



AGROFORESTRY TO IMPROVE FARM PRODUCTIVITY IN MALI



Location: Koutiala region, Mali

*A research project on improved fallows examined how short-term rotations of selected perennial tree and shrub species impact cereal yields and soil quality in subsistence maize cropping systems. The effects of improved fallows on maize yields were significant when combining a tree species (*Gliricidia*) and a nitrogen-fixing legume (*Stylosanthes*). The results suggest that this innovative agroforestry strategy holds significant promise for enhancing soil fertility, maize yields and food security throughout Mali and sub-Saharan Africa.¹*

CHALLENGE

In Mali, approximately 65 percent of the total population lives in rural areas, and some 80 percent of the nation's labor force is engaged in agriculture.² Rain-fed agriculture encounters limitations such as the availability of arable land, extreme and unpredictable weather, pest damage, and poor soil quality. Many districts experience ongoing deficits of the key subsistence crops—maize, sorghum and millet.

In the last 30 years, rapidly increasing population density has placed intense pressure on soil resources, rendering traditional methods of rotational agriculture—long bush fallow periods, where cultivations are shifted to another field to allow regeneration of the land—obsolete.³ Continual exploitation of agricultural land has severely degraded soil quality. Alleviating hunger and sustaining healthy human and animal populations mandate new and improved agricultural methods.⁴

RESPONSE⁵

Agroforestry has shown great results to combat these pressures. It integrates trees and/or herbaceous or woody perennial shrubs into agricultural systems to enhance specific ecological processes. Trees and shrubs are harvested or fulfill a variety of purposes: providing fencing and building materials, preventing soil erosion, modifying micro-climatic conditions, enhancing the habitat for beneficial arthropods, providing animal fodder, food, shade, fuel, medicine, or fertilizer for other crops.⁶ Science based agroforestry interventions have a 30 year history of improving sub-Saharan African farmers' lives.

Improved fallows involve planting fast-growing woody and herbaceous plant species for short time periods—6 months to 2 years—to replenish soil fertility prior to additional grazing or crop cultivation. Plants used in improved fallows are selected for their rapid growth (biomass production) and soil fertility enhancement (nitrogen fixing), among other characteristics.⁷ Short-duration improved fallows replace the traditional rotational farming practice of five to seven years long bush fallows for maintaining soil fertility and yields in sub-Saharan Africa.

Southern Mali's Koutiala region is known for its extremely poor growing conditions, characterized by highly eroded soils, hard iron-oxide rich pans, and low levels of plant nutrients and organic matter. Research conducted between 1996 and 1998 in the region combined on-farm experimentation in N'Goukan village and research plots at N'Tarla Agricultural Research Station. The research evaluated the impact on soil fertility and maize yields of two tree species (*Gliricidia sepium* and *Pteocarpus erinaceus*)

and a nitrogen-fixing leguminous shrub (*Stylosanthes hamata*). For both on-farm and experiment station research, treatments were compared individually and in combination with a natural grass fallow and other commonly used soil fertility management practices.

Two separate soil improvement strategies were tested: improved fallow, which involved treatments grown on site, and biomass transfer, with treatments grown off site and brought to research plots for application. At the on-farm research site, treatments were planted and allowed to grow for two growing seasons in a short fallow cycle. After two growing seasons, the agroforestry treatments were cut at a uniform height (30-40 cm), and biomass was applied to the soil surface and incorporated into the soil prior to planting a local maize variety. For the experiment station research, the same agroforestry treatments were applied using two separate biomass application rates: “Rate One” was the equivalent of 50 kilograms (kg) of nitrogen per hectare (ha) per year; “Rate Two” was a one-time application of biomass equivalent to the agroforestry treatments’ biomass potential at three to four years of age.

The impact of the three agroforestry treatments (*Gliricidia sepium*, *Pterocarpus erinaceus* and *Stylosanthes hamata*) was measured at the application rates and compared with the following commonly used treatments: the locally recommended rates of manure application (10 tons/ha); the conventional annual application rate for mineral fertilizer (100 kg/ha); and a natural grass fallow. The same local maize variety was planted in the plots at the experiment station and grown to maturity. Stover biomass, the non-edible part of the plant usually used as cattle fodder, and grain yields were measured after harvest in 1997 and 1998, and a range of soil quality assessments were conducted before and after harvest to evaluate the experimental treatments effect on soil fertility.

RESULTS

- In the on-farm experimentation, maize produced the greatest amount of grain and stover when followed by a two-year improved fallow period using *Gliricidia* alone or in combination with *Stylosanthes*, a plant that also provides high quality cattle fodder.
- The agroforestry treatments had a significant effect on crop yields: maize grain yields from the *Gliricidia* treatment plots were eight percent higher than regional averages, which are 2 tons/ha.
- *Gliricidia* plus *Stylosanthes* treatments hold the greatest promise as short-rotation improved fallow species for



Karim Traore showing his *Gliricidia* tree used for agroforestry treatments.
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enhancing maize productivity and providing livestock fodder without the use of synthetic fertilizer inputs. These treatments yield the second highest amount of maize stover (7 tons/ha), and the highest maize grain yield of any of the treatments (2.9 tons/ha).

- In contrast, maize yields from the use of synthetic fertilizer, using the conventional annual application rate, (100 kg urea/ha) were 1.7 tons/ha in 1997 and 2.6 tons/ha in 1998, not outperforming the *Gliricidia* plus *Stylosanthes* treatment.
- On average, yields from all on-farm plots with the agroforestry treatments were higher than the traditional grass fallow control, which produced only 4 tons/ha of corn stover and 0.7 ton/ha of maize grain (lower than current regional mean).
- The data suggests that annual applications of smaller quantities of biomass from agroforestry treatments (Rate One) produces better and more consistent yields than one-time application of large biomass quantities (Rate Two).
- The three species’ decomposition rates occurred with *Gliricidia* exhibiting the fastest rate of decomposition followed by *Stylosanthes* and then *Pterocarpus*. Data on decomposition rates further suggest that the combination of *Gliricidia* and *Stylosanthes* were the best candidates for providing essential plant nutrients and improving yields over the short term.
- Because of the study’s limited two year duration, it was not possible to document treatments’ lasting effects on the soil fertility parameters, including soil carbon, nitrogen, and phosphorus.

- Soil analysis showed that soil carbon and nitrogen levels were significantly, though temporarily, enhanced in the *Gliricidia* treatment and that soil carbon concentration was reduced for the fertilizer applied treatment.
- Data indicates that the agro-forestry treatments of *Gliricidia* plus *Stylosanthes* have the best potential for alleviating food insecurity in the region because they enhanced maize yield and short-term soil fertility and produced the preferred fodder.

In Mali and across Africa, agroforestry has shown real and lasting results when implemented in a thoughtful and sustained manner. From improved soil fertility, increased crop yields and food security, agroforestry shows that simple measures can have profound effects on communities.



(L) Sorghum farmer. © Swiatoslaw Wojtkowiak / FAO
(R) Maize plantation in Sissako. © IFDC Photography

Maize yields derived from agroforestry through *Gliricidia* plus *Stylosanthes* (2.9 tons/ha) are 45 percent higher than the regional mean for maize and equal to or higher than yields derived from the use of synthetic urea. Scientists suggest a special “improved fallow loan program” that would make the agroecological interventions more economically attractive and thus enhance adoption.⁸

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ENDNOTES

- 1 Kaya, B. and P. K. R. Nair. “Soil fertility and crop yields under improved-fallow systems in southern Mali.” *Agroforestry Systems* 52.1 (2001): 1-11.
- 2 CIA. *World Fact Book: Mali*. <https://www.cia.gov/library/publications/the-world-factbook/geos/ml.html> (accessed September 28, 2014).
- 3 Cooper, P. J. M. *et al.* “Agroforestry and the mitigation of land degradation in the humid and sub-humid tropics of Africa.” *Experimental Agriculture* 32.3 (2008): 235-290.
- 4 Kaya, B. and P. K. R. Nair. *Op. Cit.*
- 5 Unless otherwise indicated, the source for the data below is: Kaya, B. and Nair, P.R. *Op. Cit.*
- 6 Nair, P. K. R. *An introduction to agroforestry*. University of Florida, 1993. http://www.worldagroforestry.org/units/Library/Books/PDFs/32_An_introduction_to_agroforestry.pdf?n=161 (accessed November 20, 2014).
- 7 Hall, N. “Effect of improved fallow on crop productivity, soil fertility and climate-forcing gas emissions in semi-arid conditions.” *Biol Fertil Soils* 42 (2006): 224-230.
- 8 Kaya, B., Hildebrand B.E. and P.K.R Nair. “Modeling changes in farming systems with the adoption of improved fallows in southern Mali.” *Agricultural Systems* 66.1 (2000): 51-68.

FRONT PAGE PHOTO:

Women harvesting groundnuts. © Jim Richardson