TECHNICAL BULLETIN
No. 26, 2021

Improved Soil Fertility Management for Intensive Crop Production

Nutrient mining due to intensive cultivation of crops using only chemical fertilizers and very little or no organic matter recycling is affecting soil health in Bangladesh. Increasing acidity and emerging toxicity problems like that arising from irrigation with arsenic (As) laden shallow tube well water complicate soil fertility and plant nutrition prodens. For example, soil acidity or low soil pH may induce Ca, Mg, P and Mo deficiencies and Al toxicity, and a high As in soil may be antagonistic to P uptake by plants and may also be a human health hazard through pollution of the food chain. Soil organic matter and nutrient depletion can be minimized by the application of amendments or manure like biochar, poultry manure, crop residues, biofertilizers, composts etc. Biochar reduces As toxicity in contaminated soils through binding the As ion, and in addition, improves soil fertility through carbon accumulation and stimulation of microbial activities.

A field experiment on soil fertility management for intensive cropping

Sporadic adaptive research has been conducted by different organizations in the aforesaid areas. However, insufficient and inconsistent research findings may not solve location specific problems related to soil health and crop productivity. Therefore, a holistic and systematic adaptive research approach was undertaken to upgrade farmers' knowledge for sustaining soil health and crop productivity. The Department of Soil Science, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) explored the possibility of soil health improvement with various organic materials in a three-year adaptive research project. The main objectives of the study were to develop an improved organic matter-based soil fertility management package for intensive crop production with varied cropping patterns on diverse types of soils including As-contaminated soils.

Methodology

Adaptive trials were conducted in farmers' fields on acid soils in Khetlal, Sonatala and Badarganj upazilas of Joypurhat, Bogura and Rangpur districts, respectively, on an As-contaminated soil in Faridpur Sadar upazila and on a soil under intensive rice cultivation in Trishal upazila of Mymensingh district of Bangladesh. The treatment details for the trials are given bellow:

KRISHI GOBESHONA FOUNDATION
A non-profit foundation for sustainable support to agricultural research and development

Acid soils

T_1: Soil test based (STB) fertilizer doses for high-yield goal (HYG), T_2: T_1+crop residues (boro rice straw) on integrated plant nutrition system (IPNS) basis and T_3: Farmers' practice (FP); cropping pattern: Potato-Boro-T. Aman

Biochar prepared from different organic substances

As-contaminated soil

T_1: STB fertilizer doses for HYG, T_2: T_1+crop residues (Lentil)-IPNS, and T_3: T_1+biochar, T_4: FP; cropping pattern: Jute-T. Aman- Lentil

(residues)-IPNS, and T_3: T_1+biochar, T_4: FP; cropping pattern: Jute-T. Aman- Lentil

Intensive rice cropping soil

T_1: STB fertilizer doses for HYG, T_2: T_1+crop residues (T. Aus and boro straw)-IPNS, T_3: FP; cropping pattern: T. Aus-T. Aman-Boro

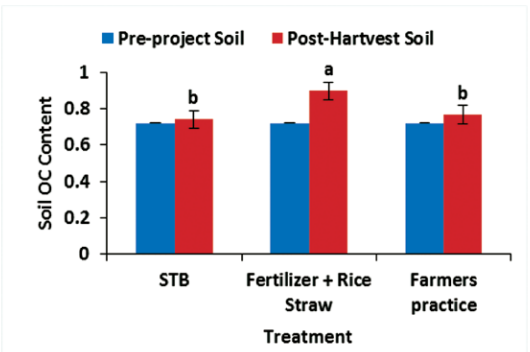
In addition to the above, field experiments were conducted in the research field of the Department of Soil Science, BSMRAU with similar treatments and cropping patterns.

Yield data were recorded and land productivity index (LPI) and sustainable yield index (SYI) calculated to assess yield potentials of crops under the different treatments. Soil samples were collected from the experimental plots after the three-year cropping cycles and analyzed to evaluate soil fertility changes due to the fertility management interventions.

Results and Outputs

Soil organic carbon (SOC) and total N

Management treatments influenced SOC build-up or depletion, especially in the top-soil up to the depth of 30 cm. In the surface soil layer (0-15 cm), SOC at the beginning of the experiment was about 0.70% which increased to 0.74%-0.89%, the variation, after the three crop cycles being obviously due to the treatments. Among the different treatments, T_2 (rice straw + inorganic fertilizer-IPNS) was most effective in increasing SOC which was possibly due to the persistence of rice straw. A similar trend in SOC accumulation was observed in the sub-soil layer (15-30 cm), too. The increase in SOC would impact soil fertility positively.

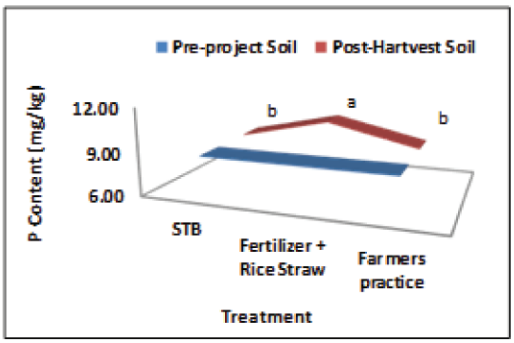


Effect of nutrient management for crops on the accumulation of soil organic carbon (SOC) in the topsoil (0-15 cm)

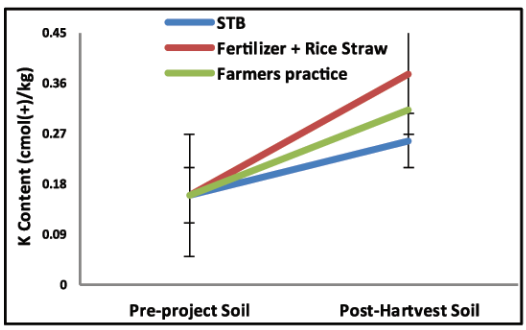
The total N content in soil did not vary significantly with treatment in the surface layer (0-15 cm) even after three years of cropping under different nutrient management regimes. The highest total N(0.092%) was observed for T_2 (rice straw + inorganic fertilizer-IPNS basis) treatment. A high mineralization rate may have flattened out the differences among treatments.

Available P in soil

The available P in post-harvest soil samples from both surface and sub-surface layers differed significantly with treatment. The available P in the surface soil (0-15 cm) after the cropping cycles varied from 8.63 to 10.11 mg/kg within the medium range according to the fertilizer recommendation guide - FRG (2012). Among the different treatments, the highest available Pof 10.11 mg/kg was found for T_2 (rice straw + inorganic fertilizer- IPNS) and the lowest with T_1 (STB fertilizer doses) 8.63 mg/kg. The available P content in the sub-soil (15-30 cm) was lower, varying from 7.74 to 8.42 mg/kg, low to medium according to FRG, 2012.



Effect of nutrient management for crops on the avilable P content of the topsoil (0-15cm)



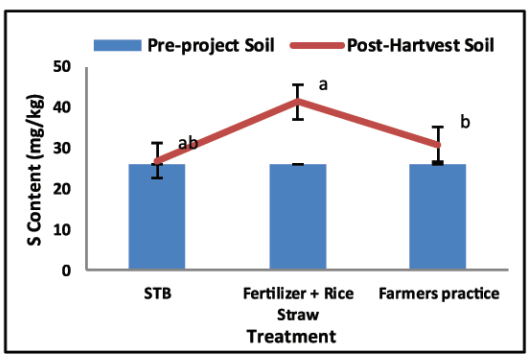
Effect of nutrient management for crops on the exchangeable K content of the topsoil (0-15 cm)

Exchangeable K in soil

Nutrient management caused a significant variation in the exchangeable K content in soil after the three-year cropping cycles. In the topsoil (0-15 cm), the K content was about 0.16 cmol/kg which increased substantially to about 0.3 to 0.4 cmol/kg after three years of cropping with various nutrient management treatments. The highest exchangeable K in soil was observed in the T_2 plots (inorganic fertilizer + rice straw-IPNS) presumably due to the high amount of K in rice straw the recycling of which enriched the soil with K. A similar trend was observed in the sub-soil (15-30 cm).

Available S in soil

The available S content in the soil, after three years of cropping were influenced significantly by the treatments. Available S in surface soil (0-15 cm) ranged from 26.93 to 41.39 mg/kg, the highest being with T_2 (rice straw + inorganic fertilizer-IPNS) the lowest was for T_1 (fertilizers-STB). At the 15-30 cm soil depth, available S content in soil varied from 27.12 mg/kg to 36.01 mg/kg, the lowest and highest being for T_1 and T_2, respectively.



Effect of nutrient management for crops on available S content of the topsoil (0-15 cm)

Crop yields and land productivity

Recycling rice straw increased Potato tuber yield by 12-17% over inorganic fertilizers alone or FP. Similar trends were observed for other crops in the different cropping patterns and across the study locations. This indicated the importance of crop residue recycling in sustainable crop yield increases. At the Faridpur location, Lentil residue in soil positively increased Jute fiber

production by 15-22%. Analysis of soil and plant samples indicated that biochar/peat can significantly reduce as toxicity and as contamination in lentil positively impacting yield. Biochar reduced As content in lentil grain, stem and root of lentil by 61%, 47% and 28%, respectively, within one year after application. The land productivity and sustainable yield indices were satisfactory. The land productivity indices were found to be >3 which indicated that the cropping systems were productive. The sustainable yield indices indicated that rice straw, lentil residue and biochar have high potential for increasing crop yields. Biochar may contribute substantially in increasing SOC by 10-20% and maintaining level which is beneficial for soil health.. It was found that irrespective of rice seasons yield increased by 5-15% in the rice straw applied treatments compared with the recommended fertilizer treatment and farmers' practice.

Expected Impacts

Integrated nutrient management can have a positive impact on land productivity and sustainable crop yield indices. An integrated inorganic-organic fertilizer regime for different cropping patterns where crop residues are recycled along with the application of recommended doses of chemical fertilizers can maintain SOC and soil fertility in the long run. Carbon accumulation in soil is a climate smart consequence of crop residue recycling in cropping systems. Addition of rice straw along with recommended fertilizers would be a simple but effective way of improving soil health contributing to a sustainable increase in land productivity. Organic matter like biochar may be highly effective in mitigating soil toxicities like arsenic.

Recommendations

- Application of rice straw and residues of other crops along with inorganic fertilizers on IPNS basis is recommended for soil health improvement and crop productivity enhancement.
- Biochar at the rate of 7.5 to 10 t ha^{-1} may be applied for soil health improvement and arsenic mitigation.

This technical bulletin has been prepared on the basis of technical information available from a completed CGP project of KGF, the details of which are given below:

Project Code and Title: TF 27-SF/15. Adaptation of improved soil fertility management practices for viable soil conditions under intensive cropping systems

Principal Investigator: Professor Dr. GKM Mustafizur Rahman, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur

Project Duration: July 2015 to June 2018

Published by:

Krishi Gobeshona Foundation, AIC Building, 3rd Floor, BARC Campus, Farmgate, Dhaka-1215, Bangladesh, Telephone: 880-2-9111041, Fax: 880-2-58150270, Website: www.kgf.org.bd, E-mail: kgf-bd@live.com