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Topic 1 - Ecological approaches to systems' health

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YIELD, PROFITABILITY AND SOIL HEALTH AS INFLUENCED BY LONG-TERM APPLICATION OF BIOMANURES, BIOFERTILIZERS AND CROP RESIDUES IN ORGANIC RICE-BASED CROPPING SYSTEMS

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Abstract: For wider adoption of organic systems in India, the crop production technologies need to be evolved for varied soils and cropping systems. Among other field limitations, inefficient nutrient management results in low yields under organic systems. A 10 years' field experiment evaluated the effect of two rice-based cropping systems and seven nutrient management practices on yield, economics and soil health under organic management. Rice-wheat-mungbean system recorded significantly higher profits, and 13% and 6% higher grain yields of rice and wheat crops, respectively, over rice-wheat system. Levels of organic carbon, total N, available nitrogen, phosphorus, potassium and micronutrients increased significantly and substantially due to inclusion of mungbean in rice-wheat cropping system. Application of FYM + crop residue + biofertilizers was most profitable practice in rice-based cropping systems.

Introduction: Among different rice-based cropping systems the rice-wheat cropping system (RWCS) is one of the largest agricultural production systems of the world. During recent years, a significant slowdown in the yield growth rate of RWCS has been observed. Key issues associated with the sustainability of this system include decline in soil organic matter (SOM) due to reduced inputs of bio-resources and lack of an adequate rotation; negative macro and micro-nutrient balances leading to depletion of soil health and nutrient deficiencies. Overcoming these interacting abiotic constraints requires adoption of more integrated farming systems that build-up and maintain SOM, need less water and improve nutrient use efficiency. In view of the above, this study evaluated the effect of including mungbean (*Vigna radiata* L.) in rice-wheat cropping system and nutrient management practices on soil health, productivity and profitability of rice and wheat crops.

Material and methods: A long-term field experiment on organic farming of rice-based cropping systems was started in year 2003 and continued till 2016 at the ICAR-Indian Agricultural Research Institute, New Delhi, India. The experiment was laid out in a strip plot design with three replications. Treatments 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 of preceding crop @ 3 t ha^{-1} for each rice, wheat and mungbean (CR), VC + CR, FYM + CR + biofertilizers and VC + CR + biofertilizers] and

control (no fertilizer applied). For biofertilizers, blue green algae (BGA), phosphate solubilizing bacteria (PSB) and cellulolytic culture used in rice, Azotobacter, PSB and cellulolytic culture in wheat and Rhizobium + PSB in mungbean. **Results:** Averaged across ten years, rice-wheat- mungbean cropping system (RWMCS) produced over 13.0 and 6.0% higher grain yields of rice and wheat crops, respectively over rice-wheat cropping system (RWCS) (Table 1). Levels of organic carbon, total N, available N, P, K and micronutrients increased significantly by inclusion of mungbean in RWCS. RWMCS was more profitable over 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 soil chemical and biological properties. Levels of organic carbon increased significantly due to inclusion of mungbean in 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 1. Mean grain yield of rice, wheat and mungbean crops in organic rice-wheat and rice-wheat-mungbean cropping systems

Year	Rice-Wheat (t/ha)				Rice-Wheat-Mungbean (t/ha)				
	Rice	Wheat	Total	Mean	Rice	Wheat	Total	Mean	Mungbean
2006-07	4.26	3.57	7.83	3.92	4.55	3.82	8.37	4.19	0.87
2007-08	4.51	4.47	8.98	4.49	4.91	4.83	9.74	4.87	0.90
2008-09	4.30	3.71	8.01	4.01	4.60	3.80	8.40	4.20	0.99
2009-10	3.94	3.81	7.75	3.88	5.10	4.04	9.14	4.57	0.81
2010-11	4.49	3.38	7.87	3.94	5.18	3.78	8.96	4.48	0.95
2011-12	3.71	3.52	7.23	3.62	4.08	3.97	8.05	4.03	0.83
2012-13	3.88	3.61	7.49	3.75	4.33	3.87	8.20	4.10	0.89
2013-14	4.11	3.11	7.22	3.61	4.59	3.82	8.41	4.21	0.98
2014-15	3.89	3.95	7.84	3.92	4.62	4.38	9.00	4.50	1.12
2015-	3.9	3.86	7.79	3.9	4.8	4.23	9.04	4.5	1.18

16	3			0	1			2	
Mean	4.10	3.70	7.80	3.90	4.68	4.05	8.73	4.37	0.95

Discussion: RWMCS improved soil health, productivity and profitability over RWCS. It also gave 0.95 t/ha additional seed yield of mungbean. Legumes fix the atmospheric nitrogen, release in the soil high-quality organic matter and facilitate soil nutrients' circulation and water retention (Stagnari, 2017). We conclude that inclusion of mungbean in RWCS enhanced grain yield, soil health and profits over RWCS. Use of FYM with crop residues and biofertilizers gave maximum profits and sustained health.

References: Stagnari F, Maggio A, Galieni A & Pisante M. (2017): Multiple benefits of legumes for agriculture sustainability: an overview. Chemical and Biological Technologies in Agriculture, **4**: 2.

Disclosure of Interest: None Declared

Keywords: Biofertilizers, mungbean, nutrient management, organic farming, rice, wheat