

COMMENT

ASTRONOMY Call for the US to rejoin the Square Kilometre Array telescope **p.363**

BIOWARFARE Behind the scenes of the USSR's bioweapons programme **p.364**



ART CERN's artist-in-residence on why he whips trees **p.366**

OBITUARY Neil Armstrong, first human on the Moon, remembered **p.368**

JIM RICHARDSON



Rhoda Mang'yana grows maize near 'fertilizer trees' to improve her farm's crop yield and soil fertility.

Plant perennials to save Africa's soils

Integrating perennials with food crops could restore soil health and increase staple yields, say **Jerry D. Glover, John P. Reganold and Cindy M. Cox.**

Rhoda Mang'yana's half-hectare farm in Malawi produces more maize (corn) than her extended family of seven can eat. Some of the extra crop she sells. Some she feeds to pigs and goats, which she also sells. With the money she makes, she can pay her grandchildren's school fees and buy essentials, such as soap and salt, that she has provided for her family since her husband died 15 years ago. As well as maize, Mang'yana's farm supplies firewood and other types of animal feed. It is also resilient, providing enough maize during good years to pull the family through leaner ones. Key to Mang'yana's improved land is perenniation — the integration of trees and perennials (plants that live for two or more years) into fields of food crops.

When Mang'yana acquired the farm in the 1990s, soil degradation limited its annual maize yield to less than 1 tonne per hectare — a common yield in Africa, but one-tenth of those seen in the Corn Belt of the US Midwest. To improve the soil, she began growing perennial pigeon peas (*Cajanus cajan*) and groundnuts (*Arachis hypogaea*), which require less fertilizer and add nitrogen to the soil¹. She also began using 'evergreen agriculture', planting various nitrogen-fixing trees² that each meet different needs. Fast-growing, short-lived plants such as *Gliricidia sepium* provided firewood and animal feed; slower-growing, longer-lived trees such as *Faidherbia albida* improved long-term soil fertility.

After a few years, Mang'yana resumed growing maize. Better yields allowed her to invest in pigs and goats, and she began using the animals' manure along with mineral fertilizer on the fields. Now she produces four tonnes of maize per hectare in a good year. Most of Africa's soils are naturally poor in nutrients compared with those of the younger landscapes found in North America, for example. Only about 16% of Africa's lands have the high-quality soils best suited to supporting livestock and crops; roughly 29% are marginal; and the rest are unsuitable for farming³. Farmers often worsen already poor lands by removing more nutrients than they return to the soil⁴.

Population growth and erratic weather driven by climate change are exacerbating the problem⁵. Although cereal production grew by 2% a year in most African countries ▶

RESCUE REMEDIES

Three perenniation systems are already doubling or tripling yields of food crops across Africa.



Maize



Faidherbia albida



Soya bean



Pigeon pea



Napier grass

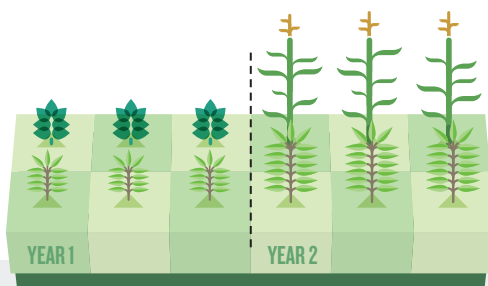


Silverleaf



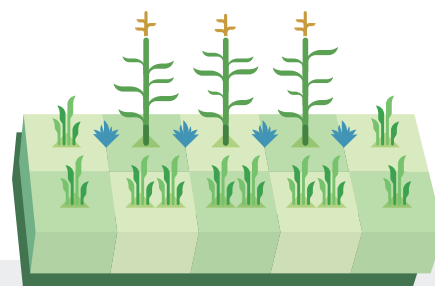
EVERGREEN AGRICULTURE

- ◆ Improves yields and provides feed, firewood
- ◆ Maintains vegetative soil cover year-round
- ◆ Increases available water and nutrients in soil
- ◆ Enhances soil carbon stores



DOUBLED-UP LEGUME SYSTEM

- ◆ Increases plants' efficiency of fertilizer use
- ◆ Improves yield of protein-rich grains
- ◆ Decreases labour requirements
- ◆ Improves families' diets



PUSH-PULL

- ◆ Helps to suppress insect pests and weeds
- ◆ Reduces need for external inputs
- ◆ Provides animal feed
- ◆ Reduces soil erosion

▶ during 1961–2003, the population grew faster (2.6% annually), leading to an overall 43.5% decline in per capita cereal production over that period⁶.

About one-quarter of the world's undernourished population — some 240 million people — live in sub-Saharan Africa. Of the various factors needing urgent attention to increase agricultural productivity, scientists from the region have identified soil quality as a top priority⁵. We believe that perenniation should be used much more widely to help farmers to meet the challenge of improving soils while increasing food production.

DEEP ROOTS

Many African farmers struggle to meet the nutrient needs of their crops. Because organic sources such as animal and plant manure are often in short supply in Africa, governments and development agencies tend to promote mineral fertilizers as the solution to low soil fertility. But investing in fertilizer can be risky — during a drought year, for instance, farmers might not produce enough to cover the costs. And without organic inputs, mineral fertilizers do little to improve soil conditions, and can even worsen them by hastening the loss of soil carbon⁷.

Perennials can gain access to more of the soil's nutrients and water, for a longer time than annual crops. Their roots often extend more than two metres deep (compared with less than a metre for most annuals), and their growing seasons are longer. These attributes make them more resilient to harsh environmental conditions. Because they produce more biomass, both above and below ground, they are better at reducing

soil erosion, transferring organic inputs to soil microorganisms and increasing the amount of carbon stored in the soil — a key component of soil health⁸. These organic inputs and microorganisms then improve soil fertility and structure as well as increase water infiltration and storage — all of which increase the amount of water available to and used by crops^{7,8}. Moreover, by supplying the soil with carbon, perennials can improve the ability of food crops to use mineral fertilizers and, potentially, help farmers to adapt to climate change^{1,2,8}.

Here we highlight three perenniation approaches that show particular promise in sub-Saharan Africa: evergreen agriculture and doubled-up legume systems, such as those used by Mang'anya, and a technique for managing crop pests called 'push-pull' (see 'Rescue remedies').

Evergreen agriculture is the best known and most widely adopted of the three. Hundreds of thousands of farmers across the Sudano-Sahelian zone and into East and Southern Africa grow 'fertilizer trees' along with maize, sorghum or millet on more than 5 million hectares of cropland². The leguminous trees in these systems, such as *Faidherbia albida*, can triple maize yields while improving the soil. The trees meet other needs as well — they provide firewood and livestock fodder, for example².

In doubled-up legume systems, which have now been adopted by more than 8,000 households in Malawi¹, farmers grow

perennial pigeon pea along with annual legumes such as soya beans (*Glycine max*) or groundnuts. After harvesting the legumes, farmers plant maize in or beside the rows of pigeon peas and then harvest both. Farmers can use different types of pigeon pea, depending on how much grain they need for food and leaves and stems for animal feed or manure. They can also change the timing and arrangement of planting to favour the maize or the legume. Nutrient- and protein-rich, pigeon peas can persist into the drier months, after maize stocks have been exhausted⁹, and they can substantially improve families' diets.

Perennial plants can help to manage pests and diseases. More than 30,000 farmers in East Africa have adopted push-pull systems to manage stem-borer moths (*Chilo partellus*) and African witchweed (*Striga hermonthica*), both widespread in sub-Saharan Africa. In this method, silverleaf (*Desmodium uncinatum*), a perennial leguminous animal-feed crop, is interspersed among maize plants. The silverleaf produces chemicals that repel or 'push' pests away, and perennial Napier grass (*Pennisetum purpureum*) grown around the edges of the fields 'pulls' the pests in by providing attractive leaves for egg-laying. Push-pull systems can more than double maize yields by reducing pests¹⁰ and increasing the amount of nitrogen in the soil.

Each of these three soil-building systems can be adapted to specific types of farming, such as conservation agriculture, organic or conventional management or production of both crops and livestock.

Organizations such as the US Agency for International Development (USAID)

“Without organic inputs, mineral fertilizers can worsen soil conditions.”



Mang'yana's pigs, which she sells to pay her grandchildren's school fees, eat maize bran, *Gliricidia* branches and weeds that grow in the fields.

JIM RICHARDSON

and the World Bank have made sustained investments in strategies discovered and developed by farmers, and these efforts have proved crucial in battling hunger over the past 50 years. Irrigation and fertilization have become specialized scientific disciplines, sparking the creation of dedicated research institutes around the world.

In many regions of Africa, farmers have taken some perenniation approaches well beyond the proof-of-concept stage. Yet many questions remain — such as which species are best suited to which types of land, and how to maximize productivity in different areas. We believe that perenniation, along with technologies such as improved seed, fertilization and irrigation, should be a priority for the international agricultural research-and-development community. This means scaling up the use of approaches known to work, such as evergreen agriculture (in suitable areas), and backing research in cultivars and techniques that farmers have not yet tested widely.

SCALING UP

Some efforts to expand perenniation are already under way. Last month, a four-year project called Trees for Food Security was launched by the World Agroforestry Centre, an international research institute based in Nairobi, Kenya, that has led the development of evergreen agriculture. The centre aims to plant millions of trees on farmland throughout sub-Saharan Africa, in partnership with the governments of Ethiopia, Rwanda, Burundi and Uganda.

Similarly, the International Crops Research Institute for the Semi-Arid Tropics, based in Patancheru, India, has worked for more than

two decades with pigeon peas, collecting and characterizing cultivars and educating farmers about their use. The institute's collaboration with Michigan State University and others has boosted the use of doubled-up legume systems considerably over the past 10 years, particularly in Malawi¹.

Many research institutes, including Washington State University in Pullman⁵, have taken up the development of perennial grains more broadly. And USAID is investing US\$9 million annually in Africa Research in Sustainable Intensification for the Next Generation, a programme that includes support for the study of perenniation strategies (www.africa-rising.net). Yet

“Many farms have taken perenniation well beyond the proof-of-concept stage.”

these are drops in the ocean compared to the scale of need.

Giving perenniation the kind of support now directed towards technologies such as mineral fertilizers and seed development could require hundreds of millions of dollars. According to Chris Reij, an expert in African agriculture at the World Resources Institute in Washington DC, \$50 million would be needed even to “show how existing successes [in agroforestry] could be scaled up”.

Yet such numbers pale in comparison to the losses of nitrogen, phosphorous and potassium from sub-Saharan farm fields each year, which are estimated to be equivalent to billions of dollars in fertilizer⁴.

Sub-Saharan Africa's population is expected to reach 1.5–2 billion by 2050. Already the population is ballooning; in many

areas, the risk of drought and flood is increasing; most soils are poor; and richer nations are buying up Africa's arable land for their own food or fuel security. African farmers have demonstrated the promise of perenniation. It is time to scale up its use and put it firmly on the research-and-development map. ■

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