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# Agriculture: a path of experiment and change

*Richard B. Flavell*

Agriculture is one of the prerequisites for sustaining populations and economies. Central to life-saving advances in agricultural production have been the improvements in the properties of plants by breeding and selection.

Only very few plants have ever been adopted into agriculture. Most would make hopeless crops. Of some 250,000-300,000 known plant species, only a few hundred are used in agriculture to any degree. Just a handful of those most suited to human needs feed most of the world's population.

The plants that early farmers chose had already accumulated mutant variants of thousands of genes by the forces of natural selection. The first farmers changed which plant types were propagated because they imposed human needs on the selection process. One of the most important natural mutations in grass crops like wheat, for instance, enabled the grain to be threshed out of the ear. Farmers could now harvest the grain in bulk by reaping and threshing. The seed that the early farmers kept, the seed they selected and planted the next year, contained this mutant gene. All the grain crops we grow today have mutations that give this same kind of useful characteristic.

Farmers and, subsequently, plant breeders accelerated the concentration of particular valuable genes by crossing plants and selecting among the progeny for improved characteristics. All farmers and consumers, including organic lovers, depend on crops that have accumulated multiple useful mutations in this way. Frequently, as with wheat and oilseed rape, for instance, early crop improvement involved interspecies hybrids.

The quest for new plant types has been driven almost entirely by consumer demand: for most of human history and prehistory, the consumers of agricultural products were the same farmers who grew them. It is only in the last few centuries in certain parts of the world that farming (and consuming) have become separate specialized occupations.

Manipulating the genetic constitution of plants and then selecting characteristics that suited human needs was the only way available to humankind and nature for improving organisms. In the past, the rate of genetic improvement has been limited by the number of favorable mutant genes available and the ability to create, find and propagate the improved variant strain. So will it be in the future.

What is different now, however, is that more genes than ever before—from plants and from other sources—are available to breeders because of "genomics." Organizations worldwide are deciphering DNA sequences of every gene in many species including key crop species. The pace of discovery is accelerating at an extraordinary rate because of substantial international public and private sector investments. This is creating a library of genetic information and knowledge of where to find the original genes. In a few years, we will know how genes vary within and between species, what they do, and what characteristics they confer on the plant. For those crops that receive the greatest research effort, plant improvement will become more efficient. In order to serve a particular human need, we will know which genes in a crop to select, which to discard, and which to change.

But of even greater significance (and controversy) are the advances that enable genes made in the laboratory to be added to most of plant species that mankind uses in agriculture and forestry. In virtually every crop species where genetic engineering has been attempted to create genetically modified plants, it has succeeded.

These advances in genomics and genetic modification have created almost unlimited opportunities to improve crop productivity and nutritional value, to convert noncrops to crops, and to diversify crops so that they can grow in inhospitable places, withstand climate changes and meet industrial needs. Some people argue that broadening the genetic competencies of plants by genetic engineering is inherently wrong and should not be adopted. I would say that this view is based in poor understanding of evolution and plant breeding to date, on an underestimation of what benefits the technical approach can bring and on a gross overestimation of risks that are inevitably associated with any such products. This attitude seems at the least unresponsive (to consumer demands) and insensitive (to the needs created by global population expansion, environmental conservation, and the desire for greater human equality).

At present, US farmers are buying genetically engineered soybean, corn, and cotton seeds because they provide better product quality and profitability for their farms. The governments of poorer nations have repeatedly said that their farmers would try equivalent products immediately if they were available at affordable prices in appropriate crop strains. We see all too frequently the results of crop failures due to drought, insects, or other pests in countries where food security is poor.

And we must recognize, too, that in the poorest countries most small farmers are women. Time spent weeding crops by hand, because herbicide-tolerant crops and safe herbicides are not available, is time not spent caring for and educating children or other more productive activities. When we consider using, or not using, a technology, we must consider all the implications before coming to cost-benefit conclusions. The biggest disservice Europeans could do for the world is to persuade it that the use of novel genes in agriculture is inherently misguided.

It has become fashionable not to marvel at scientific discovery or technological advances but to take both for granted or even reject them. The millennium bug may yet turn out to be a benefit to humanity if it serves to remind us of our dependency on technology. The annual cycle of productive agriculture upon which we all rely is a fragile phenomenon born of human endeavor, adaptability, and understanding. In trying to deal with a changing world, individuals and governments—even those who do not see subsistence at first hand—should remember that.

I would not expect everyone to rejoice at the scientific discoveries within crop genomics. I would not expect to quell the carping at the perceived inadequacies of the earliest products of plant biotechnology. I would not expect everyone to accept willingly the views of experts regarding the levels of risks associated with the use of genetically modified crops or to accept that these risks will be small compared to those of not using the tools available to help sustain populations, environments and economies. However, I would hope that debates and decisions will be based not on ignorance but on knowledge, not on bigotry but on rationality, and not solely on selfish local values but on a consideration of those who live in other societies and beyond our time. ///

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