Research shows legume trees can fertilize and stabilize maize fields, generate higher yields

October 15 2012

Inserting rows of "fertilizer trees" into maize fields, known as agroforestry, can help farmers across sub-Saharan Africa cope with the impacts of drought and degraded soils, according to a 12-year-long study by researchers at the World Agroforestry Centre (ICRAF).

The study, *Can Integration of Legume Trees Increase Yield Stability in Rainfed* Maize Cropping Systems *in Southern Africa?*, by Gudeta Sileshi, Legesse Kassa Debusho and Festus Akinnifesi, was published in this month's issue of Agronomy Journal of the Soil Science Society of America.

Three coordinated experiments, begun in 1991 in Malawi and Zambia, found that farms that mix nitrogen-fixing trees and maize have consistent and relatively high yields year after year. In Malawi, the highest average maize yield was found in fields that combined both fertilizer trees and inorganic fertilizers, but applied at just half the standard recommended amounts.

Maize mono-crops grown with inorganic fertilizers may have higher yield in some years but the yield is less reliable in the long run. Mono-cropping without replenishing soil nutrients in any way—the de facto practice of resource-poor maize farmers—was the least productive and most unpredictable of all.

"To grow their way out of poverty, Africa's small-scale farmers don't just need a good harvest for one or two years, they need long-term

stable, high-yield harvests," said coauthor Akinnifesi, former regional coordinator for the World Agroforestry Centre, Southern Africa Regional Programme. "Moreover, they need to know which farming systems will be both stable and sustainable as the environment and climate changes."

In sub-Saharan Africa, where more than one in three people is chronically hungry, variable rainfall, drought and degraded soils all cut into yields that are one-quarter of the global average.

While previous studies have shown the short-term benefits of such agroforestry practices, today's study is the first to analyze long-term yield stability in the face of environmental change. Year to year, the most dynamic environmental change is found in rainfall, which directly impacts maize yield on Africa's largely non-irrigated, rain-fed farms.

Maize accounts for more than half of the cropped area and the calories consumed in many countries in sub-Saharan Africa. The small-scale maize farming system, covering 10 percent of the region, is in crisis, with yields in many areas either stagnating or declining. As a result of rapid population growth, average farm sizes have fallen to less than 0.5 hectares in many areas.

Continuous farming without replenishing the organic matter and nutrients in soil has led to erosion and soil infertility, and there are signs of increasing soil acidity in some areas exposed to prolonged use of inorganic fertilizers and the burning of crop residues.

With climate change, maize cropping systems are expected to experience even more dramatic reductions in yield. For just 1°C of warming, more than 75 percent of the present maize-growing areas in Africa are predicted to experience at least a 20 percent reduction in yield under drought conditions.

The experiments incorporated a tree called gliricidia into maize fields. Gliricidia "fixes" nitrogen, drawing it from the air, changing it into a form that plants can use for their own growth, and inserting it into the soil. This alleviates the need for big doses of manufactured nitrogen fertilizers. The leaves shed by gliricidia also return organic matter to the soil, increasing its structural stability, erosion resistance and capacity to store water.

"Growing maize with legume trees has increased yields in many parts of sub-Saharan Africa," said Gudeta Sileshi, the lead scientist on the study and regional representative for ICRAF's Southern Africa Program. "Now we know this is not just a temporary phenomenon. For maize farmers who can't afford fertilizers, agroforestry with nitrogen-fixing trees offers a stable increase in production, allowing them to feed their families and replenish the soil."

Application of fertilizer without the addition of organic matter may not be sustainable because only organic matter helps to retain soil moisture, adds calcium and feeds soil biota, contributing to soil health and structure.

Past long-term studies have shown that continuous maize cropping with inorganic fertilizers in Nigeria resulted in significant yield declines over a 16-year period. Likewise, in Pakistan, a 14-year study showed declining rice yields even when the recommended level of nitrates, phosphate and potassium were applied.

In the United States and Europe, researchers have conducted long-term studies ranging from 20 to 120 years, monitoring the impacts of cropping systems on dynamic soil processes. Such long-term studies have been virtually nonexistent in sub-Saharan Africa.

"We need well-designed long-term trials that will allow scientific

assessments of different cropping systems with a changing climate in Africa," said Debusho, a senior lecturer at the University of Pretoria. "Such information can guide the exploration of technological alternatives and the development of policies to improve the adaptability and sustainability of cropping systems."

Provided by CGIAR