Against the grain

An Organic Research Centre project is examining how diversity-based tools can assist in the on-farm improvement of organic wheat

Two ears with markedly different appearance, both from the same population

Successful organic crop production requires varieties that are resistant to diseases, competitive against weeds, and effective at scavenging nutrients. Yet conventional plant breeding has largely neglected organic systems by breeding varieties exclusively for high input conditions. As a consequence, organic producers currently do not have enough choice of plant varieties for organic conditions.

One way to expand the choice is to create plant diversity anew and subject it to natural selection on organic farms. After several generations the dominating plants would be better suited to organic systems. This idea is being tested in the Organic Research Centre's Wheat Breeding LINK project.

Evolving wheat

At the start of the project several wheat varieties were crossed with each other to create a high level of genetic diversity. A plant breeder would then normally select a few top performing lines from the offspring and discard the rest. In the Wheat Breeding LINK project, however, all offspring from the initial crosses were sown, creating a composite cross population (CCP). After another season of growing the CCP seed was again saved from the entire population. This process of sowing, harvesting and seed saving was repeated over several generations.

The key point is that a successful plant, with lots of plump grains, will make a larger contribution to the next plant generation than a plant with few small grains. So the population will adapt to the conditions under which it is grown. For example, after several years grown on a shallow lime soil we expect to get a different population from what would evolve on a deep fen soil. We would also expect the populations to gradually adapt to the conditions of organic crop management.

Increasing the genetic diversity also enables us – scientists and producers – to actively improve the crop. A CCP exhibits a wide range of physical characteristics. By going into the field and choosing plants with desirable

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ABOVE: A wheat population (left) and a pure line variety for comparison (Clare, right)

A wheat population grown between alleys of hardwood trees at Wakelyns Agroforestry

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The Wheat Breeding LINK project is funded by Defra and is supported by several industry partners. We thank Dr Hannah Jones (University of Reading) and Helen Pearce (Organic Research Centre) for contributions to this project and to the participating farmers for their engagement, particularly Nigel Wookey of France Farm (Rushall) for providing the colour screener. For more information about the project visit **http://tinyurl.com/WBL2011**

characteristics, producers can play the role of plant breeder and develop a crop with greater yields or greater protein content. Breeders would normally make their choice by selecting single promising plants, and, if it proves to be successful, multiply its seed. For a producer, this process is too slow because it takes several generations to get enough seed for a whole field. But a different approach called 'mass selection' can help to drive and improve a diverse plant population.

Grain size

For example, by passing grain through a sieve before sowing, smaller grains can be separated from larger grains. Generally, being large improves the chances of a seed to develop into a vigorous plant. So sieving out the small-grain fraction before sowing, and sowing only the larger seeds, should lead to higher yields. We tested this idea by sowing the small grain fraction and the large grain fraction of the CCP in replicated field trials in 2009. At the following year's harvest, we found the plants grown from larger seed yielded significantly more than the plants from smaller seed. At 0.52 t/ha, the difference was considerable. Also, when we measured the grain size of the two size fractions at sowing in 2009 and again at harvest in 2010, we found that the larger seed led to significantly larger grains in the next generation than did the smaller seeds.

This means that by continually saving seed from the large size fraction and sieving it before sowing, the population could gradually increase in grain size and yield over successive years. An enthusiast participating in the project was excited by the prospect of grape sized wheat grains – but sadly, there is a limit: the morphology of the wheat ear leaves little room for huge grain size increases. Consequently, wheat breeders have traditionally considered grain size as not holding a great deal of yield potential. However, as a tool for producer-led crop improvement, size sieving does offer some potential – if there is variation of grain size to start with. In the wheat populations such variation is indeed present: when we measured grain size in 600 ears we found that the thousand grain weight ranged from 21 grams to 68 grams.

Protein

Mass selection can also be used to improve the protein content of the grain. Protein content is correlated with a dark grain colour. As different grains within the CCPs vary in colour, we hypothesized that colour sorting could improve protein content. To test this idea we used a colour screener (Satake Alpha Scan II) – typically used to detect and remove ergot and stones from grain samples. After the high throughput colour sorter separated the lighter grains from the darker ones, we measured the protein content in the light and dark fractions of grain and found the darker grains had up to 1.6% higher protein content. However, when we grew seed from the two fractions, we found the difference in protein content between the two fractions was smaller in the subsequent generation of the wheat, although it was still significant.

Looking to the future

To conclude, simple methods such as sieving or colour-separating grain can enable producers to increase wheat yield and quality. It is necessary to have sufficient diversity among the plants in order for this approach to work. Unfortunately, current seed regulation prohibits the use of diverse plant material and prescribes the uniformity of plants in traded varieties. Thus, selling (or even donating) a diverse wheat population for use as seed is currently illegal. As a result, the ability to use selection for crop improvement remains entirely with plant breeders.

Changing seed and variety law in favour of more diversity would enable producers to regain some control over plant selection and crop improvement, specifically for organic conditions. As conventional plant breeders have so far failed to respond sufficiently to the growing demand for organic varieties, more independence from their supply might help to develop crops better adapted to organic farming.

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