Why manage noncrop biodiversity

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When it comes to the diversity of nonplant taxa, the numbers alone are highly impressive. There are an estimated 5–30 million species of microorganisms globally but only two million have been formally described. In 1 g of soil, over a billion bacteria cells can be found, but fewer than 5% of the species have been named or can be grown on artificial media. For fungi, about 1.5 million species are estimated to exist and yet only 5% have been characterized taxonomically.

Nematodes remain particularly poorly described with only a fraction of the suspected half million found in nature known to man. For insects, arachnids, and myriapods only 1.1 million have been named from a potential 9 million. These numbers compare with an estimated 420,000 seed plants of which most have been described.

Knowledge of biodiversity is uneven, with strong biases towards the species level, large animals, temperate systems, and the components of biodiversity used by people. Although biodiversity underlies all ecosystem processes, modern agriculture is based on a very limited genetic pool of crops and an even more limited exploitation of the genetic resources of nonplant taxa.

This is surprising, considering that as a consequence of their diversity microorganisms and insects play pivotal roles across ecosystems that far exceed those of plants. They provide critical functions and services for food and agriculture. They are indivisibly connected with ecosystem resilience, crop health, soil fertility, and the productivity and quality of food. Modern agriculture in the developed and especially the developing world uses only a small fraction from this rich pool of genetic resources.

Conserving and using nonplant taxa

One of the vital pillars in the work of the CGIAR is the conservation and use of agrobiodiversity and related knowledge. Over 650,000 accessions of crop, forage, and agroforestry genetic resources are stored and maintained through the centers' genebank system and distributed to researchers and breeders throughout the world.

However, scientists from different CGIAR centers are also involved in collection, conservation, and sustainable use of insects and mites, fungi, bacteria, viruses, and nematodes that are either beneficial or antagonistic to crops. These research collections are used in two main areas: (1) crop health and productivity, where the collection supports screening for resistance in breeding programs, pathogen diagnostics, and the development of biological control technologies, and (2) soil health, fertility and ecosystem resilience where

Disease symptom on lettuce leaf caused by Colletotrichum fuscum. Photo by Fen Beed, IITA.

for example, collections support the development of biofertilizers.

IITA's main collections of nonplant taxa are housed at the stations in Ibadan (Nigeria) and Cotonou (Bénin). At the headquarters in Ibadan, the collection and study of plant pathogenic fungi, bacteria, and viruses of important crops are coordinated and collections are maintained. Examples are those for yam and cassava anthracnose, cassava bacterial blight, and soybean rust pathogens.

Some of the collections contain large numbers of isolates of the same species which are often unique, not being found elsewhere in the world. International repositories might hold many different species, but tend to store fewer isolates per species and rarely prospect across the developing world. A diverse range of isolates gives a more complete representation of the genetic diversity which can be crucial for understanding evolutionary patterns, pathogen variation, and population dynamics.

Aflatoxin-producing fungus Aspergillus flavus *growing out of maize grains in a culture medium.*
Photo by Joseph Atehnkeng, IITA.

It helps breeding programs to identify targets for resistance selection.

Collections of isolates of the same species can be used to develop appropriate biocontrol technologies. One such example is IITA's collection of *Aspergillus flavus*, a fungus that normally produces aflatoxin, a compound that is toxic to humans and animals. Over 4,500 strains have been collected from Nigeria alone and screened for toxin production and their ability to outcompete other strains when found simultaneously on foodstuffs. The atoxigenic and most competitive strains have been used to formulate aflasafe®, a biocontrol product (see R4D Review September 2009 issue).

Also in Ibadan, collections of beneficial soil microorganisms are studied and maintained. These organisms (such as *Rhizobia* spp. and mycorrhizae) enhance the nutrient uptake of leguminous crops and can be used as biofertilizers.

At IITA-Bénin, microorganisms and arthropods have been characterized and preserved for use in biological control programs to manage invasive crop pests and weeds. Plant pathogens have been identified and stored since the deployment of appropriate control measures first requires definitive identification of the causal agent of the disease. The biodiversity center maintains over 360,000 insect and mite specimens and is one of the largest reference collections in West Africa (see R4D Review September 2009).

Other IITA stations keep smaller working collections of nonplant taxa. At IITA-Uganda, collections of nematodes, bacteria, and fungi are maintained—mainly those associated with banana production. Certain *Fusarium* strains, for example, are used for endophyte-improved banana tissue culture for enhanced pest and disease resistance.

IITA is a lead organization for the conservation and use of nonplant taxa across sub-Saharan Africa. It is now

characterizing nonplant taxa collections across the CGIAR as part of the World Bank-funded GPG2 project (Phase II of the Collective Action for the Rehabilitation of Global Public Goods in the CGIAR Genetic Resources System). This is the first system-wide inventory and collation of the existing global, nonplant taxa collections. The aim is to provide a coordinated and harmonized service for research and use of noncrop taxa to support durable farming systems in the developing world.

Future challenges and opportunities

There is a growing appreciation of the fact that farming occurs in an ecological context with complex interactions between crop and nonplant taxa that can be beneficial or antagonistic. There is also increasing demand for sustainable and environment-friendly solutions to manage pests and diseases, with the expectation that the biopesticide market share will increase to over 4.2% by 2010 and, for the first time, reach a market of over US$1 billion. Due to the rate of population increase the World Bank estimates that the global demand for food will double within the next 50 years. At the same time, the amount of arable land is decreasing from pressure from nonfarming activities and the unsustainable farming practices that are causing losses in soil fertility. This scenario is exacerbated by the fact that 40% of what is grown in the world is lost to weeds, pests, and diseases. In developing countries it is common for up to 70% of the yield to be lost due to attacks from insects and microbial diseases.

Therefore, agricultural production needs to be intensified and more marginal land used to produce sufficient food. This requires the deployment of improved land management techniques combined with the selection and distribution of appropriate crop and noncrop germplasm to exploit interactions with beneficial nonplant taxa and resist increased pressure from antagonistic nonplant taxa. Other factors such as climate change are likely to add new layers of complexity to these challenges. To predict risk and develop appropriate adaptation strategies, CGIAR and governments will become increasingly reliant on knowledge of and access to nonplant taxa genetic resources for food and agriculture. This will be used for research, training, or direct use in agriculture and originate, or be found, in a range of countries or centers.

This is part of 12 months of samples of insects received at the IITA biodiversity center in Bénin. Photo by Georg Goergen, IITA.

Collections form the mechanism through which information and access to nonplant taxa can be obtained, but the survival of these collections is under threat from funding constraints. Appropriate policies, investments, and collaborations among CGIAR centers and with international collections are urgently needed to recognize noncrop taxa as global public goods. This would facilitate the conservation of collections, increase their visibility, and maximize their use for the benefit of sustainable farming systems. Especially in Africa, where the biodiversity is high, but the taxonomic and technological capacity is limited, work is needed to manage the full potential of nonplant taxa for food and agriculture.