Science for African Food Security

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In Sub-Saharan Africa (hereafter, Africa) agriculture provides about 70% of employment, 40% of exports, and one-third of GNP. Two-thirds of the region's 615 million people live on small-scale, low-productivity farms. Often, the food a family can produce plus the food they can afford to purchase is insufficient. As a result, 194 million Africans, most of them children, are undernourished (*1*).

These people lack "food security"; they do not have access at all times to enough food to lead active, healthy lives (*2*). Their numbers will increase as food production per capita in most African countries continues a decade-long decline, reflecting rapid population growth (averaging nearly 3% annually) and low yields. The latter results from depletion rates for soil nutrients that far exceed replenishment and crop losses caused by pests, diseases, and abiotic stresses (*3*).

Africa does not produce enough food to feed itself even with equitable distribution. Food aid to Africa—currently running at 3.23 million tons annually—helps prevent starvation but can create dependency (*4*).

Hunger is, to be sure, largely a consequence of poverty, but income gains depend on improving farm productivity. Agricultural development is necessary for economic and social development, here as elsewhere (*5*). The question is: what kind of agricultural production? Most African farmers have land assets adequate to provide food security and to rise above subsistence. To do so they need to intensify production with genetic and agro-ecological technologies that require only small amounts of additional labor and capital. This has to be sustainable in both economic and environmental terms.

We call the development and extension of this type of agriculture a "Doubly Green Revolution" (*6*). It combines elements of ecological agriculture with crop varieties designed to perform well under low-input conditions and uses inorganic inputs very judiciously. "Farmer-participatory methods" enable farmers themselves to analyze and define their needs and to adapt the resulting varieties and agronomic practices to their own conditions in the great diversity of local microenvironments that prevail in Africa (*7*).

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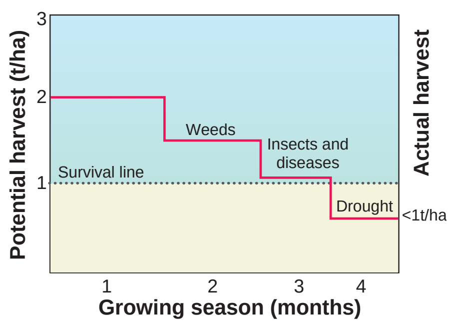
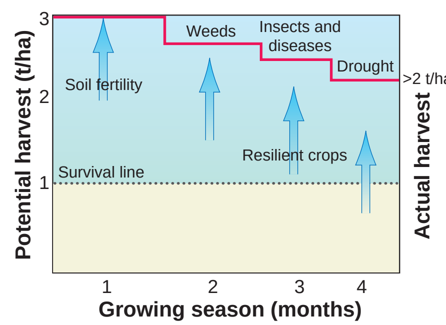
An Individual Case Study

We will refer to "Mrs. Namurunda," who represents a composite of situations existing in Africa. Mrs. Namurunda, like many African farmers, is a single mother struggling to support a family. She farms a single hectare running up one side of a hill in the Siaya district of Kenya near Lake Victoria. The soils are moderately deep and well drained, but acidic, highly weathered, and leached. Until recently, shortages of almost everything—land, money, labor, and plant nutrients in the soil—meant she was often unable to provide her family with adequate food. The two youngest children suffer from undernourishment and persistent illnesses.



An insecure farm in Africa.



A secure farm in Africa.

She needs 1 ton of mixed crops just to survive and 2 tons to generate modest income. Too often, however, she actually has harvested less than 1 ton (see figure, above left).

Low soil fertility and minimal use of fertilizer limited her potential harvest to only about 2 tons. African farmers pay the highest fertilizer prices in the world—whether in U.S. dollars or grain equivalents (*8*). Prices in Western Kenya are $400/ton of urea versus $90/ton in Europe (*9*). On average—and many use none at all—African farmers use fertilizer at only 10 kg/ha, whereas European farmers use over 200 kg/ha.

Mrs. Namurunda's staple crop, maize, was attacked by the parasitic weed Striga (*Striga hermonthica*), which sucks nutrients from roots; by boring insects, which weaken stems; and by streak virus. Despite committing 40 to 50 days each season to weeding, weeds still caused significant losses. Fungi rotted the ears that did develop, before and after harvest. Her cassava crop was devastated by cassava mealybugs (*Phenacoccus manihoti*) and a new supervirulent strain of mosaic virus. Her banana seedlings were infected with weevils, nematodes, and the fungal disease black Sigatoka when she bought them from neighbors. Her beans suffered from fungal diseases that shrivel pods and lower nitrogen fixation. And more often than not, she faced a drought during the growing season, which reduced the yield of everything.

Fortunately, scientific and technological progress has been made on many of her problems in recent years, and she is beginning to see the solutions on her farm.

With the arrival in her village of the Sustainable Community Oriented Development Programme (SCODP), a local Kenyan NGO, Mrs. Namurunda was able to obtain less expensive farm inputs (*10*). SCODP helped the farmers organize into a cooperative that negotiated more effectively for purchasing small fertilizer and seed packets and for marketing their products at the best prices. Scientists from the Kenyan Agricultural Research Institute (KARI), Kenyan universities, the International Centre for Research on Agroforestry (ICRAF), and the Tropical Soil Biology and Fertility Programme (TSBF) analyzed local soils and found a severe lack of phosphorus and shortages of nitrogen and micronutrients (*11*). These results were compared with TSBF's Organic Resource Database, which describes over 300 locally available materials that can provide specific soil inputs (*12*). Alternative strategies to enhance soil productivity were developed based on nutrient cycling, livestock-crop interactions, biological nitrogen fixation, rock phosphate, improved fallows, and efficient use of small amounts of fertilizer formulated to provide key missing nutrients.

On-farm trials were conducted by KARI and farmers to test the alternatives and to develop agronomic "best practices." These included research on seeding rates and spacing of crops and cover crops, timing and rate of application of organic material and fertilizer, and appropriate mixes of crops and inputs. They found, for example, that sowing a mixture of maize and legume plants in double rows (2 by 2), rather than every other row, provided more light for the legume, and generated greater nitrogen fixation (*13*).

The mealybugs that infested her cassava plants disappeared as the result of a biocontrol strategy implemented collaboratively by the International Institute for Tropical Agriculture (IITA) in Nigeria, the Centro Internacional de Agricultura Tropical (CIAT) in Colombia, and African governments (*14*). CIAT found a parasitic wasp, *Epidinocarsis lopezi,* in the Paraguay River basin that maintains mealybugs at very low levels in South America. It was introduced in Africa and eventually reached Mrs. Namurunda's farm.

IITA is also helping to counter the new, highly virulent strain of African cassava mosaic virus. Fourteen potentially resistant clones were "fast-tracked" for on-farm testing, including on Mrs. Namurunda's farm. Several plants show no signs of disease and are yielding well (*15*). Sequence-repeat DNA markers tightly linked to the genes for resistance are being used to introduce the resistance into cassava clones preferred in East Africa (*16*).

Mrs. Namurunda has begun purchasing maize seed from the local seed company, Lagrotech. Her favorite Lagrotech variety developed by KARI from CIMMYT (International Maize and Wheat Improvement Center) breeding lines and has excellent resistance to maize streak virus and tolerance of low nitrogen soils (*17*). It is an open-pollinated variety, so Mrs. Namurunda could save seed for subsequent plantings. However, switching to certified seed from Lagrotech will mean a guaranteed high rate of germination and freedom from contaminants that cling to her own seed.

To try to increase her income, Mrs. Namurunda purchased, on credit through the cooperative, 20 banana seedlings produced via tissue culture at a facility established by KARI and the International Service for Acquisition of Agri-biotech Applications (ISAAA). This technology generates seedlings free of nematodes, weevils, and pathogens (*18*). She recently harvested the first bananas from her "clean" tissue culture plants. They were the largest and most attractive bunches she had ever produced and rapidly sold at a premium price.

A Secure Farm

By using these technological innovations, Mrs. Namurunda now harvests over 2 tons/ha (see figure, right, previous page). She even grows vegetables as cash crops and makes enough profit to pay for her three daughters to attend school along with their brother. Mrs. Namurunda and the cooperative to which she belongs hope that they will someday be able to earn additional income by exporting more readily to the markets of Europe and the United States. Trade policies—such as the quota systems, tariffs, and subsidies established to protect European and U.S. farmers from competition—will need to change if this is to become a reality.

Although it is gradual, she recognizes that soil fertility on her farm is steadily improving, and because of the genetic resilience built into her new crop varieties, the extra effort and investment she makes in restoring soil fertility pays off in higher yields (*19*).

Mrs. Namurunda's life and prospects for her family are improving. Furthermore, she recently learned that KARI has new maize varieties, based on breeding lines from CIMMYT that yield better under drought and low-nutrient conditions, and also provide effective control of Striga (*20, 21*). Mrs. Namurunda is anxious to experiment with these new varieties and to provide feedback on how they perform and how they can be improved. She has enrolled in KARI's "Farmer Field School" to become a farmer trainer, which includes training in group learning, nonformal education methods, communication skills, agro-ecological analysis, and relevant technologies.

There are three principal lessons from this story. First, farmers need access to affordable inputs, including seeds and fertilizers, and to output markets for their products. This applies to food and cash crops, including those for export. Fair trade, with the industrialized countries providing market access for farm products of developing countries, is essential if African farmers are to rise above subsistence levels.

Second, science and technology can make a difference in African agriculture. Indigenous knowledge is important, as is the accumulated knowledge of expert breeders, soil scientists, and extension workers. Even problems that are new or were long thought intractable can be solved using modern science.

Third, the costs of developing these technologies are low. The annual budget of the Consultative Group on International Agricultural Research that supports 16 research centers (including CIAT, ICRAF, CIMMYT, and IITA) is about $350 million. Their work, conducted in partnership with national scientists, advanced laboratories, local NGOs, seed companies, and farmers themselves, is having real impact.

With such partnerships in place, there is reason for optimism. Still, much more needs to be done. African leaders need to re-establish their strong commitment to agricultural research and development. The donor community, including the World Bank and wealthy countries, needs to make a decade-long commitment of sustained support. And, advanced research institutes and private corporations need to be more proactive in sharing knowledge, skills, and research materials with African colleagues. Only then can we be reasonably confident that the food security now attained by Mrs. Namurunda's family will be achieved by small-scale farming families all across Africa.

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22. We are grateful to our colleagues in the Rockefeller Foundation's Food Security Theme, who recommended funding for, and provided information concerning, most of the Foundation-supported research and demonstration projects mentioned in this article.