Factsheet BEESPOKE Frisian clay area - pest insects and their natural enemies in cereal fields with a BEESPOKE flower strip.

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Introduction: Typical crops grown at scale by farmers in the Frisian clay area are potato, cereals (wheat, barley, oats) and sugar beets. These crops do not need animal pollinators for production, but they can be affected by insect pest species, such as aphids and certain species of beetles. Natural enemies can prevent or attenuate population increase of pest species, and reduce damage of crops. To do so, they must be locally present in sufficient numbers at the appropriate time during growth of the crop, and at close enough distance, to be able to respond adequately. For this, stable populations of pest control species should be supported in the landscape at close distance to crops. Stable and well maintained flower strips incorporated in the arable landscape can support natural enemies at all life stages. How does this work for the BEESPOKE flower strips, which are designed as stable flower-rich landscape elements with annual, biennial and perennial local species, when they are combined with cereal crops? Do they produce pest species, as well as pest control species, and how do they influence productivity?

Methods: Pest species, their natural enemies, and crop yield indicators were measured in two subsequent years in plots of 0.7-4.5 ha, planted in the early spring with (summer)wheat (n=3; 2 in 2021, 1 in 2022) or oats (n=1; 2022). No insecticides were applied. Plots had a developed 2nd year (n=2, 2021) or 3rd year (n=2, 2022), BEESPOKE seed mix based flower strip (See Strijkstra et al. 2023 for a detailed description) adjacent to the crop.

Figure 1. *Example of a cereal (wheat) field with a 3rd year BEESPOKE Frisian clay area flower strip.*

Insect monitoring in the crop was based on the protocol described by the Louis Bolk Institute for integrated pest management in cereal cultivation (Luske and Schultinga, 2019). Monitoring of pest species was performed 1-2 times each season. At least 20 grain stalks were randomly selected from an area (approximately 20 m^2 in 10 minutes) at several locations in the crop: at 1m and 10m from the flower strip, at the middle of the plot, and at 1m and 10m from the opposite field border. From each grain stalk the number of relevant pest insects (aphids, and beetles from the genus *Lema*, mostly *Lema cyanella)* in any developmental stage (egg, larvae, nymph, imago) were counted. Presence of natural enemies was also recorded: natural enemies observed on the crop or flying in the monitored area were scored while moving between the plants.

An indication of crop yield was obtained by harvesting 20 ripened grain stalks at each transect. The grains were manually separated from the grain heads and husked, and the number of clean seeds and total seed weight per stalk were recorded.

Pest species: Aphids and beetles from genus *Lema* were indeed present in both wheat and oats, but on average at very low levels. 13% Of the sampled grain stalks contained 1 or more aphids, and 4.5% had 1 or more *Lema* beetles, mostly larvae. These numbers were similar at different distances from the flower strip, and they were well below the suggested damage thresholds for interference of 30% of the stalks occupied with Aphids and/or 50% of the stalks occupied with Lema beetles (as suggested by Luske and Schultinga, 2019). (Data in appendix 1, figure 1 & table 1).

Natural enemies: The majority of the observed natural enemies were hoverflies (64.4%), followed by spiders (7.6%), green lacewings (6.2%), ladybugs (3%) and soldier beetles (2.7%). Other species of natural enemies added up to 6.8%. The total number of natural enemies was on average 0.26 (SEM 0.03) individuals per plant. There was no relation with distance from the flower strip visible. (Data in appendix 1, table 1 & 2).

Crop yield: The number of seeds and the weight per stalk/plant were quite different between wheat (37.2 seeds/stalk, 1.78 gr/stalk) and oat (81.2 seeds/stalk, 3.40 gr/stalk). After correcting for this difference by standardization, there were no apparent differences between distances from the flower strip, with one exception: in wheat plots 1m from the flower strip, the yield (29.3 seeds/stalk, SEM 1.5; 1.38 g/stalk, SEM 0.14) was around 27% lower than at the other distances (40.0 seeds/stalk, SEM 2.4; 1.88 g/stalk SEM 0.11). The affected area was limited to immediately adjacent to the flower strip at 1m: at 10m distance, seed weight (38.6 seeds/stalk, SEM 6.2; 1.82 g/stalk, SEM 0.29) was in line with the yields at other distances, limiting impact on total yield of the field. There is no clear explanation for this negative effect close to the flower strip: it may have received less light because of the higher flower strip vegetation, but differences in fertilization or other soil preparation close to the flower strip may be more likely: fertilization of the flower strip was not allowed. (Data in appendix 2, figure 2).

Conclusion: Pest insects were observed on stalks throughout the crop, but at stable low levels. Natural enemies were also present throughout the crop. The ratio of pest insects per natural enemy was well below the damage threshold of 10 pest insects per natural enemy (Luske and Schultinga, 2019). Crop yield was quite similar throughout the crop, except for the lower yield at 1m from the flower strip in the wheat plots. Taken together there was no indication of many pest insects, nor a yield problem related to pest insects in the fields, in two consecutive years in these plots without insect pest management. This suggests that the BEESPOKE flower strip does not appear to be an important source of pest insects for cereals, and that the BEESPOKE flower strip appears to have little impact on crop yield. Since the BEESPOKE flower strip harbors many pest control species that were also caught and seen in the cereal fields in high numbers (See Strijkstra et al. 2023 for a detailed description; see Boerema et al. 2023 for comparison of biodiversity between flower strips and different crops), the flower strips may play a positive role in providing necessary habitat for useful pest controlling species.

References:

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Appendix: 1 Overview of relevant pest insects and their natural enemies in relation to the distance from the flower strip.

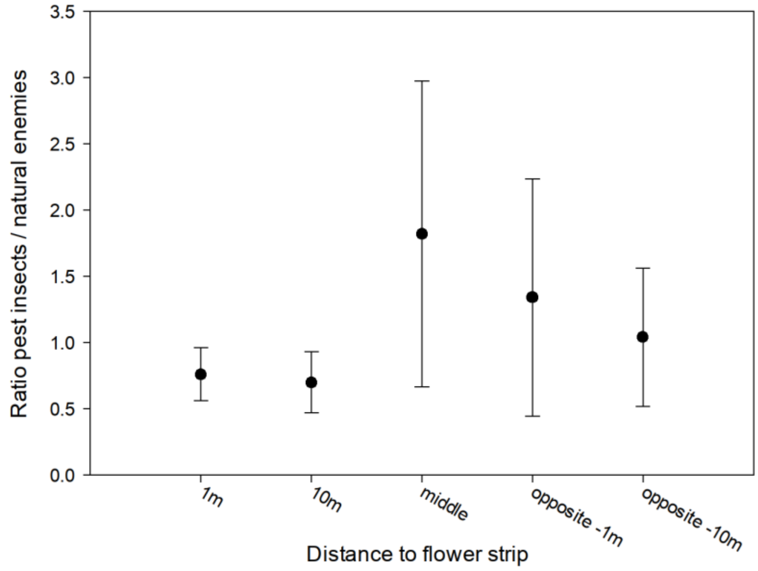

Figure 1. *Number of pest insects per natural enemy observed. The indicated damage threshold is >10 pest insects per enemy (as suggested by Luske and Schultinga 2019). This threshold was never reached in any of the four fields. The suggestion that the ratio is low close to the flower strip could not be statistically shown.*

Table 1: Average numbers of pest insects (aphids and beetles from genus Lema) and the total number of natural enemies per plant, as a function of distance from the BEESPOKE clay area flower strip.

distance from flower strip	pest species				natural enemies			
	Aphids		Lema (cyanella)		all species combined		pest species / natural enemies	
	nr / plant	*SEM*	*nr / plant*	*SEM*	*nr / plant*	*SEM*	*ratio*	*SEM*
1m	0.26	*0.14*	0.07	*0.02*	0.27	*0.04*	0.76	*0.20*
10m	0.29	*0.12*	0.04	*0.02*	0.26	*0.03*	0.70	*0.23*
middle	0.24	*0.09*	0.04	*0.02*	0.19	*0.07*	1.82	*1.15*
opposite -10m	0.24	*0.15*	0.04	*0.03*	0.28	*0.09*	1.34	*0.90*
opposite -1m	0.22	*0.10*	0.08	*0.04*	0.33	*0.13*	1.04	*0.52*

Table 2: Species groups of natural enemies (as suggested by Luske and Schultinga 2019) and their percentage observed for all 4 fields.

Natural enemies of pest species observed

name	scientific name	% of total
hover flies	Syrphidae	64.4
spiders	Araneae	7.6
green lacewings	Chrysopidae	6.4
lady bugs	Coccinellidae	3.0
soldier beetles	Cantharidae	2.7
Carabus granulatus	Carabus granulatus	2.3
ichneumon wasps	Ichneumonidae	1.9
Reduviidae	Reduviidae	1.5
rove beetles	Staphylinidae	1.1

Appendix 2: Crop yield of cereal fields as a function of distance to the flower strips.

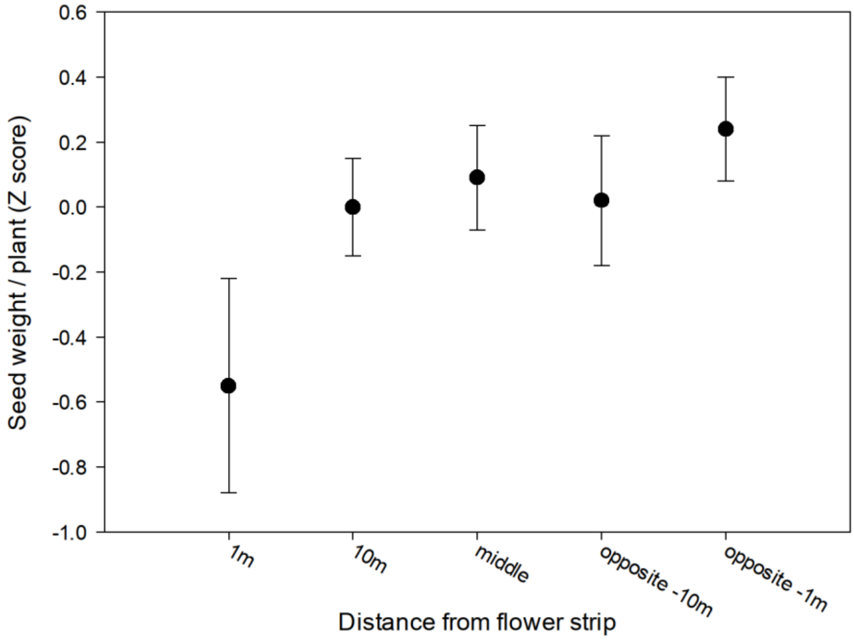

Figure 2: *Average seed weight, standardized within fields (z-score) to be able to correct for field and crop differences. Yield appeared relatively stable across the different distances, but next to the flower strip the yield was lower by on average 15% (25% in wheat) in comparison to the other distances. The difference is not statistically significant (One-Way-RM-Anova, F=1.604, p=0.236). In oat, the yield was relatively high at 1m from the flower strip, in wheat it was relatively low. The achieved power of testing (0.148) is quite low with only 4 fields. These differences should not be over-interpreted.*