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Resisting Viruses and Bugs

Cassava in Sub-Saharan Africa

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Cassava has long played an important role in ensuring food security, particularly among the poor. In Sub-Saharan Africa, where food security is a concern for many, about 95 percent of the cassava produced is used for human consumption. It was initially adopted by farmers as a famine reserve crop because it provided a reliable source of food during drought, locust attack, and during the "hungry season," the period before seasonal food crops are ready for harvest.[1] Cassava appeals to millions of rural and urban households because it is a cheap source of calories. More generally, cassava is also appealing because it is useful as a livestock feed and industrial starch.

Cassava is largely taken for granted today, yet in the 1960s and 1970s it was under severe threat from the twin occurrences of the mosaic virus disease and the mealybug pest. The International Institute of Tropical Agriculture (IITA) in Nigeria led a global research effort to combat these two problems. The two interventions resulting from this research were resoundingly successful and have revitalized cassava production, which has nearly tripled from 33 million tons per year in the early-1960s to 90 million tons per year in the early-2000s.[2] Those additional 1.4 million tons per year are enough to feed 29 million people.[3]

While the food benefits alone are noteworthy, these interventions have had an additional unanticipated impact: they have contributed to overcoming the generations-old perception that cassava is only valuable in Sub-Saharan Africa as an inexpensive calorie source for the poor and as an emergency crop in case of famine or other food crises. With sharply declining prices that accompanied cassava's production boom, the commensurate uptick in demand for cassava has broadened its appeal as a cash crop, providing an additional source of revenue to producers, especially via sales in urban centers. This dramatic shift in production can be attributed in large part to interventions that controlled the mosaic virus and the mealybug.

A Cassava Primer

Cassava, also commonly known as yucca, manioc, or tapioca, is a perennial shrub from South America that was introduced into West Africa in the 16th century and into East Africa in the 18th century.[4] Cassava is grown principally for its swollen roots though its leaves, which contain a significant amount of protein and other nutrients, are also eaten in some parts of Sub-Saharan Africa. It is currently cultivated in around 40 African countries, covering a wide belt from Madagascar in southeastern Africa to Cape Verde in the northwest.

In Africa, there are four common groups of cassava foods: fresh root, dried root, pasty products, and granulated products. Dried cassava root flour is widely prepared and consumed throughout Africa, especially in rural areas.[5] *Gari*, a common toasted cereal-like cassava food product that is especially popular in Nigeria, is appreciated for its convenience as a ready-to-eat food.

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Cultivating cassava

Overcoming Mosaic Disease

Transmitted by a white fly and the planting of contaminated cuttings, mosaic disease has been known to reduce cassava yields by an estimated 30 to 40 percent.[6] This disease has been prevalent in East Africa since the 1890s, and efforts to combat it began as early as the 1920s when much of the region was under colonial rule. However, it was not until IITA in Nigeria started breeding specialized cassava in 1971 that serious headway was made. Researchers drew on a rich stock of genetic resources that had been developed during the previous several decades in an effort to combat the disease. In particular, they improved on an already developed but poor performing mosaic-resistant cassava variety by cross-breeding it with genes for high-yielding, good-quality roots and low toxin levels (the latter of which is important because raw cassava can contain toxic levels of cyanide).

By 1977—after just six years of research and development—IITA achieved its goal. The high-yielding, mosaic-resistant cassava varieties that IITA developed are resistant not only to the mosaic disease, but also to other common cassava afflictions including bacterial blight, the mealybug, and the green mite. The mosaic-resistant varieties improved cassava yields by a full 40 percent, from 13.6 to 19 tons per hectare of land.[7] By the turn of the century, Nigeria was producing 32 million tons of cassava per year and became the largest producer worldwide, outpacing Brazil, Indonesia, and the Democratic Republic of Congo.[8]

While the disease-resistant cassava quickly took off in Nigeria, its adoption was slower in neighboring countries mostly due to a lack of political will and perceived need. However, disease-resistant cassava did eventually get picked up in Ghana, sparked by a two-year drought in the early-1980s, and in Uganda upon a major outbreak of a serious form of mosaic disease in 1988. In Uganda, mosaic-resistant cassava increased from 20 percent of the total cassava area under cultivation in 1993 to 80 percent in 1998, and the incidence of the disease declined from more than 90 percent on the local varieties to less than 20 percent on the mosaic-resistant varieties.[9]

A Global Effort Defeats the Mealybug

The mealybug is a pernicious pest that feeds on the cassava plant, injecting a toxin that causes the plant leaf to curl and eventually wither. The cassava mealybug was accidentally introduced in the Congo on infested planting materials brought over from South America in the early-1970s. It soon spread to other African countries and sharply reduced cassava yields. Yield loss in infested plants is extreme, estimated to decimate up to 60 percent of the root and 100 percent of the leaves.[10] Within 10 years of its introduction, the cassava mealybug—especially when coupled with the mosaic virus—threatened to wipe out cassava entirely throughout the continent.[11]

Not only farmers, but also scientists, agricultural policymakers, and political leaders became increasingly alarmed by the scope of losses to cassava wrought by the mealybug. In 1973, an international conference was convened in the Congo to discuss how to manage this problem. Researchers and policymakers reviewed the options and decided that the classical biological control solution—reuniting predators with prey—was the most expedient approach to pursue.

Therefore, researchers returned to the source of the problem for their solution. Because both cassava and the cassava mealybug evolved together in South America, starting in the late-1970s a systematic search for the cassava mealybug and its natural enemies was undertaken in much of Central and South America. Although huge areas were scanned, the mealybug was found only in a very restricted area of South America. Eventually, scientists found a natural enemy, a small parasitic wasp that uses the mealybug as the site for laying its eggs; the mealybug ultimately succumbs to the wasp's developing larvae.

After the wasps were collected and then quarantined in England for a sufficient period of time to ensure that they would not endanger indigenous plants and animals, they were released over a 13-year period (1981 to 1994) in more than 120 locations in 30 African countries. Seven years after the release of the wasp, the mealybug population declined substantially.[12] According to a large-scale survey in Ghana, yield losses due to cassava mealybug were reduced by 2.5 tons per hectare of land.

While simple on paper, the undertaking to control the cassava mealybug in fact required a massive global collaborative effort. At the regional level, based on an agreement among several African countries, the Africa-Wide Biological Control Program was established in 1980, with its headquarters at IITA in Nigeria. IITA, under the auspices of the Africa-Wide Biological Control Program, then organized a network of collaborators in Africa, Europe, and North, Central, and South America to put all the pieces together to tackle the mealybug. This effort included identifying, collecting, rearing, and quarantining the predatory wasp; preparing for its controlled release in Africa; conducting field and laboratory studies; monitoring and conducting studies on impact; and raising awareness about this new solution to the mealybug problem.[13]

Cassava's Production Boom Boosts Food Security and Incomes among the Poor

The control of the cassava mosaic disease and cassava mealybug together resulted in a tremendous increase in production and, subsequently, decreased prices for cassava and products derived from it, such as *gari*. In fact, after accounting for

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Preparing cassava, West Africa

Farmer with healthy, disease-resistant cassava plants, western Kenya

inflation, the price of *gari* dropped by a full 40 percent after the mosaic disease and mealybug were brought under control. This dramatic price reduction represents a significant savings for the millions of rural and urban households who consume cassava as their staple food. In terms of fighting hunger, the disease-resistant cassava varieties alone contributed an extra 1.4 million tons of *gari* per year compared with what would have been available from local varieties—enough to feed an extra 29 million people.[14]

Low-income households benefited not only from more affordable cassava products for consumption, but also from increased income from cassava sales. With the production boom that came with the control of mosaic virus and mealybug afflictions, cassava has become a major source of cash income for farm households in many African countries. Studies conducted in the early- to mid-1990s in nearly 300 villages across six African countries revealed that cassava accounted for 25 percent of farm household food crop income, as compared with 15 percent for yam, 14 percent for maize, and 10 percent for rice, with numerous other food crops accounting for the remaining 36 percent.[15]

What Does the Future Hold for Cassava in Africa?

The main question of sustainability that arises with the advent of disease-resistant cassava ironically is borne out of its success. Though increased productivity is yielding a higher gross income, farmers are also facing increasing labor costs because high yields demand a substantial increase in work, especially at the harvesting stage as cassava is an especially heavy and bulky crop. When cassava was produced as a famine reserve crop or as a rural food staple, harvesting could be done piecemeal and as such was not a particularly labor-intensive task. But farmers who produce cassava as a cash crop for urban markets are more compelled to move their product and consequently are straining under the burden of high cassava harvesting labor and refinement costs, which are increasing in direct proportion to yield. Taken together with the declining prices that have come with the production increase, this extra cost may well serve as a disincentive for farmers to sustain production at current levels.

These constraints indeed appear to have dampened production somewhat. From the early-1990s to the early-2000s, after the period of rapid diffusion of disease-resistant varieties in Nigeria, cassava production per capita declined while prices to consumers increased. Progressive farmers who were planting the high-yielding, mosaic-resistant varieties were planting less cassava because of the high labor costs and bottlenecks. However, labor-saving devices such as mechanized methods of cassava-grating for *gari* preparation, are being developed and already spreading throughout Nigeria and Ghana.

The sustainability of the mealybug control effort appears to be more promising. Without question, control of the cassava mealybug using a biological control agent—in this case, its enemy in nature, a particular breed of wasp—is an important scientific success story in African agriculture. The speed of the dispersal of the wasps after their release was high, with wasps observed in a wide area beyond each original release site just two years after their release.[16] There is no reason to expect that wasps will one day disappear from cassava fields unless there are no mealybugs on which their larvae can feed.

Keys to Success

Although these two interventions were quite different in their approach to protecting the cassava crop from near extinction, they share a number of common features. First, their success can be attributed to the collaborative, global approach to problem solving. Cassava is Africa's most significant global commodity. It was brought to Africa some 300 years ago from Latin America and it is rapidly replacing maize as Africa's most important food crop. The research for controlling cassava mosaic disease originated in Tanzania in the 1930s and 1940s under colonial rule. Thirty years later in Nigeria, IITA's research on cassava mosaic virus drew on earlier findings and developed the high-yielding, mosaic-resistant cassava varieties.

The defeat of the mealybug similarly featured a global effort. To tackle the mealybug problem, an Africa-wide biological control center was established at IITA in Nigeria. IITA brought together an international group of scientists and donors who crisscrossed Central and South America and eventually found a parasitic wasp that kills mealybugs in the process of reproduction. Both the cassava mosaic and the mealybug control programs demonstrate the critical role played by global partnerships and cooperation in tackling complex problems that involve multiple players and countries.

Research was another key component of success, not only in the discovery of solutions to the problems plaguing cassava, but also in providing an understanding of the impacts of these solutions. For example, research analysis documents how the rapid adoption of cassava varieties with improved resistance to cassava mosaic disease led to dramatic increases in cassava production in the 1980s and 1990s in Nigeria, Ghana, and Uganda, and how a surge in demand for food products such as *gari* has sparked further expansion of cassava production. That said, more research is needed to further maximize the potential benefits of cassava's booming productivity, for example, in terms of its possible use for industrial purposes and as an export crop.

Both interventions also have benefited from sustained human and financial investments. Strong and committed leadership for more than two decades provided an enabling environment in which hundreds of cassava specialists were successfully trained through graduate degree and other specialized programs. The continuity of scientific leadership is also important in pinpointing and addressing second-generation problems, such as the harvesting labor bottlenecks that arose from planting the high-yielding, mosaic-resistant varieties.

Conclusion

The mosaic and mealybug control programs have been successful and they reinforce each other. The achievements of both control programs in contributing to the high yield of cassava have been sustained for a period of about 25 years. Although these programs appear to have stood the test of time, research efforts on the mosaic and mealybug controls should continue to ensure success in cassava production throughout Sub-Saharan Africa. ■

NOTES

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