University of Zurich[UZH]

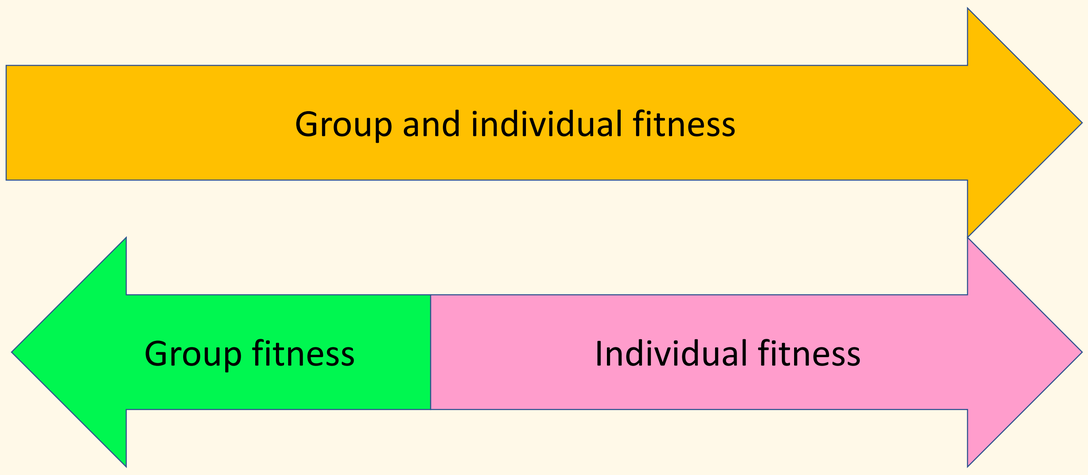
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Département fédéral de l'économie, de la formation et de la recherche DEFR
Agroscope

Can genotypic variation of social behaviours in soybean be quantified and cooperative behaviours be associated to specific genes?

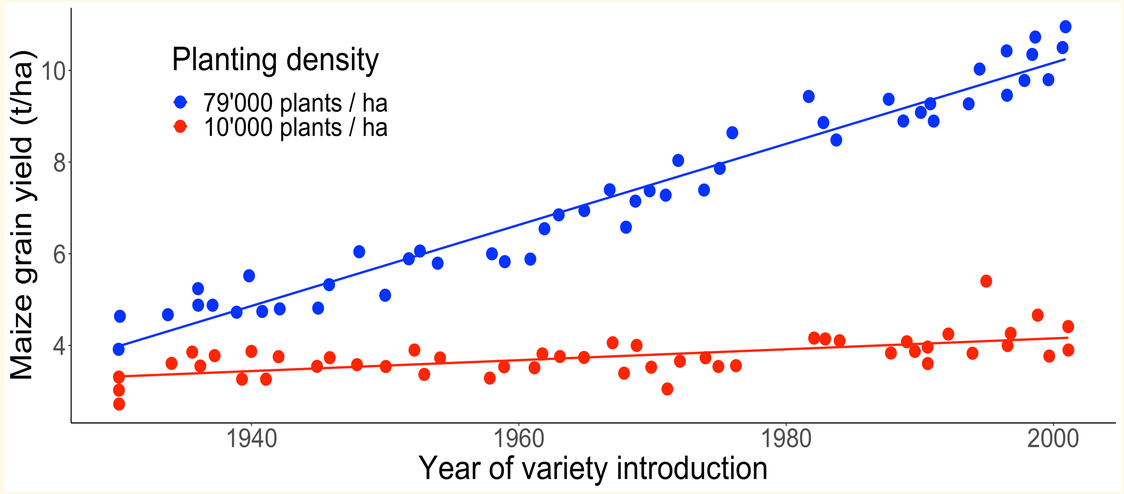
Emanuel Kopp[1,2], [1]*Breeding Research, Agroscope,* [2]*Dep. of Evolutionary Biology and Environmental Studies, University of Zurich*

Evolutionary background



One key hypothesis of evolutionary agroecology is the existence of a trade-off between a plant genotype's individual fitness and its performance as a (monoculture) group. While traits that increase individual fitness have been optimised by natural selection and are unlikely to offer much potential for breeding (top), there might be traits that increase group performance while decreasing individual fitness (bottom).
Figure adapted from Weiner, 2019.

Agronomic background



Maize yields in the last century increased massively only at high densities. This indicates an improvement at group level rather than at individual level (modern varieties can grow in dense stands without wasting much resources in competitive behaviours – leading to higher group yields even though the yield of the individual plants didn't increase).
This didn't happen in soybean.
Figure adapted from Duvick, 2010

Can we exploit this trade-off to quantify genotypic variation in social behaviours and identify cooperative soybean genotypes?

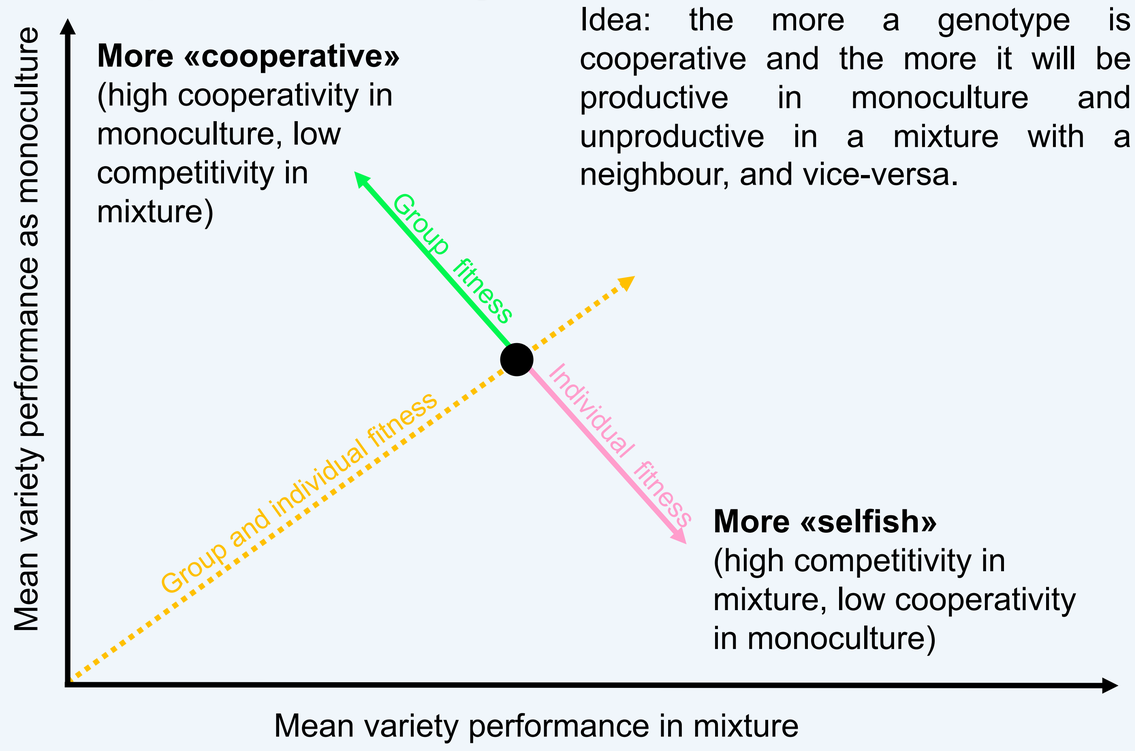
We performed a factorial experiment where 90 soybean genotypes were grown in different social environments – either as monoculture (blue) or with a non-related neighbour (yellow).

Following from game theoretical considerations, the more cooperative genotypes will perform better in competition with themselves than in competition with other, less cooperative genotypes

	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	g_1	g_2	g_3	g_4	...
g_1													
g_2													
g_3													
g_4													
...													...
...	...	...	...	...	...	...	...	...	...	...	...	...	...

In each pot there are two soybean plants, either of the same variety (monoculture) or of different varieties (mixture). We will use the trade-off between monoculture group performance and individual performance in mixtures with non-related neighbours to rank the genotypes along a "group vs. individual" strategy gradient (G-I ranking).

Concept for G-I ranking



Idea: the more a genotype is cooperative and the more it will be productive in monoculture and unproductive in a mixture with a neighbour, and vice-versa.

We will use the ranking of the genotypes along the green/pink line (group vs. individual trade-off) to associate traits or genes to the variations in social behaviours.
Figure adapted from Wuest, 2019

Vision

The identification of genes for cooperation in crop species would be of high interest as it would allow for seamless integration of breeding for more cooperative genotypes into modern breeding schedules.

Literature

Duvick, D. N., Smith, J. S. C., & Cooper, M. (2010). *Long-Term Selection in a Commercial Hybrid Maize Breeding Program*. *Plant Breeding Reviews* (Vol. 24). https://doi.org/10.1002/9780470650288.ch4

Weiner, J. (2019). Looking in the Wrong Direction for Higher-Yielding Crop Genotypes. *Trends in Plant Science*, *24*(10), 927–933. https://doi.org/10.1016/j.tplants.2019.07.001

Wuest, S. E., Pires, N. D., Luo, S., Vasseur, F., Messier, J., Grossniklaus, U., & Niklaus, P. A. (2019). Increasing plant group productivity through latent genetic variation for cooperation. *BioRxiv*. https://doi.org/10.1101/641449