DIVERSify Factsheet no. 7

RESILIENCE AND ECOSYSTEM SERVICES

Yield stability in plant teams under extreme weather conditions

ABSTRACT

Climate change will involve more frequent extreme weather conditions such as heavy rainfalls, storm and/or extended drought periods to varying extents in different regions. Growing mixed cultures of two or more crop species on the same piece of land at a given time may enhance crop yield stability in more extreme weather conditions, as the different crops are likely to **have different responses to the environmental stress**. However, a rigorous test of the yield-stabilising effect of mixtures is not simple.

Below, we present results from across **two years with contrasting weather** (2018 and 2019) where we obtained the opportunity to test the yield-stabilising effect of mixtures as we had grown various **barley and pea, and wheat and faba bean mixtures** during both years in seven experimental trials (locations) across Europe, from Spain to Sweden. A **stability index** was calculated as the ratio between the expected and observed variabilities, with **values >1 indicating greater stability of the mixed crops**.

Yield indices were **similar to or <1 in most locations**, except for one location where the observed yield variability (in mixtures) for the faba bean and wheat plant team was lower than the expected variability (from monocrop). Furthermore, the yield stability index increased with increasing mean yields across all locations. In addition, use of plant teams composed of local crops could be a measure to enhance a yield-stabilising effect.

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CONTEXT

A changing climate leads to **changes in the frequency, duration and timing of weather extremes**, and it is likely that the occurrence of extreme weather events will increase in the future, implying larger year-to-year variations in weather. Greater year-to-year variation and more frequent extreme weather conditions are expected to **decrease yield stability over time**. Mixed cropping, i.e., growing more than one species simultaneously in the same field, has been reported to enhance yield stability, but evidence is ambiguous.

One way to test the yield-stabilising effect of mixed cultures is to **compare the year-to-year variability in the yields of pure and mixed cultures across a wide range of pedo-climatic conditions**. Mixtures of cereals and legumes are often a feasible option with routes to market being available for these crops (for further information see DIVERSify Factsheet no. 13) as well as the opportunity to take additional advantage of the nitrogen-fixing characteristics of the legumes when grown in mixture, and potential benefits in terms of disease, pest and weed control (see DIVERSify Factsheet no. 2).

WHAT IS YIELD STABILITY?

Yield stability refers to **how stable the yield of an agricultural system is over time** from one year to another, and **high yield stability implies obtaining around the same yield amount each year**. The grain yields of **barley and pea**, and **wheat and faba bean** grown in a plant team or monocrop were recorded in seven experimental trials across Europe during two years with contrasting weather (2018 and 2019).

We measured grain yield stability based on the expected year-to-year yield variation of the plant team components grown separately versus the corresponding observed yield variation when the same components were grown in **50:50 mixtures**. Mean yield differences between the two years were calculated for the sum of the two mixture components grown in monocrop, and for the total yields in the corresponding 50:50 intercrop (always calculated for the same land area basis). **The ratio between the year-to-year yield differences in the pure and mixed cultures is the stability index. Values >1** indicate **greater stability of the mixed cultures** and **values <1** indicate **greater stability of the pure cultures**.

Fig. 1 Faba bean and wheat growing in intercropping plot trials at SLU, Uppsala, Sweden. Credit: Martin Weih

YIELD STABILITY FROM 2018 TO 2019

Yield stability indices assessed in the seven experimental trials across Europe were **similar to or <1 in most locations**, except for the Danish trial where the year-to-year yield difference of the mixtures (especially of faba bean and wheat) was lower than the year-to-year differences calculated from the corresponding pure cultures, resulting in a stability index clearly >1 (**Fig. 2A**). The Danish trial also produced the highest yields, and the stability indices from **Fig. 2A** increased with increasing mean yields across all locations (**Fig. 2B**). A **yield-stabilising effect of mixtures is thus more likely to occur in generally higher-yielding conditions**, like the Danish trial in this study.

In addition to these facts, the use of dedicated **mixtures based on farmer experiences with local crops and varieties** can also be an efficient measure to enhance the yield-stabilising effects of crop mixtures. An example of such a local solution is growing strips of *Phaseolus* beans with maize as a supporting crop, alternated with strips of pumpkin as is practiced as part of the 'three sisters' system in Austria (**Fig. 3**). As canopy closure is rather late in the bean and maize mixture, leading to bare soil for extended periods, pumpkin plants can regulate weed and moisture content of the soil at the ground level (particularly at the border regions) and thus also support enhanced yield stability of the bean plants.

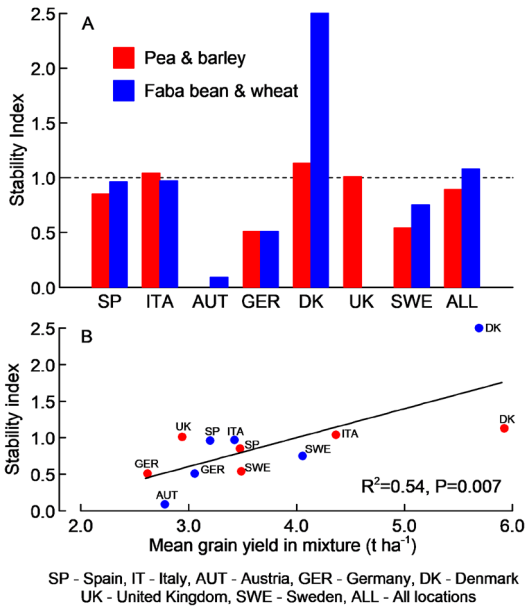

Fig. 2 **(A)** The stability index from 2018 to 2019 between intercropped and monocropped peas and barley, and faba bean and wheat, was calculated across seven plot trials in Europe. **(B)** Stability index was found to increase as grain yield in mixture increased

Fig. 3 *Phaseolus* beans are grown with maize and pumpkin as part of a successful plant team in Austria. Credit: Eveline Adam

Choosing the most appropriate **sowing density** of each mixture component, as well as similar **maturity dates** for all components is critical. DIVERSify Factsheet no. 1 offers some general advice. Local farm advisors and other farmers in your region can give valuable advice on choosing the most appropriate crops and cultivars for your local conditions.

CONCLUSION

In terms of risk evaluation and cropping security, interest in intercropping should increase if the system supplies more stable yields in adverse conditions compared to growing the components as separate monocrops; particularly, if there is a market for the intercropped products. **We have developed a yield stability index that can be applied on farm or across a network of farms where the crops are produced as mixed or pure crops in a similar location.** The index reflects temporal (year-to-year) yield differences seen in the pure cultures of the mixture components in relation to the temporal yield differences observed in the mixtures.

Our results indicate that a yield-stabilising effect of plant teams is less likely to occur in low-yielding environments and appears to become more likely as the growth conditions become more favourable for high yields. The yield-stabilising effects of plant teams can be further enhanced by designing locally adapted crop mixtures according to the advice provided by local farm advisors. Farm advisors and local farmer networks are likely to be able to share the most appropriate management measures and variety choices for your region.

FURTHER INFO

> Weih M. *et al.* (2021) Grain yield stability of individual cereal-legume mixtures grown across Europe. Aspects of Applied Biology 146:241–247
> Weih, M. *et al.* (2021) Grain Yield Stability of Cereal-Legume Intercrops Is Greater Than Sole Crops in More Productive Conditions. doi.org/10.3390/agriculture11030255
> Farmer-led trials of plant teams from across Europe, particularly Austria, Denmark, Italy, Switzerland and the UK, have been summarised at plant-teams.org.
> Read on to discover more about the benefits of plant teams: DIVERSify Factsheet no. 8

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