Soil health and crop nutrient management: Building resilience and increasing the efficiency of nutrient application

BACKGROUND

Soil health is fundamental for the productivity of cropping systems. It relies on three interlinked pillars: (1) availability of sufficient nutrients, (2) organic matter and (3) soil biota. Organic matter regulates pH and supports nutrient availability, water retention and soil biodiversity. Soil biotas decompose organic matter and improve soil structure by forming soil aggregates.

Soil health is affected by unsustainable agricultural practices, leading to soil degradation. Soil degradation has negative impacts on each of the pillars and can result in high economic and environmental costs e.g., the loss of ecosystem services. It also undermines food security. In Africa alone, not acting against nutrient loss caused by soil erosion will cost up to 286 billion US-Dollars in cereal yield losses over 15 years.

Nutrient inputs, mainly nitrogen, potassium, and phosphorus, are important to maintain nutrient availability and crop productivity. These nutrients originate from mineral or organic sources.

The global mineral fertiliser market is concentrated in a limited number of suppliers and thus vulnerable to supply shocks. The war against Ukraine has aggravated a global increase in fertiliser prices. The livelihoods and yields of smallholder farmers of whom some are highly dependent on external inputs have been put at risk. As a result, governments have been inclined to boost mineral fertiliser subsidies. This risks incentivising inefficient use while at the same time increasing the debt burden.

Mineral fertiliser prices have started to normalise lately, but they remain at a high level. In addition, long-term challenges e.g., limited mineral phosphorus reserves and environmental impacts of mineral fertilisers persist. The production of Nitrogen-fertiliser is very energy intensive. Its inappropriate use can result in water contamination, soil acidification and disturbance of soil functions. The application of nitrogen fertiliser also causes greenhouse gas emissions in the form of nitrogen oxides particularly if overapplied and wrongly timed.

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THE GLOBAL PROGRAMME IN BRIEF

As part of the German special initiative „Transformation of Agricultural and Food Systems", the Global Programme "Soil protection and rehabilitation for food security" (ProSoil), supports and advises smallholder farmers in Ethiopia, Benin, Burkina Faso, India, Kenya, Madagascar and Tunisia on agroecological and climate-smart agricultural practices and transformation processes focusing on sustainable land management. Alongside the respective government agencies of each country, stakeholders from the scientific community, civil society and the private sector are also actively involved in the measures. The Global Programme is commissioned by Germany's Federal Ministry for Economic Cooperation and Development (BMZ) and co-funded by the European Union (EU) and the Bill & Melinda Gates Foundation. Since the beginning of the Global Programme in 2014, soil degradation has been reversed on more than 500,000 hectares of land. This results in an average yield increase of 40 per cent, directly benefitting the lives of 1.7 million people. Almost 40 percent of the farmers targeted are women. Thanks to climate-smart soil management solutions, the carbon footprint could be reduced by around 400,000 metric tonnes of carbon dioxide in 2022 alone, because healthy soils are an important carbon sink

Why soil health and crop nutrient management is important:

Soil health is fundamental for sustainable agricultural productivity and fertiliser use efficiency. An integrated approach to crop nutrient management which builds on organic fertilisers combined with the tailored use of mineral fertiliser is essential for productive and sustainable agricultural production systems.

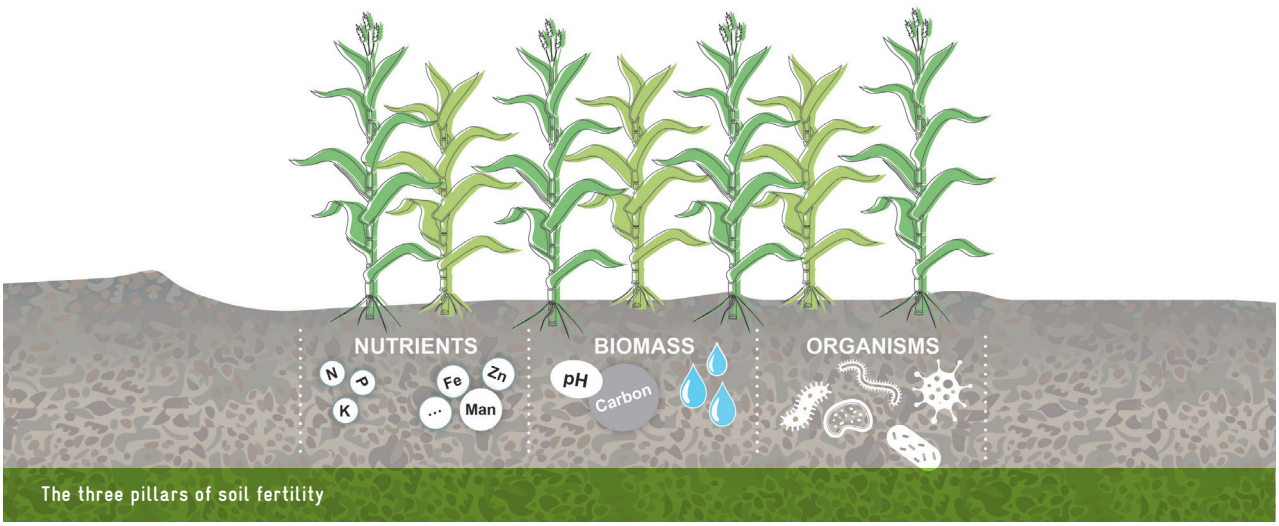
Organic inputs also add carbon to the soil and reinforce its role as a carbon sink. Depending on the specific production process they can even be qualified as a negative emission technology. If they are produced locally, they contribute to economic development. Circular approaches valorise existing organic waste streams.

The site specific and targeted use of organic and mineral fertilisers increases their use efficiency while limiting the negative environmental effects from inappropriate use. Providing such recommendations to farmers enables them to make the most out of the resources they can access.

Challenges for integrated crop nutrient management

Many agricultural soils in Africa and South Asia are depleted and characterised by low productivity and the limited ability to respond to nutrient applications. Farmers face various barriers for implementing soil health management practices, which are often knowledge, labor and sometimes capital intensive. These barriers typically include insufficient awareness and lack of access to inputs such as seeds, tools and machinery as well as high quality organic and inorganic fertilisers.

In many countries, the data infrastructure and extension systems for delivering site specific soil health management recommendations are lacking. In addition, the products with the most appropriate nutrient composition for the targeted and correct combination of nutrients in the right ratio for each crop and situation are often not available.



The three pillars of soil fertility

How can the challenges be overcome?

The work of the Global Programme successfully demonstrates the interplay between different essential principles. Agroecological approaches, centered on integrated soil fertility management, play a key role. An essential step with which the process begins is the production and retention of biomass. Soil that is rich in biomass responds more efficiently to mineral fertiliser. At the end of the day, the goal is to minimise or even to replace the need for mineral fertiliser e.g., with the application of green manure cover crops which fix nitrogen and store it in the soils. In addition, as part of the project work, processes for on-farm production of mineral fertiliser alternatives like vermicompost have been developed and disseminated. The production of the inputs needed for these approaches e.g., seeds for cover crops or compost itself is a complementary activity for farmers and offers an additional income. Often women can particularly benefit from it. On acidic soils the application of agricultural lime is another quick win to improve the response to nutrient application. Together with the government of Ethiopia and the private sector, the project has established a lime value chain in the country. Moreover, erosion control measures have been promoted to counter soil erosion and, as a result, the loss of nutrients.

Beyond farm level, the Global Programme works on circular approaches which tap into the potential for unused waste streams. These approaches include compost made from urban organic waste, the use of phosphate rich slurry from biogas fermenters and the utilisation of other organic material along agricultural value chains. Together with its partners the project has also supported the development of digital solutions and has helped to establish the data infrastructure for developing and delivering site specific advisories. Examples include soil testing services, the institutionalisation of an app based advisory platform in India or the support of the Ethiopian government to establish a nationwide system for fertiliser recommendations.

"We had no idea what urban compost is initially. (…) When it arrived, we tried it in a small part. Later, when compared to the part where it was not used, we could see the difference in the green colour of the crops and its growth."

Ashok Zungaji Phalke, farmer, India

Outcomes

- More land made usable for agriculture again: On a global level, the Global Programme has protected or rehabilitated 565,000 hectares of land. Average yields have increased by nearly 40 per cent compared with reference areas. In total, over 1.7 million farmers have directly benefited from better soil health management.
- Women in focus: Women benefit particularly: Figures from Ethiopia show that women were able to increase their yields and can now earn an average additional income of 100 USD per year from the sale of worms needed for vermicompost.
- The response of crops to fertiliser application on acid soils is tremendously increased by complementing it with lime, as research from Ethiopia demonstrates. Wheat yield can increase by 132 per cent by combining lime and fertiliser instead of applying fertiliser alone.

EXAMPLE FROM THE FIELD

With almost 40 per cent of land in India affected by soil degradation, the demand for alternatives to expensive mineral fertiliser is increasing. In the state of Maharashtra, cities produced 28,602 metric tonnes of compost from organic waste. The high-quality organic fertiliser is then sold to local distributors or directly to farmers to be applied as soil enhancers on agricultural land in rural areas. This situation is the starting point for an intersectoral circular economy approach to integrate urban organic waste as a valuable resource into agricultural value chains.

The innovative approach developed by the Global Programme and its Indian partners contributes to the Urban-rural Nutrient & Carbon Cycle (URNCC) Initiative, 'HARIT'. HARIT stands for a certification of sustainable urban compost as well as an online marketplace for selling and buying urban compost. The certification is carried out at state level and involves urban local bodies who check whether the composting complies with the local fertiliser control order and is thus eligible to receive the 'Harit'-label. In addition, local farmers learn to produce compost through virtual and physical trainings. The 'HARIT Ticker' app connects farmers as consumers with compost producers and facilitates an efficient distribution of the valuable compost. The label assures farmers that they bought an organic, safe and effective fertiliser.

- Organic inputs can help to fight climate change and enhance soils as carbon sinks: The use of one metric tonne Terra Preta in India for example can mitigate up to 200 kilogram of CO_2 while taking into account the emissions during the production process from pyrolysis and composting.

Key messages

- Nutrient input to soils is indispensable for sustainable yields, although not the only determinant. Pragmatic approaches that integrate organic and mineral fertilisers are particularly needed. Successful nutrient management relies on broader soil health management and site-specific application of nutrients.
- The appropriate nutrient management strategy depends on the initial soil conditions. Degraded soils require higher nutrient inputs from organic and, if needed, mineral sources as well as the building up of organic matter. In case of over-fertilised soils, the focus should be on an overall lower nutrient input from mineral sources and on pH control, if soils are acidic. Still, it is important that the right nutrient mix is applied.
- Developing business models and value chains to produce inputs (i.e. organic fertilisers, seeds) and provide services that enable farmers to improve soil health management are important for long term adoption. Support of governments i.e. by repurposing subsidies for targeted investments in innovations for organic fertilisers and increased fertiliser use efficiency as well as engaging the private sector are important for success.
- Adoption also requires that practices add value to farmers' bottom line and food security or provide other benefits e.g. decreasing volatility in production. Additional income from increased production and careful consideration of labor burden are key. Payment for ecosystem services could contribute to incentivise adoption.

"Since I follow the rules of sustainable soil management, my yield has steadily increased. Back in the days I could only harvest three to five 50kg-bags of maize per hectare. I have used the green manure cover crop Mucuna three years in a row. By now I yield 42 bags of maize per hectare."

Gniré Guera, farmer, Benin

- Small mechanisation devices might be needed in order to allow farmers to cope with increased workload from additional farmed land recovered through rehabilitation, more labor-intensive technologies or for quicker sowing-after – increasingly unreliable – rainfalls.

Local biochar production in Burkina Faso

Sources

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A multi-billion-dollar opportunity – Repurposing agricultural support to transform food systems (fao.org)

Nitrogen Fixation in Tropical Cropping Systems – Ken E. Giller - Google Books

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