T3: New Breeding Strategies and Bioinformatic Tools

New breeding strategies for mixed cropping in a barley (*H. vulgare* L.) pea (*P. sativum* L.) model system

Benedikt Haug[1]*, Monika M. Messmer[1], Emma Forst[2], Tristan Mary-Huard[2,3], Jérôme Enjalbert[2], Isabelle Goldringer[2], Pierre Hohmann[1]

[1]FiBL Research Institute of Organic Agriculture, Frick, Switzerland
[2]GQE Le Moulon, INRA, Univ. Paris Sud, CNRS, AgroParisTech, Université Paris-Saclay, Gif sur Yvette, France
[3]MIA-Paris, AgroParisTech, Paris (France)
*E-mail: benedikt.haug@fibl.org

Keywords: plant breeding, mixed cropping, pea, barley, intercropping

Crop mixtures consisting of cereals and legumes have proven as a well-adapted arrangement due to their complementarity towards important resources, especially nitrogen. Crop mixtures combine high yield performance and yield stability. They can contribute to a diversified cropping landscape and adaptation to climate change. The search for alternatives to protein imports from overseas and investments in post-harvest separation technologies are currently fostering their adoption by farmers in Western-Europe, especially under organic and low-input farming conditions. However, screening and breeding for mixed cropping has hardly been explored for arable crops. Thus, the objective was to develop novel breeding strategies and tools specifically for mixed cropping systems.

We tested mixtures and pure stands of a morphologically diverse panel of 32 spring pea (*Pisum sativum* L.) and eight spring barley (*Hordeum vulgare* L.) cultivars in replicated field trials at two locations in Switzerland over two years with pea as the focal species. In an incomplete factorial design (Fig. 1) we determined general and specific mixing ability (GMA and SMA, respectively) of pea and barley in analogy to GCA and SCA (general and specific combining ability) in hybrid breeding. Key traits, such as early vigour, canopy height and leaf morphology parameters were measured, due to their potential use as covariates or indirect selection criteria for mixing ability. Our results show that total yield of mixtures can only partly be explained by pea pure stand yields ($R^2 = 0.35$), making the latter a weak predictor for mixture yield. Pea GMA variance was predominant over SMA variance which underlines the potential for breeding for mixing ability using a tester. Key traits, such as pea stipule area were correlated ($R^2 = 0.56$) with total mixture yield and merit further investigation as indirect selection criteria. The separated yield fractions of pea and barley in mixtures allow to decompose GMA of pea into the producer effect of pea cultivar on pea fraction yield and the associate effect of pea on barley fraction yield. This novel concept allows to elucidate key trait effects on fraction yields of pea and barley which might otherwise be masked when solely using a GMA approach.

barleys / peas		P01	P02	P03	P04	P05	P06	P07	P08	P09	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25	P26	P27	P28	P29	P30	P31	P32
No barley (pure stand pea) / No pea (pure stand barley)		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
B1	1	1				1				1			1			1			1		1			1		1							
B2	1	1			1			1			1			1		1			1		1				1		1						
B3	1			1	1			1			1			1			1	1		1					1			1				1	
B4	1		1				1			1			1	1				1			1			1			1			1		
B5	1			1		1			1		1				1			1			1	1		1		1						1
B6	1	1			1			1		1		1				1	1		1			1	1			1					1	
B7	1	1			1		1		1			1	1		1					1			1	1								1
B8	1		1			1		1			1		1			1		1			1			1		1		1				1

Figure 1. Incomplete factorial design of 8 barley and 32 pea cultivars

Acknowledgments