Agriculture isn't all rocket science

Ecological approaches to agriculture have a major role to play, alongside biotechnology.

One lesson that the COVID-19 pandemic has emphasized is that low-tech approaches can be as important as high-tech ones. For example, behavioural interventions such as face masks and social distancing can dramatically reduce infection transmission in the absence of vaccines, at least in the short term. A similar principle applies to food security — a range of ecological and evolutionary approaches are often overlooked in favour of more sophisticated and potentially more expensive technologies.

One such approach is mixing varieties within a single crop to improve yield, yield stability and disease resistance, as Wuest et al. discuss in a Perspective in this issue. The authors argue that crop variety mixtures represent a middle ground between intercropping of different species and full monocultures. While intercropping has a long and successful history in specific circumstances, and has considerable ecological benefits, it is difficult to reconcile with mechanized agriculture given that different crops require different harvesting. Monocultures, on the other hand, are efficient but at greater risk from pests and system shocks, and can be detrimental to biodiversity in the surrounding environment. Varieties of the same crop, by contrast, can usually be harvested in the same way but still retain some of the ecological advantages that result from diversity. Despite these benefits, crop variety mixtures remain underutilized.

The authors explore how use of variety mixtures could be increased, while acknowledging that there are still considerable hurdles in developing the approach further. For example, in biodiversity experiments in natural ecosystems, ecosystem function generally increases with diversity, but the mechanisms are often complex. Without more detailed mechanistic understanding in specific circumstances, we cannot be absolutely sure that the same diversity–function relationship will apply with mixtures of intensely bred crops, where specific traits have been selected. So it is not a trivial task to decide what crop mixtures would actually work — agriculturalists need to get the combination of traits right and minimize competition. Finding the right combination can be logistically challenging given the sheer range of possibilities. One potential approach that bypasses this problem is evolutionary breeding, in which genotype mixtures are deliberately bred in crosses and then exposed to selection to find the best-performing combinations.

Other agroecological approaches include integrated pest management, in which farmers attempt to keep pests at acceptable levels rather than eliminate them, using chemical control only as a last resort, and integrated soil–crop system management, in which farmers minimize nutrient use through a detailed consideration of local soil conditions and appropriate selection of varieties[1]. Both of these approaches apply ecological knowledge and existing technologies to improve yields and reduce environmental impacts.

Another recent study in this journal examined the economic and yield benefits of the agroecological approach of biological pest control, compared with 'Green Revolution' improvements to crops[2]. Over the time period 1918–2018 across the Asia-Pacific region, the authors showed that 75 different biological control agents for 43 different pest species allowed yield-loss recoveries of 73%, 81% and 100% for cassava, banana and coconut, respectively. This translates to US$6.8, 4.3 and 8.2 billion of revenue loss avoided annually, which the authors compare favourably with an estimated US$4.5 billion benefit from improved rice germplasm.

It's simplistic to suggest that all agroecological approaches are low-tech, but many of them make use of existing crop varieties, which are less likely to require monetary investments on the scale that crop improvement through genetic technology or even conventional breeding can involve. And yet, they can make substantial contributions to food security, either now or after further development, and it is possible to put monetary values on these contributions. Indeed, ten years ago, in a very high-level global analysis, Foley et al. showed that optimizing yields and environmental protection involves a range of fairly simple solutions alongside improved technology[3].

The benefits of ecologically informed agricultural practices are for both people and nature, and can be considered either as direct benefits or public goods (although the two can overlap). Improving yields and reducing losses to pests are obvious benefits to individual farmers, but so are improved local soil quality and other ecosystem services. Other benefits to biodiversity, such as reduced local extinction, can also benefit people, but not necessarily at the level of an individual farm, so they can be considered public goods. Given these different types of benefit, it is important that agroecological approaches are considered and applied at all levels, from individual farms up to national and international food policies. ❐

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