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Cover: Research worker in IITA's maize field collecting tassels for hand pollination.

Photo by C. Ono-Raphael.

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A success tale on improving two legume crops in Africa

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Cowpea and soybean are cultivated by poor and middle-income farmers as a sole crop or as intercrop with maize and other cereals for their protein-rich grains which are consumed in different forms. The haulms from plant residues and the dry pod walls of both crops are good sources of quality fodder for livestock.

The two crops contribute substantially to sustain crop production through their ability to fix atmospheric nitrogen, some of which is left behind in the soil after harvesting for subsequent crops. IITA and its partners have been involved in improving legume production systems for several decades. An overview of these efforts is presented in this article.

Cowpea

Cowpea—indigenous to sub-Saharan Africa (SSA), is grown on about 14 million ha worldwide, with over 84% of this area in SSA. Between 1985 and 2007, the rate of growth was 4.5% in land area planted to cowpea, 4.5% in grain yields/ha, and 5.9% in quantity of cowpea produced. These data indicate

that the increase in the quantity of grain produced over the period resulted mainly from an expansion in the land area and less from an improved yield/unit area. In well-managed experimental stations, yields of up to 2 t/ha can be obtained but globally the average yield is about 375 kg/ha.



Improved cowpea varieties being tested in a field trial.

Photo by L. Kumar.

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Several abiotic and biotic factors keep the productivity of cowpea low in African farmers' fields. Notable among these are drought, poor soil fertility, inappropriate agronomic practices, an array of fungal, viral, and bacterial diseases, and parasitic flowering plants (*Striga* and *Alectra*). Cowpea is particularly susceptible to infestation by several insects with devastating effects on plants in the field and seeds in storage.

Efforts in genetic improvement have been and are still being made to develop varieties with resistance to these various yield-limiting factors and in various research institutions across SSA, IITA, and other advanced research institutions. Cowpea breeders from these various institutions meet regularly to share information and exchange ideas on the way forward.

Elite lines generated from IITA's breeding nurseries are shared with interested colleagues from the national research institutions who evaluate these at their stations and in farmers' fields. Those

that perform well are recommended for release in the respective countries. For example, in Mali, a cowpea line IT99K-499-35 was recently adopted by many farmers in the Segou area and because of its superior performance and resistance to *Striga*, given a local name, Jinguia which means 'hope'.

Under the Tropical Legumes II (TL II) project, several new cowpea varieties [IT97K-499-35 (in 2008), IT89KD-288 and IT89KD-391 (in 2009), IT99K-573-1-1 and IT99K-573-2-1 (in 2011)] were released in Nigeria. Regional trials are being conducted for two cowpea lines (IT97K-1122 and IT00K-1263) identified through farmers' participatory selection as part of the TL II project in Tanzania to facilitate their official release. In 2011, three IITA cowpea lines (IT97K-1069-6, IT00K-1263, and IT82E-16) were released in Mozambique; and IT99K-494-6 was released by Bunda College in Malawi as an *Alectra*-resistant variety in 2011.

Research on integrated pest management (IPM) for cowpea has resulted in the development and deployment of biopesticides including the use of entomopathogenic organisms combined with botanicals, and biological control agents such as hymenopteran parasitoids which attack and feed on some of the cowpea pests. An example is the mixture of a specific entomopathogenic virus capable of infecting and killing the legume pod borer *Maruca vitrata* with aqueous formulations of neem oil. This has proved to be as effective as the use of conventional insecticidal sprays. With regard to biological control, a small parasitic wasp which attacks the flower bud thrips, another major pest of flowering cowpea, has been introduced and established in most of Bénin and parts of Ghana. It has been reported to reduce the thrips population on wild alternative host plants by up to 40%.

The development of improved cowpea varieties has so



Legume scientists in a disease resistance screening trial. Photo by L. Kumar.

far depended on conventional breeding methods. However, efforts are being made to apply molecular breeding tools to cowpea improvement. Fairly saturated genetic linkage maps of cowpea have been produced in several laboratories. The linkage maps have been used for the detection of DNA markers associated with resistance/tolerance to *Striga*, drought, *macrophomina*, and bacterial blight, and seed characteristics such as size. A few of the markers have been converted to user-friendly markers which will make them

readily available for breeders in the national systems. Molecular markers are contributing to progress in variety development.

IITA is collaborating with Purdue University, USA, in implementing the Purdue Improved Cowpea Storage (PICS) project on the hermetic storage of cowpea grain in Nigeria, Bénin, Togo, and Cameroon. From 2008 to 2010, IITA and its partners disseminated hermetic triple-layer bags for storage in more than 13,500 villages in the cowpea-producing areas of Nigeria, Cameroon, Togo, and Bénin. This project

addresses one of the most important constraints to cowpea production which is grain damage in storage. Furthermore, by not using any type of chemical, this hermetic storage method is protecting farming families and consumers from accidents from the mishandling of and poisoning by the chemicals used in cowpea storage. To date, farmers have purchased more than 30,000 PICS bags in these countries.

IITA is also collaborating in an adoption study that will provide information about the reach of the

technology. Another study on analysis of the supply chain of the PICS bags in the same four countries will help to improve the farmers' access to the PICS bags through a better distribution network.

Soybean

Soybean is a fairly new crop in SSA and has few biotic constraints. Fewer than 400 ha were planted to soybean in SSA during the 1980s but this exceeded the 1-million ha mark by 2007. Grain yield/ha increased from about 900 kg/ha in the 1980s to >1000 kg/ha between 2005 and 2007. Initially most varieties grown in parts of SSA had the problem of seed longevity. Farmers could not store seeds successfully from one cropping season to the next. This problem has now been

solved so that seeds of the newly developed varieties remain viable over a longer period. Another constraint to soybean production was pod shattering, which resulted in seeds being lost in the field. Farmers could not leave their crop to dry in the field before harvesting without losing some of the grain. The varieties that have been developed at IITA have tolerance to pod shattering, and resistance to rust—a fungus (*Phakopsora pachyrhizi*) that causes significant yield losses, especially in the moist savanna agroecology. Some genotypes of soybean are noted for their abilities to reduce the seed bank of *Striga hermonthica*, a parasitic weed which can cause serious damage to cereal crops.

Several elite lines from IITA's breeding nursery have been evaluated in many countries in SSA and found to perform well in farmers' fields. Some of these have been recommended for release in the different countries. For example, rust-resistant TGx1835-10E and TGx1987-62F have been released in Nigeria; TGx1740-2F was released in Malawi; TGx-1485-1D, TGx1740-2F, TGx1904-6F, TGx1908-8F, and TGx1937-1F were released in Mozambique in 2011. These were the first batch of varieties ever released in Mozambique. The development of improved varieties also involved farmers' participation in selection, which made it possible for farmers to have some knowledge on performance of the lines being selected, thus facilitating rapid adoption and dissemination. IITA, in collaboration with Laval University in Canada, completed genotypic [using single nucleotide polymorphism (SNP) markers] and phenotypic characterization of 300 soybean genotypes for rust resistance and symbiotic performance.



Improved soybean varieties. Photo by IITA.



In addition to efforts on genetic improvement of soybean, major emphasis has been placed on promoting and using soybean to encourage consumption, and thus create markets for farmers to sell their produce. Recipes were developed to promote the use of soybean grain for food. This promotional activity was necessary because the crop was new in many parts of the region and people were not familiar with how it could be best used as food. Vegetable oil millers were also encouraged to accept soybean as a raw material from where good quality oil could be extracted.

Legumes fix atmospheric nitrogen in their root nodules through the symbiotic association between the crop and rhizobium, a free-living soil bacterium. Legume seeds are inoculated with the rhizobium before sowing to increase the number of rhizobium available to the plant for infection and nodule formation, and subsequently enhance the quantity of the nitrogen fixed. Soybean is one such crop that requires rhizobium inoculation

if a good crop is to be established on soils with no existing rhizobia or inadequate number of rhizobia.

At IITA, some soybean varieties have been developed which are capable of fixing atmospheric nitrogen using the native rhizobium present in the soil. These varieties which require no inoculation before sowing are characterized by promiscuous nodulation. Growing such varieties will save the farmers some expense and the time needed to purchase the inoculants with which the seeds are treated.

Conclusions

Decades of collaborative research efforts on genetic improvement of these two important legume crops involving scientists in the national agricultural research systems of different countries in SSA, IITA, and advanced research institutions in Europe and North America have resulted in the development and promotion of different improved varieties to meet the preferences of farmers and consumers. Improved varieties

developed through this partnership have been released in over 70 countries around the world, which signifies the success of this partnership for legume crop improvement.

Further efforts will focus on use of innovative approaches to pyramid pest and disease resistance genes into improved lines and varieties; application of molecular markers to rapidly introduce genes for simply inherited desirable traits into popular varieties; and genetic modification using recombinant DNA technology to produce insect-resistant cowpea varieties (*Bacillus thuringiensis* or Bt cowpea for resistance to the *Maruca* pod borer). Efforts will be continued to address diseases, such as the need to develop improved cowpea and soybean lines with combined resistance to different fungal, bacterial, and viral pathogens. The factors that influence tolerance to drought in cowpea requires further elucidation, as this would facilitate progress in developing new varieties with enhanced drought tolerance.

A photograph of a man wearing a brown bucket hat and a checkered shirt, looking down at a corn plant in a field. The image is overlaid with a semi-transparent white filter.

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