Mixing things up!

Identifying early diversity benefits and facilitating the development of crop variety mixtures with High Throughput Field Phenotyping

Flavian Tschurr[1*†], Corina Oppliger[1†], Samuel E. Wuest [2], Norbert Kirchgessner[1] and Achim Walter[1]

[†]Contributed equally, flavian.tschurr@usys.ethz.ch, corina.oppliger@usys.ethz.ch

[1]Group Crop Science, Institute of Agricultural Sciences, ETH Zurich, Switzerland
[2] Group Breeding Research, Division Plant Breeding, Agroscope, Wädenswil, Switzerland

1 Core Ideas

- Overyielding effects in crop variety mixtures with different numbers of mixture partners were evaluated.
- Grain yield overyielding ($OY_{grain\ yield}$) was found to be correlated with early measurable traits i.e. canopy cover overyielding ($OY_{canopy\ cover}$).
- High Throughput Field Phenotyping (HTFP) can be used at early vegetative stages to predict the potential of crop variety mixtures.

2 Material & Methods

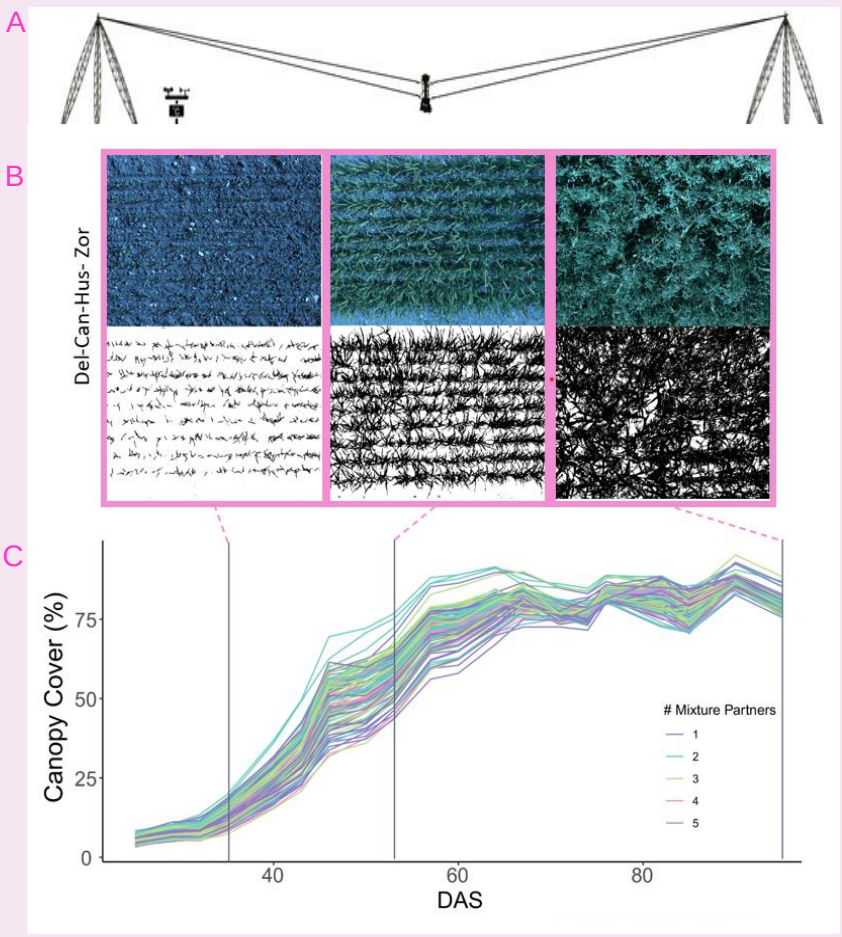

Figure 1: Methods overview. A: Visualization of the Field Phenotyping Platform (FIP), a rope suspended camera system. B: Example of a variety mixture, top panel: FIP-Images of the plots, lower panel: segmented images, where black represents plant pixels. C: Canopy Cover (%) over time from all treatments, spatially corrected.

- Images of the experimental plots were taken with an RGB-camera attached to the FIP[1] sensor head.
- The Images were processed with a semantic segmentation approach[2], to determine Canopy Cover (CC) as ratio of plant : soil – pixels.
- After spatial correction $OY_{canopy\ cover}$ was calculated for each mixture composition and each time point.
- $OY_{canopy\ cover}$ refers to deviations of mixture CC from expectations derived from the average of component pure stand CC. $OY_{grain\ yield}$ refers to the deviations of mixture grain yield derived from the average of pure stand.

3 Results and Discussion

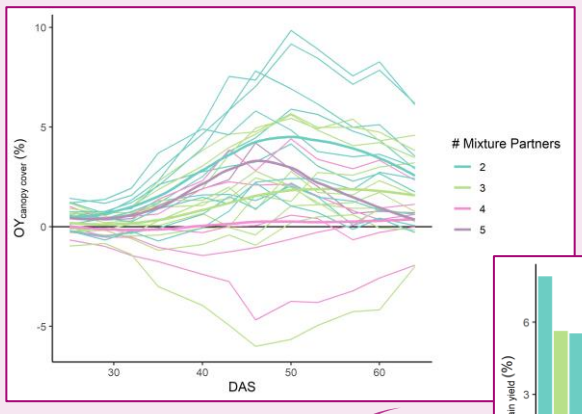

Figure 2: Overyielding of canopy cover ($OY_{canopy\ cover}$) per plot (spatially corrected) is displayed in percent over time. Positive values show an overyielding, negative values an underyielding effect.

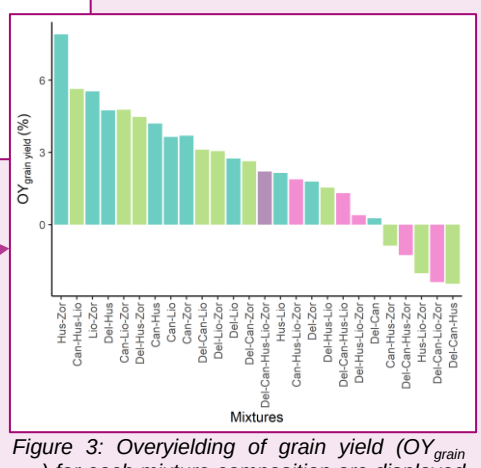

Figure 3: Overyielding of grain yield ($OY_{grain\ yield}$) for each mixture composition are displayed in percent. Positive values indicate overyielding, negative values indicate underyielding.

- $OY_{grain\ yield}$ was highest in two-way mixtures and decreased with the number of component.
- $OY_{canopy\ cover}$ was calculated for each time point, and overyielding estimates were also overall positive and peaked around 50 DAS.
- Positive interactions between oat varieties occur already at an early stage.
- Positive interactions may lead to increased potential for light interception.
- High Throughput Field Phenotyping offers non-destructive measurements to screen for high performing varietal mixtures.

4 Conclusion

This study demonstrates the potential of High Throughput Field Phenotyping to investigate different partners and complexities of variety mixtures. A significant correlation between the $OY_{grain\ yield}$ and $OY_{canopy\ cover}$ at early crop development stages was found. This shows the potential of non-destructive measurement for canopy cover overyielding as an early predictive trait for beneficial mixture compositions.

References

[1]Kirchgessner, N., et al., (2017). "The ETH field phenotyping platform FIP : a cable-suspended multi sensor system". doi: 10.1071/FP16165

[2]Zenkl, R., et al., (2022). "Outdoor Plant Segmentation With Deep Learning for High-Throughput Field Phenotyping on a Diverse Wheat Dataset". doi: 10.3389/fpls.2021.774068.626