**Long-term effects (20 years) of cropping systems and nutrient management practices on grain yield of organically-grown basmati rice and soil fertility**

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The soil fertility is rapidly declining in India, particularly the organic matter decline has become a serious issue. The conventional farming has also reduced the biodiversity and farmers’ income besides polluting the air, soil and water. Rice crop has largest cultivated area (43.5 million hectares) in India among all the crops, being grown mostly by conventional methods. The conventional rice production system has become unsustainable, and thus replacing it partly by organic production may sustain the production and soil fertility. In view of the above, this study evaluated the effect of including mungbean (*Vigna radiata* L.) and later *Sesbania* (*Sesbania aculeata*) green manuring in the rice-wheat cropping system and nutrient management practices on soil health and productivity of rice crop.

The long-term field experiment (20 years) on organic farming of rice-based cropping systems was started in year 2003 and continued till 2023 at the ICAR-Indian Agricultural Research Institute, New Delhi, India (Table 1). The experiment was laid out in a strip plot design with three replications. Treatments during first 10 years (2006-07 to 2015-16) consisted of 2 rice-based cropping systems (rice-wheat and rice-wheat- mungbean), six combinations of different organic materials and biofertilizers [farmyard manure equivalent to 60 kg N ha-1 (FYM), vermicompost equivalent to 60 kg N ha-1 (VC), FYM + crop residue (CR) of preceding crop @ 3 t ha-1 for each rice, wheat and mungbean, VC + CR, FYM + CR + biofertilizers and VC + CR + biofertilizers] and control (no manure applied). For biofertilizers, the blue green algae (BGA), phosphate solubilizing bacteria (PSB) and cellulolytic culture used in rice, *Azotobacter*, phosphate solubilizing bacteria (PSB) and cellulolytic culture in wheat and *Rhizobium* + PSB in mungbean. Subsequently, during the years 2019-20 to 2022-23 (4 years), the rice based cropping systems were rice-wheat-mungbean and rice-wheat-*Sesbania* green manuring (SGM), but the nutrient management options were the same as during the previous years (2006-07 to 2015-16) in the fixed plots. All the cultural and management practices were followed as recommended by the Government of India for organic crop production. The insect-pests and diseases were managed through organic methods.

**Table 1.** History of the long-term organic farming experiment (2001 – 2023) at the New Delhi, India

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year** | ***Kharif* (rainy season)** | ***Rabi* (winter season)** | ***Zaid* (summer season)** | **Remarks** |
| 2001-03 | Basmati Rice | Wheat | - | Conventional farming |
| 2003–04 to 2004-05 | Basmati Rice | Wheat | - | Transitional period |
| 2004–05 to 2005-06 | Basmati Rice | Wheat | - | Transitional period |
| 2005–06 | Basmati Rice  Basmati Rice | Wheat  Wheat | -  Mungbean | Transitional period |
| 2006–07 to 2015-16 | Basmati Rice Basmati Rice | Wheat  Wheat | -  Mungbean | \*OF: 10 cycles completed |
| 2016-17 to 2017-18 | Soybean  Soybean | Wheat  Wheat | Mungbean  SGM\*\* | \*OF: 2 Cycles completed |
| 2018-19 | Maize  Maize | Wheat | Mungbean  SGM\*\* | \*OF:1 Cycle completed |
| 2019-20 to 2022-23 | Rice  Rice | Wheat  Wheat | Mungbean  SGM\*\* | \*OF:4 Cycles completed |

\*Organic farming, \*\*SGM: *Sesbania* green manuring

Averaged across the 10 years (2006-07 to 2015-16), the rice-wheat- mungbean cropping system (RWMCS) produced about 13.0 % higher grain yields of rice over the rice-wheat cropping system (RWCS) (Table 2). Levels of organic carbon, total N, available N, P, K and micronutrients increased significantly by inclusion of the mungbean in RWCS. RWMCS was more profitable over the RWCS. Increase in grain yields of rice and wheat crops was the most when biofertilizers and crop residues were combined either with farmyard manure (FYM) or vermicompost (VC). Application of vermicompost + crop residue + biofertilizers (BGA + cellulolytic culture + PSB in rice, *Azotobactor* + cellulolytic culture + PSB in wheat, *Rhizobium* + PSB in mungbean) was most productive and FYM + crop residue + biofertilizers was most profitable. Both these combinations also resulted in a significant improvement in the soil chemical and biological properties. Levels of organic carbon increased significantly due to the inclusion of mungbean in the RWCS. Simultaneously, the soil microbiological properties, viz., microbial biomass carbon, microbial biomass nitrogen and enzymatic (alkaline phosphatase, acid phosphatase, dehydrogenase, glucosidase, FDA hydrolysis, etc.) activities were also significantly higher in soils of RWMCS than in RWCS. All the nutrient management practices increased the SOM contents substantially over the control.

**Table 2.** Mean grain yield of organically-grown basmati rice (t/ha) across the nutrient management options in two different cropping systems

|  |  |  |
| --- | --- | --- |
| **Year / cropping system** | **Rice-Wheat Cropping System (RWCS)** | **Rice-Wheat-Mungbean Cropping System (RWMCS)** |
| 2006-07 | 4.26 | 4.55 |
| 2007-08 | 4.51 | 4.91 |
| 2008-09 | 4.30 | 4.60 |
| 2009-10 | 3.94 | 5.10 |
| 2010-11 | 4.49 | 5.18 |
| 2011-12 | 3.71 | 4.08 |
| 2012-13 | 3.88 | 4.33 |
| 2013-14 | 4.11 | 4.59 |
| 2014-15 | 3.89 | 4.62 |
| 2015-16 | 3.93 | 4.81 |
| Mean | 4.10 | 4.68 |

The mean grain yield of organic rice during the last 4 years (2019-20 to 2020-21) were significantly higher (Fig.1) in the rice-wheat-*Sesbania* green manuring cropping system (RWSCS) over the rice-wheat-mungbean cropping system (RWMCS).

\*SGM: *Sesbania* green manuring

Thus, the cropping systems have important role in influencing the productivity of the component crops. Overall, the organic production of basmati can be sustained by diversifying the cropping systems and adopting the efficient nutrient management practices. Such practices also enhance and sustain the soil fertility and profitability as well.

**Key words:** basmati rice, farmyard manure, green manuring, organic production, vermicompost

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