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Reaping Benefits of Crop Research

IN 2009, FOR THE FIRST TIME SINCE THE 1950S AND THE EARLY STAGES OF THE GREEN REVOLUTION, food security was taken seriously by policy-makers. There was substantial output from the International Assessment of Agricultural Knowledge, Science and Technology for Development, and with studies by the U.S. National Academy of Sciences and a UK government Foresight group due this year, there is no sign that this renewed interest will fade. This revival follows assessments by the United Nations Food and Agriculture Organization and others that population growth, urbanization, climate change, and the availability of natural resources present a challenge to global food security. Somehow the world must produce 50 to 100% more food than at present under environmental constraints that have not applied in the past.

Although raw statistics indicate that enough food can be produced with existing technologies, the figures hide the inequity and unsustainability of current global food production. Inequity is evidenced by 1 billion hungry people. Unsustainability is a stark reality, because the highest levels of food crop productivity in many regions deplete stocks of nonrenewable resources, damage ecosystem services, and have a large carbon footprint (through carbon depletion of soils, fuel combustion, and the energy cost of fertilizer production). Thus, the challenge not only concerns the amount of food produced, it is also about equity, energy use, and sustainability.

Last year, a UK Royal Society working group, which I chaired, concluded in the report *Reaping the Benefits** that there are few opportunities to cultivate additional land without causing environmental damage. "Sustainable intensification" was proposed, in which biological sciences play a prominent role, calling for crop production that is resistant to stresses and disease; produces consistent yields using renewable inputs; avoids depletion of minerals, biodiversity, and natural capital; and protects ecosystem services.

Achieving these goals will require new research that integrates current practices in diverse agricultural systems with rapidly advancing research in genomics, systems biology, microbiology, and cell biology. Genome sequencing is particularly valuable because it facilitates exploitation of the vast untapped genetic variation in crops and crop relatives. An integrated research strategy will allow progressive refinement of existing crop varieties, so as to bolster pest and disease resistance, while developing varieties and crop management practices that use water and fertilizers efficiently. Radical changes also may be possible, such as perennial cereals, the widespread use of companion cropping with nitrogen-fixing legumes, asexual seed production to capture hybrid vigor, and even supercharging photosynthesis. Many of these innovations, some of which involve genetically modified crops, would allow high yield with lower inputs of water or fertilizer than in current industrial agriculture. Any gross yield reductions associated with sustainability innovations in these industrialized systems would be justified by reduced use of scarce or nonrenewable resources. On a global scale, such a decrease should be offset by increases in developing countries, where there is great scope to boost gross output because the current average yields are so low.

A critical factor, emphasized in the Royal Society report, is a major gap in skills and training. Scientists who can link practical applications related to crops with the latest developments in the life sciences are in very short supply. Molecular genetics has led to rapid progress in understanding crop plant biology, but unless universities rethink their strategies for training in all of the disciplines relevant to food crop science, there will be a continued shortage of appropriately trained scientists who can translate this progress into practical applications. Universities and funders should also internationalize training through collaborations with developing countries, so that modern science can be linked to practical needs in regions where there is great need for technological advance.

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*http://royalsociety.org/Reapingthebenefits.

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