts trap plants were exposed monthly throughout the growing season in 2012. Further population densities of insects were monitored directly in Brussels sprouts and oilseed rape fields in 2012 – 2014. Population densities of insects in white cabbage and curly kale were monitored in 2013 additionally. Organisms in focus include *Aleyrodes proletella, Brevicoryne brassicae, Mamestra brassicae, Plutella xylostella, Pieris brassicae, P. rapae* and their natural enemies. In all years land use at 1km radius around the study sites was GIS mapped. Linear regression models were used to analyse the impact radius, the land use type, and weather data. For more details on sampling and analysis see Ludwig et al. (2014), Ludwig et al. (2017) and Ludwig (2017). Additionally in 2014 at least 20 adult cabbage whiteflies were collected on oilseed rape and neighbouring Brussels sprouts fields to investigate population genetics in more detail. Therefore 5 newly developed microsatellite loci were used to quantify the genetic structure and calculate specific population indices (Hüweler, 2014).

3. Results

In the following paragraph a summary of results published elsewhere is given. In general landscape composition in the neighbourhood of investigated Brussels sprouts fields was dominated by cereals followed by settlement, grassland and maize. Oilseed rape fields followed a gradient covering 0 –14 % area of the landscape (Ludwig et al., 2017). Cabbage whitefly, cabbage aphid, and diamondback moth were the most abundant pest species on Brussels sprouts in all years, while hoverfly larvae belonged to the dominant predatory species.

Colonisation of trap plants peaked in July for many pest species. While colonisation decreased gradually towards October for cabbage whiteflies and hoverfly larvae, a second peak occurred for cabbage aphids and diamondback moth in September and October (Ludwig et al. 2017). Impact of the different factors on pest and natural enemies was highly variable. For example cabbage whitefly was mainly influenced by oilseed rape cultivation on the larger radii, with a positive impact of wind direction and a negative impact of air temperature (Fig. 1) (Ludwig et al. 2017). A similar though weaker impact was observed for the cabbage aphid, but we could not detect any landscape effects on colonisation of Brussels sprout by diamondback moth or on whitefly parasitism. The presence of hoverfly larvae depends mainly on prey density on trap plants, where prey species were predominantly whitefly larvae (Ludwig et al. submitted). Impact of landscape elements on hoverfly activity varied from negative (oilseed rape) to slightly positive (permanent habitats). Wind and air temperature were less important for hoverfly activity (Fig. 1). On the main crop, i.e. the Brussels sprout field, population development correlated quite well with insect densities on trap plants. In 2012 and 2013 population densities of cabbage whitefly peaked on the crop in August, and counts per leaf were at similar range. In contrast, population density of cabbage whitefly on oilseed rape remained on a more then 20-fold lower level, with a distinct peak in July (Ludwig & Meyhöfer, 2017).

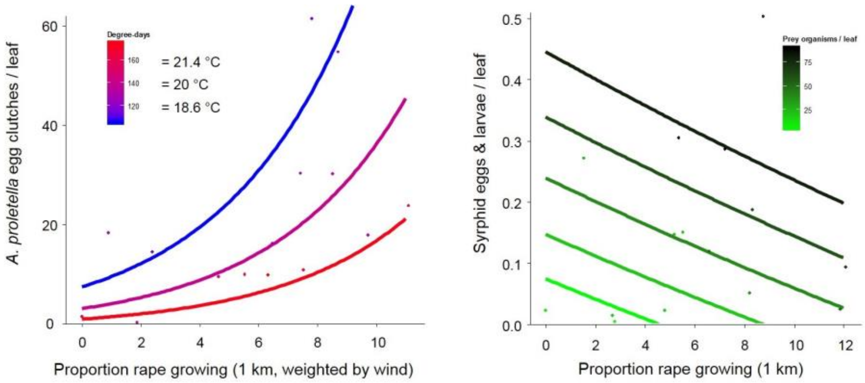

Fig. 1 Relationship between rape growing within 1km radius, egg laying, and temperature (cabbage whitefly, left graph) and prey density on activity density (hoverflies, right graph) on Brussels sprouts. Temperature is given as degree days above activity threshold of 10 °C and equivalents in average daytime temperature (redrawn from Ludwig et al. 2017).

Population densities of cabbage whitefly cabbage aphid and cabbage whitefly parasitoids (Ludwig et al. 2014) on the Brussels sprout fields monitored in 2012, 2013, and 2014 peaked in October, while aphid parasitoids peaked in August. In all years, except 2013, the colonisation of Brussels sprouts fields by cabbage whiteflies in early summer (June-July) was significantly correlated with oilseed rape cultivation. Moreover the abundance of cabbage whiteflies in October was correlated with oilseed rape cultivation in all years (Ludwig, 2017). On farm scale cabbage whitefly and cabbage aphid were not only frequent pests on Brussels sprouts but also on curly kale and white cabbage. While cabbage whitefly population density on Brussels sprouts and curly kale were at a similar range with a distinct peak in October, population levels on white cabbage remained at a very low level.

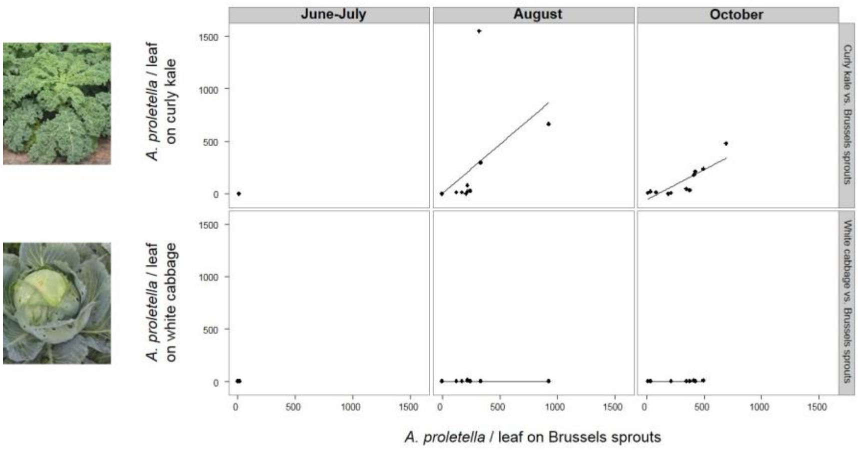

Fig. 2 Relationship between cabbage whitefly infestation on Brussels sprouts (x-axis), curly kale (upper graphs) and white cabbage (lower graphs) in different month of the cropping season (y-axis) (redrawn from Ludwig et al. in preparation).

In contrast, cabbage aphid population density on all three cabbage crops were at a similar level, but peak density was reached approximately two month later on curly kale compared to Brussels sprouts and white cabbage. As a consequence population densities of cabbage whitefly on later planted curly kale correlated significantly with pest densities on Brussels sprouts already in August but also later in the season (Fig. 2). A similar relationship could be identified for cabbage aphids on curly kale and white cabbage, indicating a strong impact of Brussels sprouts on white cabbage already in August, but later in the year also on population densities on curly kale. Comparison of genetic structure of cabbage whitefly populations on rape and Brussels sprouts by AMOVA revealed no to moderate differentiation. At low proportion of rape growing (<8%) 8 out of 9 populations on oilseed rape and Brussels sprouts had a similar genetic structure, showing a high rate of exchange. At high proportion of rape growing (>8%) significant differences between populations on rape and Brussels sprouts could be detected only for 2 out of 6 populations which indicates moderate differentiation. Possible reasons and implications are discussed later and in Hüweler (2015).

4. Discussion

Concerning important pest insects on vegetable cabbage crops it is likely that oilseed rape is the most important source habitat. This is at least true for cabbage whitefly but also likely for cabbage aphid. For other cabbage pests (diamondback moth, cabbage moth etc.) other habitats are also of relevance. The distance of impact of rape fields seems to be quite large since at least oilseed rape fields at up to 1km distance should be considered as major source habitats for pests. But not all rape fields in the neighbourhood are always of similar importance. Wind directions are of high importance at least for smaller insects and results show that oilseed rape fields upwind from vegetable crops are of higher importance then rape fields located downwind (Ludwig et al. 2017). Additionally take off from host plants needs a certain temperature threshold. With oilseed rape fields located upwind from the Brussels sprouts field, pest densities might be increased up to 8-fold. Finally, the high importance of oilseed rape for colonisation of Brussels sprouts by cabbage whiteflies could also be shown with molecular methods, which proved that insects move between those habitats (Hüweler, 2015). Correlations between the colonisation of Brussels sprouts fields could surprisingly not be found in all years. The reasons therefore may be differences in crop protection. Framers used nets of different mesh size. Often nets with a net width of 0.8 mm were used. Although those nets are not impermeable for cabbage whiteflies, they hinder colonisation and can mask the effect of oilseed rape as a source habitat (Lessing 2013, Ludwig & Meyhöfer, 2016). However, the efficacy of those nets is not sufficient to supress pest populations until October and thus in October a correlation between whitefly presence and of oilseed rape framing could be found in all three study years. Other cabbage crops then Brussels sprouts are most likely affected by similar processes, although more detailed studies are needed to verify functional relationships. The same is true for secondary infestations among different cabbage crops. Given that crops are susceptible for the same pest insects the earliest cabbage variety planted in the season most likely serves as source habitat for secondary infestations of later planted crops. The synthesis of project results also shows that importance of habitats for pest insects not necessarily favours abundance of natural enemies, e.g. *E. tricolor*) and hoverflies. Habitat requirements of pest and natural enemies might differ fundamentally. For example flower foraging hoverflies are negatively affected by rape growing, either due to low prey densities, low nutritional quality of oilseed rape flowers and/or negative impact of intense pesticide use in oilseed rape. On the positive side there are few indications that permanent habitats are of higher importance for natural enemies, but additional research is needed.

5. Conclusions

For preventive plant protection strategies the implications of the results are manifold. The increasing cropping areas for oilseed rape as energy plant and animal feed lead to massive pest problems in related vegetable crops. From a plant protection perspective it would be best to grow Brassica vegetables only in regions with low oilseed rape growing. But due to market demands this strategy most likely is not in the interest of most vegetable growers. Supplying the market with many different vegetable crops seems to be mandatory. Nevertheless the appropriate risk assessment on the farm level might help the grower. On the one hand there is a need to intensify monitoring efforts in high risk areas. Doing so pest problems on the crop can be detected early enough and appropriate intervention strategies can be applied in time. For cabbage aphid and cabbage whitefly oilseed rape fields upwind from the vegetable crop are of special interest (Ludwig et al. 2017). On the other hand growers should promote in the long run natural enemies on the farm level to decrease risks, for example with tailored flowering strips, appropriate overwintering habitats and a high habitat connectivity in the agricultural landscape. The potential to manipulate the functional biodiversity in the agroecosystem is high and we are just at the beginning to understand and manipulate the complex interactions.

6. Literature

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