Designing crops for variable environments

M S Wolfe
Elm Farm Research Centre, Hamstead Marshall, Newbury, Berks RG20 0HR, UK
Email: martin@wakelyns.demon.co.uk

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Modern high input farming produces large amounts of a few staple crops through high yields. This depends on high levels of soluble synthetic inputs, partly to provide for high potential outputs and partly to try to control environmental variation, but also on varieties that are bred and selected for this approach. The system as a whole leads to high environmental costs, directly, for example through soil loss and degradation, and indirectly, for example through high energy costs at all stages.

The alternative is some form of sustainable agriculture which limits or removes the use of soluble synthetic inputs. This has direct advantages, for example through soil maintenance, and indirectly, for example via a better return per unit of fossil energy used. Overall, ecosystem services from agriculture are significantly improved. Currently, this approach involves reductions in yield per unit area and potential increases in unreliability because of the reduced control of the environment. These disadvantages can be reduced by inter-linked changes in farming and marketing, including the provision of varieties that are bred and selected for such approaches.

In alternative systems, reductions in yield and increases in yield variation are manifested often through reduced and variable fertility, with increases in weed competition and pests. These negative aspects can be reduced by farming systems that include rotations for fertility building and weed control, and by spatial arrangement in cropping systems that can impede the spread of diseases and pests.

One such form of spatial arrangement is inter-cropping in which the component species are grown separately in close proximity. However, interactions are often improved by more intimate inter-cropping. For example, one method that has been proven both experimentally and on large scales of production is the use of variety mixtures in cereals. This can help to increase yield reliably through stable reduction of disease, without impairing crop quality. It seems likely that mixture performance could be improved by selecting varieties that perform well together. Indeed, for other crops and diseases, such as potato and late blight, we have found it essential first to screen varieties for their ecological combining ability, partly because much of the growing season involves varieties growing together in the absence of the blight pathogen.

Another approach is to re-consider the value of ‘ecological plant breeding’. Here, a wide range of appropriate parent varieties are inter-crossed in all combinations. The resultant segregating populations are then exposed to natural or mass selection across a range of environments. A new wheat composite is now being exposed to both the controlled environment of high input systems and to the variable environments of organic farming systems. Population evolution will be followed closely to determine the differential adaptation of the same starting populations. The populations exposed to variable environments will also be assessed for their potential use as stable production crops under those conditions.