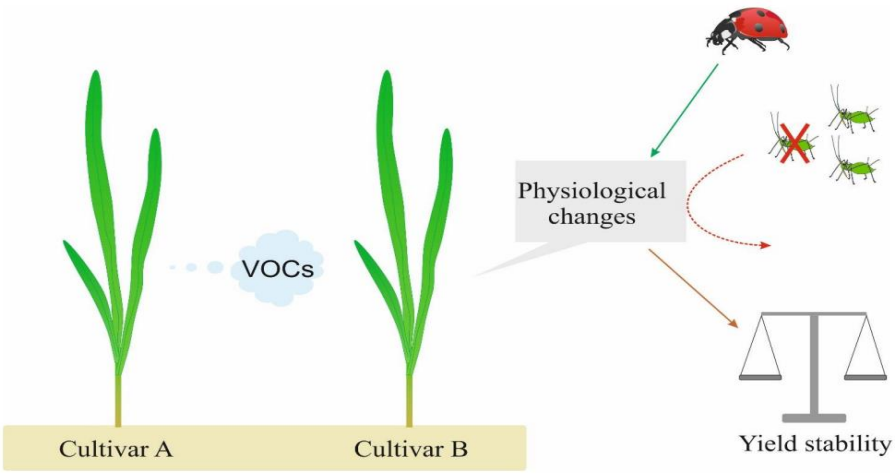
Crop cultivar mixtures to enhance insect biocontrol: implementation, monitoring and improvement

The overall objective of EcoStack is to develop and support ecologically, economically and socially sustainable crop production via enhancement of ecosystem services provision and protection of functional biodiversity.

Context

High crop yields are a principal objective of the current and conventional agriculture through hybridization and selection of plants. But simplified cropping systems are associated with negative impact on environment and biodiversity. The agroecological practice of cultivar mixtures, an intraspecific diversification of the system, increase the genetic diversity of the crop and can provide functional diversity that limits fungal disease and pest colonisation. The mix of cultivars include varieties with different abilities in terms of weed competition, disease and pest resistance, and can represent an interesting alternative to stabilize yields.

But knowledge of the processes underlying differential pest responses is required to better understand the consequences on yields and agrobiodiversity. Ecostack research was focused on the interaction of the plants with each other that effect aphid settling. It was important to grasp the mechanisms behind effects of cultivar mixtures because of the necessity of measuring herbivore response to individual mixture components. Little research has been done so far on the effects of intraspecific diversity on arthropod pests and natural enemies especially on wheat pest control. One of the mechanisms that can contribute to reduce the presence of pest insects in cultivar mixtures is the induced resistance mediated by plant volatiles. The protection is based on the stimulation of defence mechanisms and metabolic changes that prime neighbouring plants against insect attack.



Aphids are the main food source of ladybird beetles. Most consuming are the larvae of ladybird beetles, further lacewing and hoverfly larvae are effective predators of aphids.

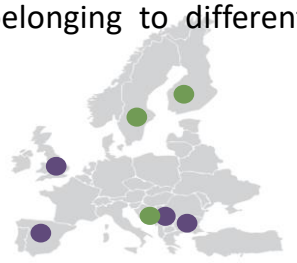
Summary diagram (Dimitrije Markovic (2023)

Methodology

Approach and field studies

Field studies investigated the impact of cultivar mixtures on arthropod pest and natural enemies of cereal aphids in analysing whether cultivars mixture can be used as cultivation method that contributes in the field to resilience against aphids and may affect occurrence of aphid natural enemies such as ladybirds. Small field plot trials with cultivar mixtures in barley and wheat were conducted from 2019-2021 in different European countries (Finland, Sweden, UK, Spain, Serbia, Bulgaria, Bosnia and Herzegovina) with locations belonging to different pedoclimatic regions.

In each country, three regional relevant cultivars were selected. Two-way cultivar combinations that prevent aphid settling on cereal plants were identified in laboratory experiments. Based on this screening, cultivar mixtures were investigated regarding their impact on cereal aphid Abundance in the field trials.



with barley
with winter wheat

Country	Crop	Cultivar 1	Cultivar 2	Cultivar 3
Sweden	Barley	Salome	Fairytale	Anakin
Sweden	Barley	Salome	Fairytale	Anakin
Sweden	Barley	Salome	Fairytale	Anakin
Finland	Barley	Alvari	Toria	Vertti
Finland	Barley	Alvari	Toria	Vertti
UK	Wheat	Claire	Hereward	Xi19
UK	Wheat	Claire	Hereward	Xi19
Spain	Wheat	Florence Aurora	Montcada	Forment
Spain	Wheat	Florence Aurora	Montcada	Forment
Serbia	Wheat	Simonida	NS40S	NS Rani otkos
Serbia	Wheat	Simonida	NS40S	NC Rani otkos
Bulgaria	Wheat	Enola	Apolon	Lazarka
Bulgaria	Wheat	Enola	Apolon	Lazarka
Bosnia and Herzeg.	Barley	Matej	Jaran	Scarlet
Bosnia and Herzeg.	Wheat	Simonida	NS40S	NC Rani otkos
Bosnia and Herzeg.	Barley	Matej	Jaran	Scarlet

Table 1: Small scale field experiments specifications per country and study year (from the report D4,1 Velemir and al, EcoStack, 2023)

In Spain, the selection of non-cereal species (under-sowing species) was based on farmers local knowledge and functional traits of species. The selected cultivars were exposed to the volatiles of each other in pairwise combinations, followed by assessment of aphid colonisation of the plants after receiving VOCs from the other cultivar.

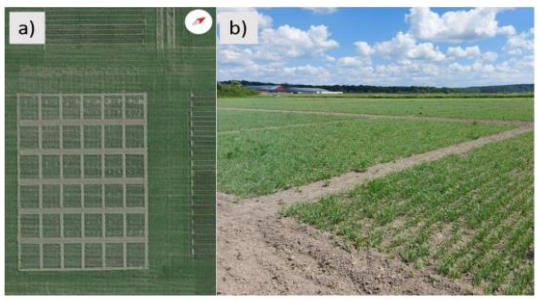


Figure 1: Field side in Sweden (from the report D4.1 Velemir and al, ECOSTACK, 2023)
a) Field plot design from the air, b) barley plants growing on the experimental field.

Key findings

1- In the field, the effect on aphids varies with great differences between the years. Most countries experienced high and dry temperatures.

2- Specific combinations were able to reduce aphid infestations in field trials but the effects on aphid abundance are very cultivar mixture specific.

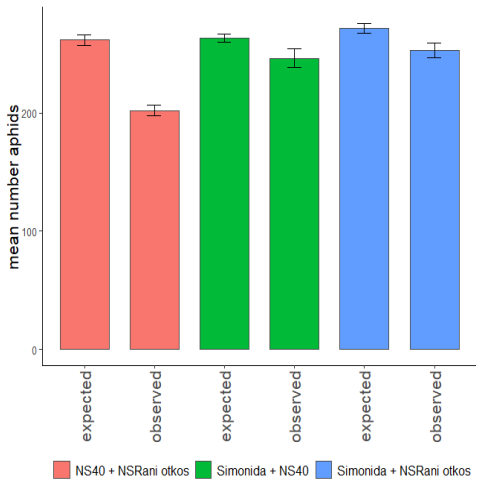
3- An impact of the climatic factors might be antagonistic to the positive effects of cultivar mixtures on pest suppression. As high and dry temperature during the field studies may weaken the plants and impact their physiology.

4- Laboratory and field studies revealed a high specificity of mixture effects, highlighting the importance of finding the right cultivar combinations for mixtures instead of simply increasing general genetic diversity to promote aphid resistance.

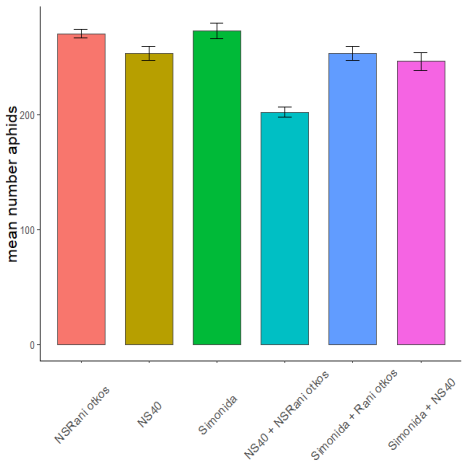
5- Plant volatile organic compounds (VOCs) play an important role in plant-plant interactions in the cultivar mixtures.

6- Volatile mediated interactions between plants can reduce the host acceptance (settling) of aphids on cereal plants and thus increase the plant resistance. The impact on aphids is clearly cultivar and mixture specific.

Example from winter wheat in Bosnia and Herzegovina to illustrate the effect of the mixture as well as highlighting the specificity of the mixture effect:



(from the report D4,1, 2023)



We found a significant reduction in NS40 + NS Rani otkos.

The graph shows the number of aphids as well as the expected number (as expected from the number of aphids in the monocultures) compared to the actually observed number of aphids in the field.

Conclusion

Lessons learnt and perspectives

- In the field, significant reduction in aphids infestation in cultivar combinations of barley or winter wheat have been identified for some locations. However, also indifferent results were found.
- The aphid attacks was significantly reduced when their abundance was high. However, this phenomenon was not observed in all tested cultivar combinations.
- Some combinations with barley was shown to reduce diseases abundance in some years. In some combinations, we found significant increase in the yield.
- It became apparent that aphid suppressive mixtures are highly cultivar specific and it is necessary to find suitable combinations for different countries, climate conditions and new bred cultivars.
- Cultivar mixtures showed the potential to impact the physiology of plants grown in the mixture and might be beneficial for growers.
- Volatile organic compounds are important mediators of mutualistic interactions between plants and their physical and biological surroundings.
- Investigation of plant VOCs from different cultivars could facilitate the identification of beneficial mixtures based on plant volatiles.
- The disruptive effect of a non-host plant on aphids could be increased by using different spatial arrangement and increasing the non-host plant biomass.

Questions? Please contact us: velemir.ninkovic@slu.se, awezel@isara.fr or info@ecostack-h2020.eu

This project receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773554.
Duration of project: September 2018 - September 2023