Chaff is more than waste: towards sustainable combine harvesting

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Background

In conventional and organic farming, weed control is a major challenge that often has negative consequences for the environment and biodiversity. In a current project conducted in the Federal State of Hesse (Germany) and funded by the German Federal Agency for Nature Conservation (BfN) from 2018-2022, the main goal has been to enable more sustainable weed control through an innovative harvesting technology (Fig. 1).

In the BfN project, a prototype of a combine harvester was developed and tested that collects weed seeds contained in the chaff in a special tank so that they no longer fall on the soil. In the medium to long term, this should reduce the amount of seeds in the soil and enable less intensive weed control.
Additionally, the seeds collected in the combine's tank can then be used to establish flower strips along edges of fields.

With this technology, the chaff with its weed seeds, which, until now, has been considered "waste", will be valuable for nature conservation.
In a Master's Thesis presented here, the aim was to contribute to the evaluation of the degree of effectiveness of the developed seed collection method, as well as to evaluate biodiversity effects of exemplary flower strips established with collected seed material.

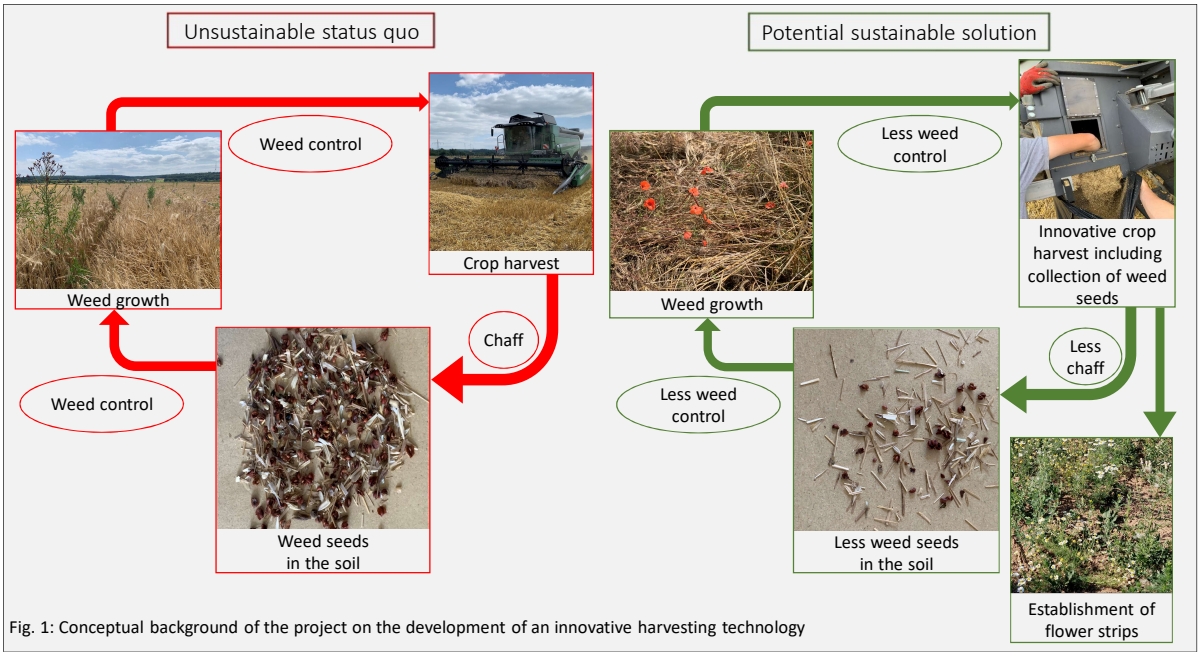

Fig. 1: Conceptual background of the project on the development of an innovative harvesting technology

Methods

I. To test the effectiveness of the developed technology, a field experiment was conducted during harvest in late summer 2021. In the experiment, the chaff including weed seeds of two conventionally and two organically managed plots (600 m²) was collected in the tank of the harvester and from the ground. For this, a foil was laid on the ground, from which the seed material was picked up. Standardized samples of the collected material (12 repetitions of 10 g sampled material per field) were placed in germination trays with sterilized soil (30 x 20 x 1 cm³) under optimal germination conditions in a greenhouse (25 degrees; regularly watering of the trays). The germinated weeds were determined to species level over six weeks in winter 2021/22.

II. In early May 2022, the soil of three field margins was prepared for the sowing of flower strips. Half of the flower strips were sown with seed material collected in the tank of the innovative technology (10 g per m²), while the second half remained unseeded as controls. In mid-August 2022, a total of 24 plots (2 m x 1 m) in the flower strips were investigated with respect to the number of individuals of the developed species. Additionally, the Shannon Diversity Index was calculated for each plot. For each flower strip, four plots in the sown partial strip and four plots in the unseeded partial strip were examined. Statistical analysis (analysis of variance, Tukey HSD, Levene's text, Shapiro-Wilk normality test) was performed using R.

Results

I. As one would expect, the number of germinated weeds was much higher in the organically than in the conventionally managed fields (Fig. 2). In both systems, the majority of weed seeds were collected in the tank during the threshing process. However, it appears that the developed technology is less effective for small-seeded weeds and herbs.

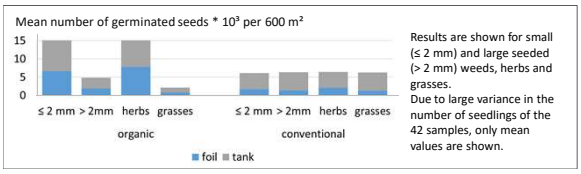

Fig. 2: Results on the effectiveness of the innovative harvest technology

II. The biodiversity in the sown flower strips is significantly higher than in the partial strips that were not additionally sown (Fig. 3). However, the numbers of species and individuals as well as the Shannon Diversity Index are quite low in all partial strips.

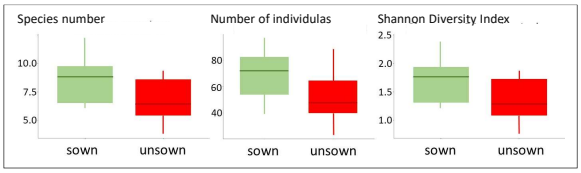

Fig. 3: Biodiversity effects of flower strips sown with collected seeds
Plot size: 1 m x 2 m; sown: n=12; unsown: n=12;
Box-plots: max/min; 1st and 3rd quartiles; median; 95 % confidence interval

Conclusions

Experiment I shows that the technology developed is suitable to collect weed seed material in a tank. This applies to both small- and large-seeded herbs and grasses. However, the technology is more effective in collecting large-seeded weeds and grasses and should therefore be further optimized in a follow-up project.
Experiment II shows that the seed material collected is suitable for increasing the biodiversity of field margins. However, the study year 2022 was characterized by a prolonged heat wave with drought. Further experiments should be carried out under less extreme weather conditions and with different sowing periods (spring, late summer) and seed densities.

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