Stabilising wheat yields

Can genetic diversity increase reliability of wheat performance

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Key Points

Climate change means our weather patterns are becoming more changeable and less predictable.

Employing high genetic diversity within a crop is one way in which arable production can buffer against such increased variability.

The potential of this approach to combat variability has been demonstrated in field trials where genetically diverse wheat populations have shown high yield stability across years.

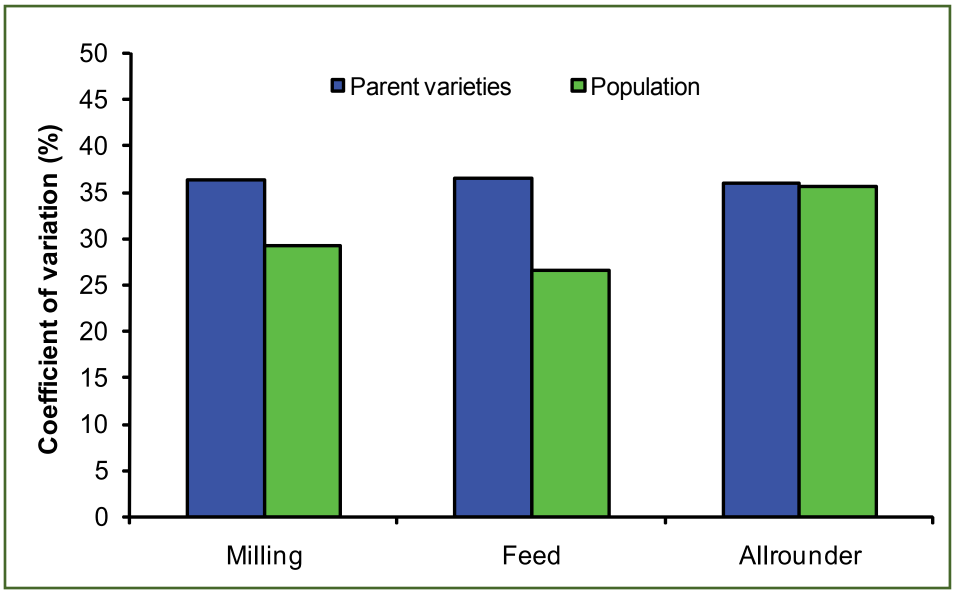

Figure 1. Yield stability is higher in genetically diverse wheat, indicated by lower coefficients of variation. The coefficient of variation of grain yield is shown for composite cross populations of three different end uses, as well as for their respective parent varieties.

Introduction

Weather talk is always exciting, especially when the weather is as changeable as it is in Britain. However, there could be rather too much excitement about the weather in the future. With higher variability and more extreme weather events projected through climate change, the weather is very likely to become much less predictable and less reliable. For arable farming, this will have severe consequences as seasonal droughts, heat waves, or torrential rainfall events can strongly disrupt crop growth. A key question is how can arable farmers respond to such challenges?

Striving for stability

One possibility is to develop crops that can perform reliably under more variable environmental conditions. Thus, what we need are crops with high stability, returning relatively reliable and high yields in the face of a changing and increasingly unpredictable climate. In a series of field experiments the Organic Research Centre has been investigating the stability of twenty wheat varieties, over three years on four trial sites. More importantly, however, the research also tested whether greatly increased genetic diversity within the crop could help to boost stability.

Diversity for adversity

In order to explore potential in this area twenty winter wheat varieties were grown not only as monocultures, but also as crosses with each other, and the bulked-up offspring from these crosses were re-sown in the field. In these composite cross populations, or just “populations” as we call them, it is probable that every wheat plant is genetically different from every other plant. With such a huge genetic diversity within the crop theory predicts that the population should demonstrate an increased ability to buffer against adverse or fluctuating environmental conditions. For instance, in a dry year some plants within the population will be able to compensate for the failure of others, which in turn may do well in another wetter year. In contrast, a monoculture of a wheat variety could be expected to exhibit this compensatory ability to a much lesser degree. By comparing the populations with their parent varieties it is, therefore, possible to test if high genetic diversity within the crop increases the ability to produce stable yields. In total, three different populations were created:

- a milling population (called "Q" for quality), derived from a subset of the twenty varieties that are known for their high quality,
- a feed population (called "Y" for or yield), derived from high-yielding parents,
- an all-rounder (called "YQ"), derived from all twenty parent varieties.

Trial setup

With the help of Defra funding experiments were conducted on-farm at Wakelyns Agroforestry, Metfield Hall, Suffolk, and at TAG Morley, Norfolk, as well as on Sheepdrove Organic Farm in Berkshire. The parent varieties as well as the three different populations were tested in randomized complete block designs with three replicates. For each of the four sites, stability of yield was measured with the coefficient of variation across the three trial years (2004/05 to 2006/07). A lower coefficient of variation means greater stability.

Trial results

Comared to the averages of their respective parents, the three populations showed significantly lower coefficients of variations regarding grain yield (Figure 1). This shows that, consistent with expectations, the highly diverse wheat populations are more stable and can buffer better against environmental fluctuations (compared to varietal monocultures). These experiments therefore demonstrate that high diversity (e.g. by growing plants with different genotypes together in the field), represents a way to stabilise yields. Crucially, the populations also out-yielded the average of their respective parents.

Farmer-led breeding

A further key feature of the wheat populations is their ability to change over time. When a part of the harvested crop is retained as seed for sowing, those plants that have fared well will contribute more to the next season's seed than those with poor performance. By sowing and re-sowing the wheat population year after year a farmer will therefore slowly build a wheat crop that is more and more adapted to the local farm conditions. Indeed, using natural selection the farmer is able to breed their own 'modern landrace'.

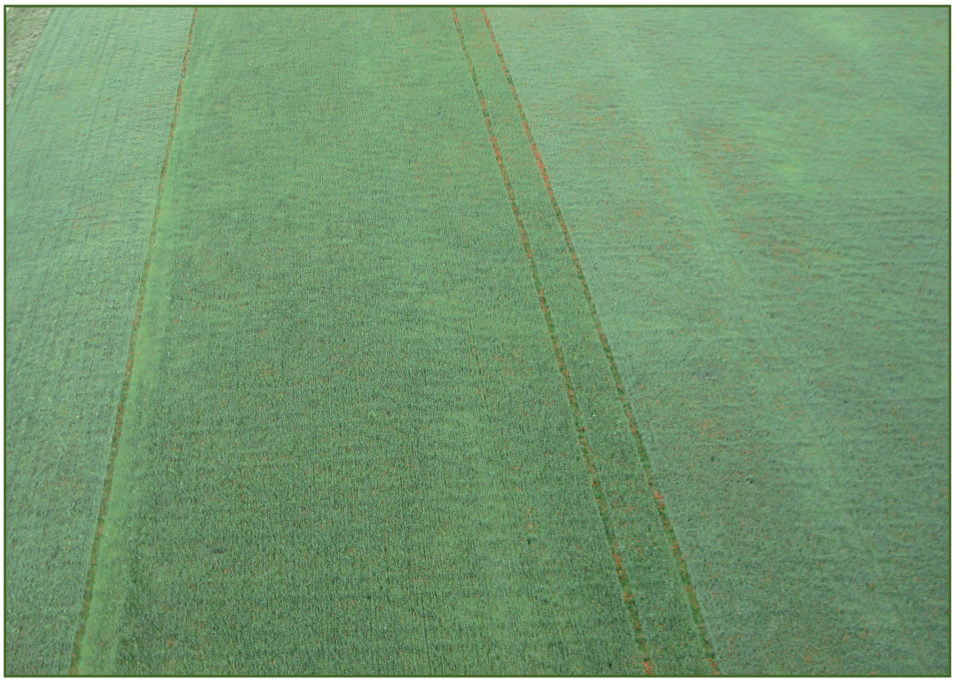

Figure 2. An aerial picture of a wheat population strip in a field of Claire at Rushall Farm, Wiltshire.

Evidence for adaptation

From trials at Wakelyns Agroforestry in Suffolk, some evidence is emerging that the wheat populations are indeed highly adaptable. As an almost brutal test, the populations, originally derived from winter wheat varieties, were sown in spring to study their ability to cope with drastic environmental changes. In the first year, yields and overall plant performance were relatively low. However, after subsequent re-sowing of the grain harvested last summer, yields look likely to increase substantially this year given the current appearance of the crop (we'll know more once the yield is in the bag!). There is also anecdotal evidence that the populations can adapt to much colder winters within two generations. After having almost died off completely in a harsh Hungarian winter, a wheat population was re-sown from the survivors and the offspring out-yielded the local competition.

Popular populations

Currently, a further project sponsored though the Defra LINK programme, in association with and industry partners, and led by the Organic Research Centre, is investigating the potential applications and uses of the wheat populations in more detail in the UK. The populations are being tested for milling, baking and distilling quality, but are also being examined regarding their agronomic performance in the field. Around two dozen farmers across the UK are currently growing the wheat populations on their farms, along with a control variety (Figure 2). This research project will provide interesting information on the yield stability of the wheat populations over a longer time period and larger geographical areas. This should help to confirm our findings to date and improve our understanding as to whether local adaptation of the populations, to the respective farm conditions, can generate consistent grower benefits.

Acknowledgements

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