The future of global food production

Meals, not myths

The stakes are high in the future of agriculture. If we are to feed nine billion people by 2050, myths about the right ways forward in agricultural production need to be replaced by policies based on scientific evidence.

The global population is expected to exceed nine billion people by 2050. This will more than double the demand for food and put unprecedented pressure on our ecosystem. Views on what this means for the future of agriculture differ strongly. Many otherwise well-informed people have acquired perceptions about agriculture that are not based on scientific evidence. Interestingly, most of these people live in rich urban centres such as San Francisco, Sydney or Paris. This is in sharp contrast to prevailing views in urban areas in developing countries, such as Lima or Nairobi, where many people still have links to agriculture or have relatives living in rural areas.

There are five main myths about agriculture that need to be dispelled. And there are five terms crucial to understanding these myths. To start with, all substances are *chemical*, because they are composed of atoms and molecules. Molecules of *organic* substances contain carbon, while molecules of *mineral* substances do not. Both are chemical in the sense that they are composed of atoms and molecules. Humans, plants and animals are all organic.

Natural compounds are those produced without human interventions, such as petroleum, water, natural gas (methane) and rock phosphate. *Synthetic* compounds are those transformed through human intervention to produce compounds different from their natural state.

To give an example, gasoline, nitrogen fertilizers and phosphorus fertilizers are synthetic products. The first two are transformed from petroleum or natural gas, while phosphorus fertilizers are transformed from rock phosphate. Thus, petroleum and natural gas are organic and natural, while gasoline is organic and synthetic.

Mineral fertilizers are bad

The first myth is that mineral fertilizers are bad. But plants do not care whether the nitrate or phosphate ions they absorb from soils come from a bag of fertilizer, a piece of manure or a decomposing leaf.

Mineral fertilizers do not cause environmental harm when the recommended application is followed. But if nitrogen fertilizers are applied at excessive rates, nitrate leaches into ground water, and nitrous oxide gas is emitted into the atmosphere. Nitrous oxide is a potent greenhouse gas. The main source of human-made N_20 emissions is fertilizers, either mineral or organic.

Mineral fertilizers, when in contact with seeds, can cause 'salt burns' to emerging seedlings. Farmers know this very well and place mineral fertilizers a few centimetres away from the seeds to prevent this problem. Organic fertilizers do not have this effect on seeds.

Another difference between organic and mineral fertilizers is nutrient concentration. Urea, for example, contains 46% nitrogen, while most organic fertilizers contain 2-4% nitrogen. A farmer will need 10 to 20 50-kg bags of dry manure to equal the nitrogen contained in one 50-kg bag of urea.

While plants do not care about the source of the nutrient ions they absorb, soil does, and it needs the carbon provided by organic fertilizers, which mineral fertilizers do not contain. Organic carbon improves soil porosity and water-holding capacity. Also, since organic fertilizers originally derive from plants, they contain all essential nutrient elements, while mineral fertilizers contain only a few.

Like most nourishing substances, fertilizers, whether mineral or organic, are effective when used in the appropriate quantities, but can cause harm if used excessively. Most successful farmers therefore use a combination of mineral and organic fertilizers, taking advantage of their pluses and minuses. There is probably not a single successful sustainable farmer in a rich country that uses only mineral fertilizers. Is that the case for the opposite, organic farming, as well?

Rich countries need organic farming

The second myth holds that organic is the *only* way to go in rich countries. There is nothing conceptually wrong with

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The heart of the matter: circular computer scanner used to read sections of DNA sequencing autoradiograms

organic farming, as long as it can provide crops with the necessary plant nutrients at an economically viable cost.

The shift from conventional to organic farming usually temporarily reduces yield (one to three years in the United States). This is because nutrients held in the soil are needed for the organic material to grow. Soil nutrient reserves begin to deplete since no more mineral fertilizer is added.

After that transition period, organic agriculture really begins to function with proper nutrient cycling. The crop yields do not differ much at this point from those of conventional agriculture.

Organic farming, however, usually requires additional space and additional time to grow the organic fertilizers. The latter can be anything from green manure, which is then incorporated into the soil, to hay that is cut and fed to animals. There are few comparisons between conventional farming versus organic farming that take into account the extra land or time needed.

Pests, diseases and weeds are more of a challenge to control without the use of insecticides, fungicides and herbicides in organic farming. But pesticides also destroy beneficial organisms. If used solely in conventional systems, they can create an increasing dependency, as the pathogens themselves mutate and develop tolerance.

Purely organic pest, disease and weed control is carried out by using tolerant crop varieties, crop rotations and conserving natural enemies. The best approach is integrated pest management, which is based on the sound principles of organic agriculture with strategic applications of insecticides and herbicides.

The question of whether to practice organic or conventional agriculture in rich countries boils down to whether the premium prices organic products receive are sufficiently high to compensate for the harder work organic agriculture requires. Organic farming is one way to go in rich countries, but certainly not the only one.

Poor countries need organic farming

The third myth holds that organic is *the way* to go in poor countries. Some consider organic farming to be the best sustainable option for smallholder farmers in poor countries. This view is usually advocated by non-governmental organizations (NGOs) in rich countries as an alternative to mineral fertilizers. Actually, most African farmers are organic farmers by default, because they use only low-quality manures and compost.

But what happens with organic farming when the soils of smallholder farmers are depleted of nutrients, and cereal yields an average of one ton/ha, as opposed to ten in the United States and Europe? Also, the quantity and quality of cattle manure depends on the quantity and quality of the fodder they ingest, which depends on the nutrient capital of the soil. So much of the manure in Africa is low quality and produced in small quantities. It has few nutrients to offer crops.

The problem would diminish if organic inputs were brought from outside the farm. But high transport costs make this a very expensive endeavour, especially in Africa, where the infrastructure is poor. A more sensible agriculture is needed, based on the wise combination of both organic and inorganic inputs called 'integrated soil fertility management'.

For example, in nutrient-depleted African soils, the initial application of mineral fertilizers is a sensible and often necessary way to start. Soil organic carbon increases when there are high crop yields and crop residue returns, and organic inputs become more effective as more carbon becomes available for micro-organisms.

A purely mineral-based agriculture may be the best option in the initial years and can be gradually supplemented with >

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more organic inputs, produced on site to minimize costs. Ideally, the bulk of the nitrogen could come from nitrogen-fixing trees and cover crops that also recycle other nutrients. The overall effect would reduce but not eliminate the use of mineral fertilizers.

The evils of having to purchase seed every year

The fourth myth concerns the supposed evils of having to purchase seed every year. Many believe, especially in NGO circles, that multinationals are now forcing farmers all over the world to purchase seed every year instead of saving grain from the previous harvests. Buying seed is actually nothing new. It has been the norm since the advent of hybrid maize over 70 years ago.

There are two main types of seed, varieties, and hybrids. Varieties were developed originally by early farmers, who selected and reproduced their best seeds. Crop breeders have been practicing the same selection system for over two centuries. They may cross a tall-statured but high-yielding rice variety with a short-statured but low-yielding rice variety, the objective being to develop a short-statured high-yielding rice variety.

Individual plants of the first generation (F1) are selected and crossed to produce the subsequent generation, F2. This generation of plants usually shows enormous variability in the desired traits. Subsequent generations are selected and crossed again until plants with the desired traits dominate. Seed from such varieties can be planted again for several years.

Hybrids are the F1 generation and possess the 'hybrid vigour'. But this hybrid vigour is lost when one plants the F2s from these hybrids. Farmers usually prefer hybrids because the yield is 25-75% higher than varieties.

This technology was introduced in the 1940s. The hybrid vigour of the F1 seed and improved agronomic practices doubled maize yields in the United States and Europe in just a few years.

The benefits of hybrid seeds are well known globally. Smallholder farmers participating in a government subsidy programme in Malawi, for example, could choose between five kilograms of the country's best maize varieties or three kilograms of the best hybrid maize suitable for use in Malawian agriculture. In both cases, they had to pay only a quarter of the market price. Over 70% of the one million or so farmers opted for the hybrids, knowing very well that they could not plant the seed they would harvest the following year.

Transgenic crops are bad

The fifth myth states that transgenic crops are bad for the environment and human health. Thanks to genomics, breeders can now select genes in their crossing programmes, instead of using the visible traits of individual plants. They can also transfer a gene from one species to another, eventually resulting in transgenic crops that can be either a variety or a hybrid.

A large number of transgenic hybrids or varieties of crops have been released in the last 20 years. Examples include maize, soybeans and papaya, most of which are to provide resistance to insects and certain herbicides.

Their widespread use has saved millions of hectares of crops from insecticide applications that would have also killed beneficial insects. In Hawaii, a transgenic papaya resistant to the ring spot virus was developed about 10 years ago and currently covers most of the papaya growing areas of these islands.

Transgenic crops are now being developed for increased nutritional value as well. 'Golden rice', a seed with a precursor of vitamin A taken from a dandelion gene, is an example. It has the potential of eliminating vitamin A deficiency and blindness in millions of children in Asia. Transgenics are also being developed for drought tolerance. A drought-tolerant maize crop would provide a buffer to hunger for millions in Africa.

Why the opposition?

So why is there so much opposition to this use of science for the public good among well-informed people in Europe? Why are NGOs so resistant to using transgenic crops, while other countries, rich and poor alike, are rapidly planting more and more transgenic crops? The main claim against their use is that these human-made crops are harmful to our health and to the environment.

Studies such as the US National Research Council's *The Impact of Genetically Engineered Crops on Farm Sustainability in the United States* have shown that the transgenic crops currently being grown have no ill effects on human health or the environment. Good biosafety procedures continue to be extremely important to ensure that future transgenic crops meet the same standards.

The opposition to using transgenic crops in Europe remains a mystery. Faltering trust in science and scientists as a result of outbreaks such as mad cow disease has certainly played a part. But we must ensure that science and hard evidence are put back on policy-making agendas. ■

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