Food and Agriculture Organization of the United Nations

Sustainable soil management as a keystone of nutrition sensitive agriculture in **Bangladesh**

Country factsheet

GLOBAL SOIL PARTNERSHIP

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Key messages

- In Bangladesh, more than half of the population suffers from malnutrition. Severe acute malnutrition affects 450 000 children, while close to two million children suffering moderate acute malnutrition (icddr,b, 2022).
- Nutrient deficiencies are due to the wide consumption of nutrient-poor staple crops, grown on nutrient-depleted soils. In Bangladesh, deficiencies of iron, zinc and boron are particularly widespread.
- According to the Food and Agriculture Organization of the United Nations (FAO), the intensification of agriculture in Bangladesh, with several harvests per year of high-yielding varieties and a heavy reliance on imports of chemical fertilizers, leads to declining soil fertility and jeopardizes food security.
- The Fertilizer Recommendation Guide, published in 2018 by the Government of Bangladesh (BARC, 2018), advises farmers to apply balanced micronutrient fertilization to the soil. However, in practice, micronutrient application is still low, as is organic matter use.
- The results of the Soils4Nutrition project showed that the application of organic fertilizers, combined with crop associations and integrated fertility strategies leads to a medium- and long-term increase in soil organic matter.
- Soil health is important for a long-term nutrient supply capacity and must be considered in nutrition-sensitive agriculture.
- It was also observed that it is necessary to control soil pH in order to optimize nutrient assimilation in acid soils such as those prevalent in Bangladesh. The addition of micronutrients at the right time, the right place and with the right source increases yields and the micronutrient content of food, while reducing the chemical fertilizer needs by 50 percent compared to the recommended fertilizer dose (RFD).
- Finally, it was confirmed that the use of biofortified rice varieties – common in Bangladesh – allows the assimilation of high zinc content, when grown in healthy soils.
- As a scaling-up opportunity, the implementation of the Global Soil Doctors Programme as a farmer to farmer training strategy proved to be very efficient in encouraging the adoption of sustainable soil management linked to nutrition-sensitive agriculture, and provided training to 450 farmers in three different districts in Bangladesh.

Background

Bangladesh is the most densely populated country in the world, with about 165 million people living in a landmass of 147 570 km^2, with around one-third of the population being under 15 years old (BBS, 2022).

Agriculture is the largest employment sector in the country, making up 13 percent of Bangladesh's GDP in 2020 and employing about 50 percent of the workforce (BBS, 2021). Bangladeshi agriculture has made a significant contribution to the country's food security through intensification, including the introduction of high-yield biofortified varieties that are selected for their increased capacity to fix micronutrients, and hold the potential to contribute to a nutritionally improved diet.

Bangladesh is the world's third-largest rice producer (Al Mamun *et al.*, 2021) as well as the third-largest rice consumer (Shew *et al.*, 2019). In collaboration with the CGIAR research programme, HarvestPlus, the Bangladesh Rice Research Institute (BRRI) and the International Rice Research Institute (IRRI) released seven zinc-biofortified rice varieties. By the end of 2021, nearly 13 million farming households were growing biofortified crops, with 64 million people benefitting directly. This has also contributed to a 192 percent increase in rice production (HarvestPlus, 2022).

Figure 1. Harvesting rice crops in the Soils4Nutrition project field trials

However, in spite of significant economic progress and poverty reduction, malnutrition issues still affect large parts of the population, especially women and children (UNICEF, 2017) and about 35 percent of Bangladesh's population remains food insecure:

- More than 54 percent of preschool-age children are stunted.
- More than 50 percent of women suffer from chronic energy deficiency.
- Anemia affects 52 percent of children under five years of age.
- Forty-one percent of children under five years of age are stunted.
- Sixteen percent of children under five years of age are wasted.
- Thirty-six percent of children under five years of age are underweight.
- A quarter of women are underweight.
- Around 15 percent of women have short stature, which increases the risk of difficult childbirth and low-birth-weight infants.

Agricultural intensification and deforestation have put a tremendous pressure on arable land, mining soil nutrients and reducing soil organic matter (SOM) content. This has led to decreasing soil fertility, as well as other related degradation processes such as soil erosion, pollution, increased soil salinity, compaction and pan formation and acidification, all affecting soil productivity and ultimately decreasing crop yields and crop nutrient content.

According to FAO's Global Information and Early Warning System (GIEWS), the cropping system in Bangladesh involves up to three cropping seasons per year of high-yielding crop varieties (FAO, 2022) leading to the decline of soil fertility, thus jeopardizing longer term soil productivity and food security.

In order to maintain soil productivity, increasing amounts of mineral fertilizers have been utilized. The Bangladeshi Government issued a Fertilizer Recommendation Guide (BARC, 2018) including recommendations on the dose and time of application of fertilizers based on agroecological zones (AEZ), and including macro- and micronutrients. Bangladesh has been divided into 30 AEZ, subdivided into 88 agroecological sub-regions, and further subdivided into 535 agroecological units on the basis of physiography, soils, hydrology and crop rotation patterns.

Farmers mostly rely on macronutrient fertilizers like urea, triple superphosphate (TSP), diammonium phosphate (DAP), muriate of potash (MOP) and gypsum, with very little or no use of micronutrient fertilizers like zinc (Zn) and boron (B), particularly in rice cultivation. Thus, the processes of nutrient imbalance and soil organic matter loss are exacerbated and resilient healthy soils are unable to be built. For instance, a long-term study of Bangladesh soils from the Soil Resource Development Institute (Hasan *et al.*, 2020) showed that the area of soils having low to very low Zn content has increased from 29 percent to 79 percent between 2010 and 2020, and from 26 percent to 31 percent in the case of B.

Consequently, as the amount of soil nutrients available to plants decreases over time, even biofortified crops are not able to obtain the nutrients they require. If managed unsustainably, soils can pose limits to the effectivity of the biofortification approach, while conversely, improvement in soil fertility management may enable biofortified foods to be more successful.

In addition, the cultivation of biofortified crops can lead to low dietary diversity, with negative effects on the nutritional status of the population. Monocropping of biofortified crops has also deleterious environmental effects, in particular for biodiversity.

Therefore, sustainably benefitting from biofortified crops requires a comprehensive approach, of which sustainable soil management is an important component. Sustainable soil management (SSM) includes a correct application of micronutrients, crop diversification and organic additions to the soil. Agrifood systems including biofortified crop varieties, can improve the micronutrient content in foods by 10 to 40 percent while producing between 10 and 20 percent higher yields and maintaining soil health, thus contributing to a long-term food security strategy. SSM can contribute to the transition towards a socially-supportive, commercially competitive and environmentally sound agrifood system.

Soils4Nutrition project

In 2019, FAO and the government of Bangladesh launched the project Sustainable Soil Management for nutrition-sensitive agriculture (Soils4Nutrition) to assess the impact of SSM on biofortified crops in the districts of Chandina, Chuadanga and Baliadangi. Biofortified varieties were cultivated in several field trials under different management practices. The yields and nutrient content of crops were then analysed in order to produce management recommendations. The objective was to provide policy makers and extension services with the knowledge needed to promote an increased and longer term nutrient supply to plants so allowing a higher nutrient content in crops and contributing to better nutrition while respecting the environment.

Healthy soils: The basis for healthy crops and better nutrition

Soil organic matter plays an important role in maintaining soil health and preventing soil degradation. The soils of Bangladesh are naturally low in organic matter with an organic content for mineral soils below 2 percent (between 0.05 and 0.9 percent in most cases) (Huq and Shoaib, 2013). The organic material (OM) supply in soil is one of the major constraints for the country's agriculture. Due to intensive agriculture, the SOM has declined even further (see Figure 1) and has led to the further deterioration of soil health (SRDI, 2020).

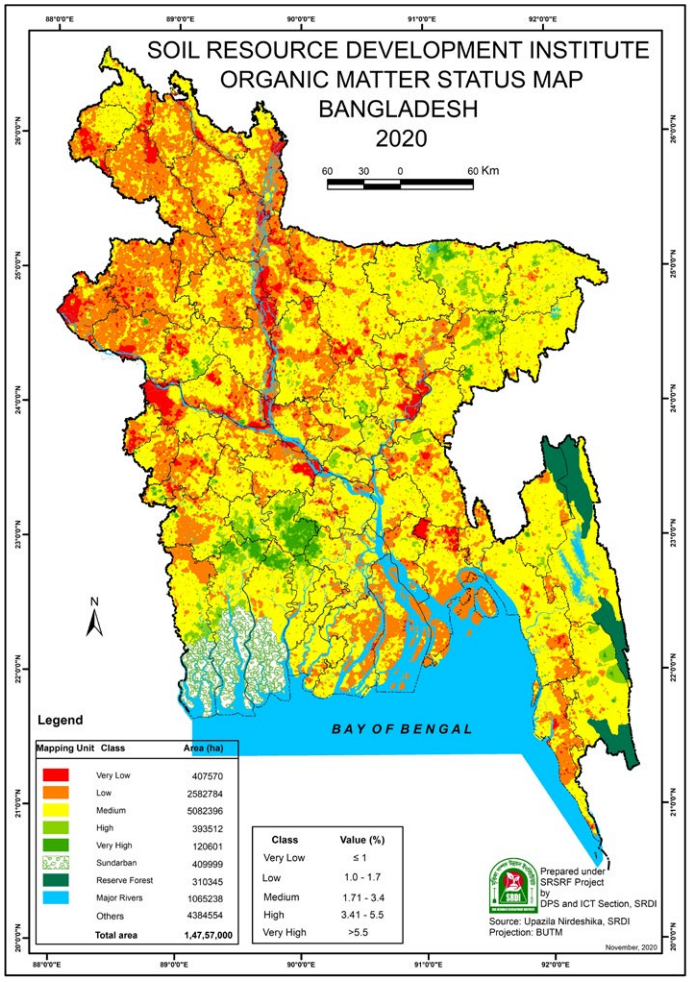


Figure 2. Soil organic matter status of Bangladesh

Source: SRDI (Soil Resource Development Institute). 2020. Soil Fertility Atlas Bangladesh 2020. Dhaka, Ministry of Agriculture. *http://www.srdi.gov.bd/sites/default/files/files/srdi.portal.gov.bd/publications/cdfc33d1_1d11_4263_9efb_5d3f94b8e502/2021-07-19-04-53-72e64dc42c94b35b3d503c34078e72d1.pdf*

Sustainable soil management practices like the application of organic manure to the soil and the inclusion of legumes such as mung beans to the cropping system, improves soil health by increasing the soil organic carbon content. This ultimately results in enhanced yields, higher nutrient content crops and larger farm profits. This has been shown in the field trials of the Soils4Nutrition project. Organic matter additions allow the soil organic matter content to increase and maintain crop yields while reducing the fertilizer needs by 50 percent when compared to the RFD.

When used together with a cover crop (mung bean), the SOM increase was optimized in the different cropping patterns where rice was the staple crop in rotation with cauliflower, maize or potato (see Figure 3). Added benefits include nitrogen (N) fixation, the diversification of diets, increasing biodiversity and increasing resilience to unpredictable climate.

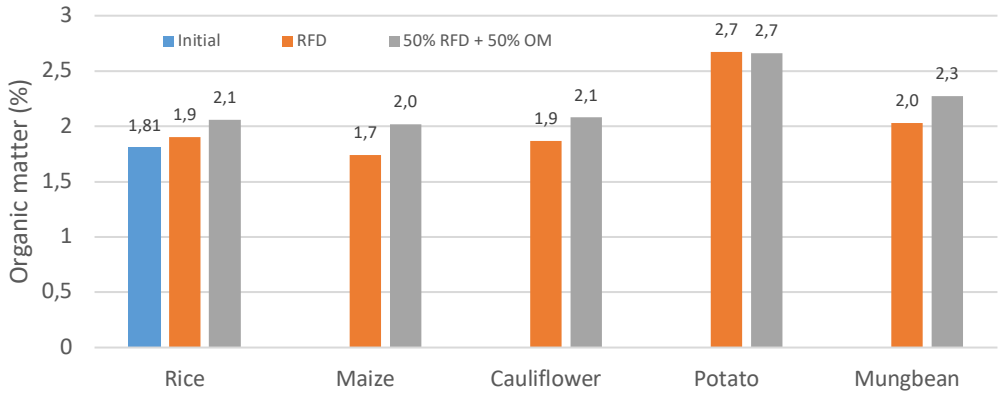


Figure 3. Changes in soil organic matter content using organic manure for different crop rotation patterns, with rice as staple crop

Source: Soil4Nutrition project

RFD: recommended fertilizer dose.

The benefits of OM application were consistently observed as an increase of around 20 percent of SOM in the medium and long term (see Figure 3 and Figure 4). Fertilizer management had no significant effect on soil pH (see Figure 5), so acidity amendments may be required for Bangladesh's common acid soils to optimize soil fertility and reduce the toxicity effects.

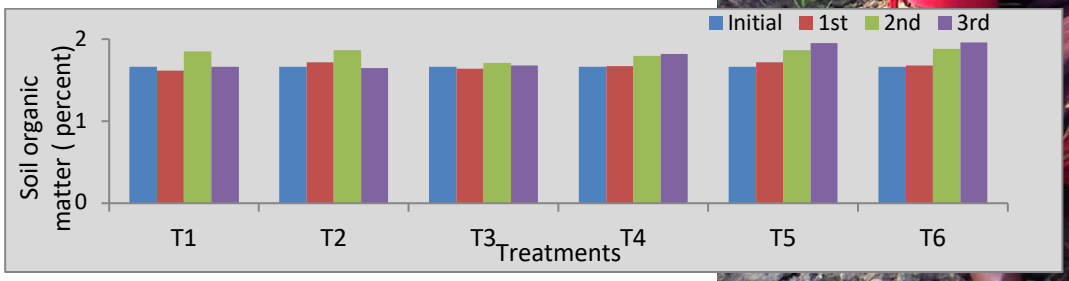
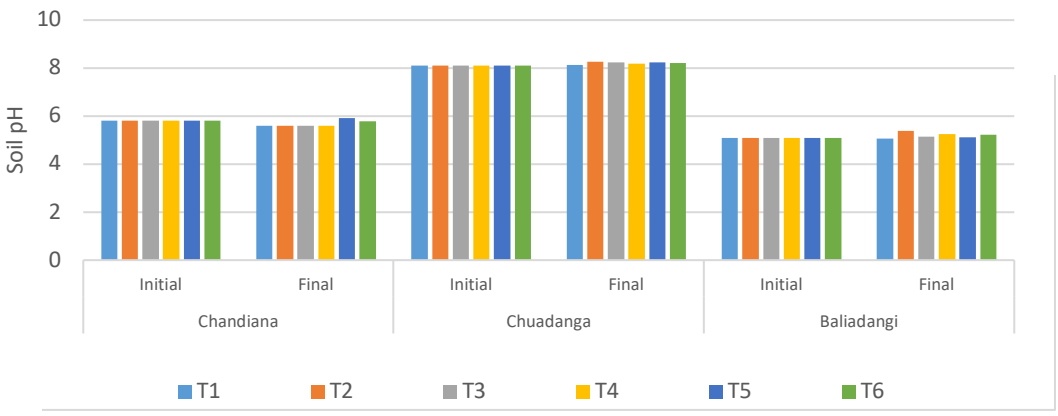


Figure 4. Medium- and long-term SOM status in rotation pattern (three crops/year) with different treatments

Source: Soil4Nutrition project

T1 = farmers practice; T2 = recommended fertilizer dose of NPKS (RFD) with Zn as basal; T3 = RFD with Zn as foliar spray; T4 = RFD with Zn and B as foliar spray; T5 = 50 percent RFD + 50 percent organic manure; T6 = 50 percent RFD + 50 percent organic manure + Zn and B as foliar spray.



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T6 = 50 percent RFD + 50 percent organic manure + Zn and B as foliar spray.

Source: Soil4Nutrition project

Figure 5. The stability of soil pH under different fertilizer treatments at the three demonstration sites

The right rate, time, place, and source of micronutrients

Basal application of Zn is recommended in Bangladesh by the Fertilizer Recommendation Guide (BARC, 2018). The results of the field tests carried out under the Soils4Nutrition project have shown that applying Zn and B as foliar spray during the flowering period of crops optimizes both yield and the amount of Zn in crops in comparison with the application of basal fertilizer only (see Figure 6 and Figure 7).

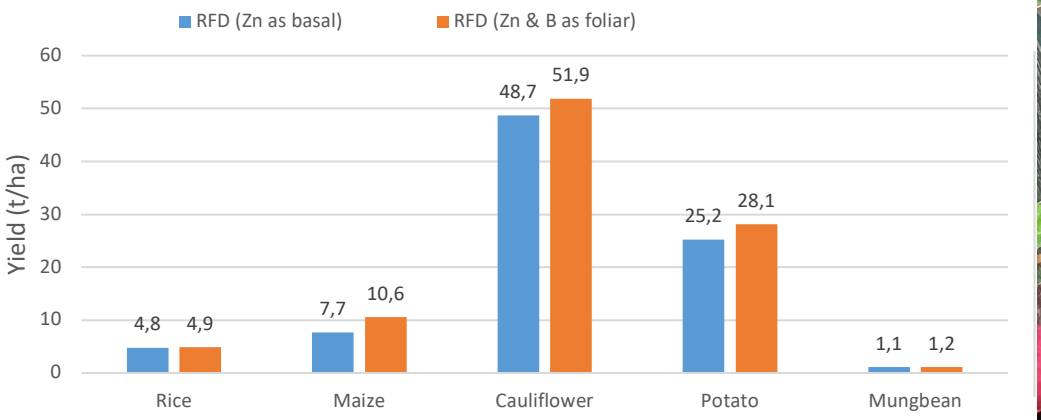

Figure 6. Comparison of yields between foliar application of zinc and boron and basal application of zinc

Source: Soil4Nutrition project

This indicates that strategies combining both basal and foliar applications provide the best outcomes. While basal fertilization improves soil nutritional status, thus enhancing the system's long-term capacity for improved plant nutrition, foliar applications provide immediate increases in both yields and nutrients in the edible parts of crops.

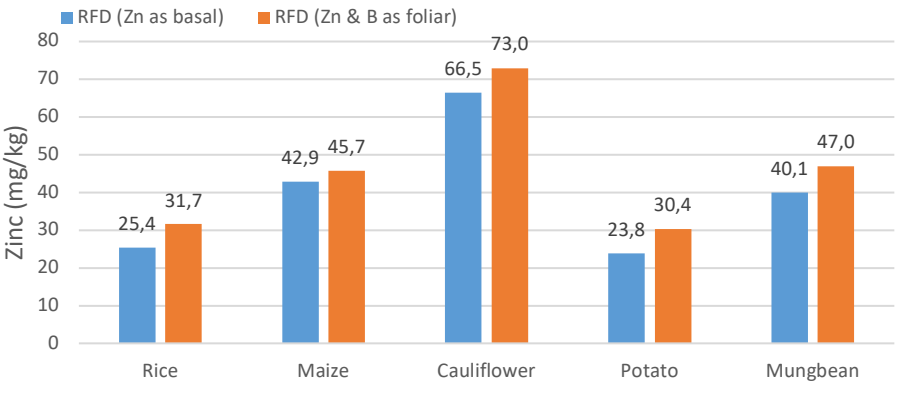

Figure 7. Increasing zinc content of grain or edible parts of different crops with foliar application of zinc and boron (recommended fertilizer dose of NPKS [RFD])

Source: Soil4Nutrition project

In any soil fertilization programme, it is fundamental to consider the growing cycle of plants, the soil characteristics and climate in an integrated long-term approach. The characterization of the soil nutrient pool and the nutrient cycling through periodic soil measurement and monitoring will allow for the efficient use of the right fertilizers, at the correct rate, time and place.

Moreover, scientific work on micro- and macronutrient deficiencies and the interactions between them should be strengthened in order to identify target areas for integrated nutrient management interventions, rather than focusing on stand-alone strategies based on individual macronutrients.

This needs to also be accompanied by a precise understanding of the composition and quality of fertilizers, in order to avoid toxicity issues and to achieve the maximum cost–efficiency.

Technology dissemination and capacity development

Farmer-to-farmer extension initiatives such as the Global Soil Doctors Programme (GSDP) have demonstrated to be very efficient in order to foster wide adoption of SSM by farmers. In Bangladesh, the GSDP has provided training to 450 farmers on the basic concepts of soil health, soil sampling, soil pH, soil nutrients and soil management in the three pilot sites. Fifteen farmers were then appointed as Soil Doctors to share and disseminate knowledge on sustainable soil management and soil health to peer farmers (see Figure 7). Upscaling such activities to the country scale can potentially help farmer communities to understand their soils, its limitations and the management needed to ensure soil productivity and its contribution to their food security and nutrition.

Figure 7. Soil Doctor training group

Recommendations and way forward

Through an in depth review of the scientific literature on nutrition-sensitive agriculture (FAO, 2022) and based on the Soils4Nutrition project results in Bangladesh, the following recommendations are advised:

- Soil health must be considered and regularly monitored within any nutrition-sensitive agriculture intervention.
- The use of biofortified crop varieties has to be embedded into a SSM strategy, in order to ensure that soils are capable of providing a long-term supply of nutrients while maintaining a healthy status.
- The incorporation of a legume cover crop to the existing cropping pattern through intercropping or crop rotation is advised in order to improve soil health, by increasing OM and N fixation, while fostering biodiversity and diversifying diets.
- Integrated soil fertility management (ISFM) should be mainstreamed, including the combined use of organic and mineral fertilizers and foliar and basal applications. The convenience of pH correction through liming must be also considered within ISFM. Other soil degradation issues should also be addressed before any soil fertility intervention.
- Organic manure should be applied to the soil to improve its physical and chemical properties, to increase yields and to reduce the expense of mineral fertilizers.
- A foliar application of a balanced dressing of micronutrients should be included during the flowering period to increase the micronutrient content of grains or edible parts.
- The Global Soil Doctors Programme should be implemented countrywide to improve technical know-how of farmers on soil health, food security and human nutrition.

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Acknowledgements

Authors

Ronald Vargas, FAO-Global Soil Partnership
Carolina Olivera Sanchez, FAO-Global Soil Partnership
Cruz Ferro Vazquez, FAO-Global Soil Partnership

Contributing authors

Baktear Hossain, BARC, Bangladesh
Khairul Alam, BARC, Bangladesh
Lutfar Rahman, SRDI, Bangladesh
Parimal Kanti Biswas, FAO Bangladesh
Taiabur Rahman, SRDI, Bangladesh

Editors

Andy Murray, FAO-Global Soil Partnership
Isabelle Verbeke, FAO-Global Soil Partnership

Art direction

Matteo Sala, FAO-Global Soil Partnership

The Global Soil Partnership (GSP) is a globally recognized mechanism established in 2012. Our mission is to position soils in the Global Agenda through collective action. Our key objectives are to promote Sustainable Soil Management (SSM) and improve soil governance to guarantee healthy and productive soils, and support the provision of essential ecosystem services towards food security and improved nutrition, climate change adaptation and mitigation, and sustainable development.

Land and Water Division
GSP-secretariat@fao.org
www.fao.org/global-soil-partnership

Food and Agriculture Organization of the United Nations
Rome, Italy

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