Effect of synthetic fertilisers and organic manures on soil physico-chemical properties and soil nutrient status under rice-wheat cropping system of western Uttar Pradesh, India

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Long-term sustainability is the concern of today's agriculture. A field experiment was conducted in western Uttar Pradesh during the *rabi* season of 2021–22 to evaluate the combined effect of different combinations of synthetic (nitrogen, phosphorus and potassium (NPK) and $ZnSO_4$) and organic fertilisers (vermicompost, Azotobacter + phosphorus solubilising bacteria (PSB)) on soil physico-chemical properties under a rice-wheat cropping system. The experiment consisted of ten treatment combinations with variable sources of nutrients and biofertilisers such as T_1 (Control), T_2 (75% Recommended dose of fertilisers (RDF) NPK), T_3 (100% (RDF-150:75:60 kg ha^{-1}) NPK), T_4(75% (RDF)NPK + $ZnSO_4$ (25 kg/ha.) T_5 (75% (RDF) NPK + Vermicompost @ 2.5 t/ha), T_6 (75% (RDF) NPK + $ZnSO_4$ + Vermicompost @ 2.5 t/ha), T_7(75% (RDF) NPK + Azotobacter+PSB), T_8(75% (RDF) NPK + $ZnSO_4$ + Vermicompost @ 2.5 t/ha+Azotobacter+PSB), T_9(100% (RDF) NPK + $ZnSO_4$) and T_{10}(100% (RDF) NPK +Azotobacter+PSB). It was observed that combined application of organic and synthetic fertiliser resulted in a positive influx of macro- and micronutrients by increasing electrical conductivity, soil aggregation, organic carbon content, available nitrogen, phosphorus, potassium and zinc of soil. The lowest physico-chemical properties were recorded in the control except soil pH and soil bulk density; the highest were recorded due to combined application of synthetic fertiliser along with organic manure. The highest organic carbon (0.51%), available N (186.0 kg ha^{-1}), P (21.4 kg ha^{-1}), K (131.1 kg ha^{-1}), Zn (0.85 mg kg^{-1}) were recorded under the treatment of 75% (RDF) NPK+$ZnSO_4$ +Vermicompost @ 2.5 t ha^{-1}+ Azotobacter + PSB, followed by 100% (RDF) NPK + $ZnSO_4$ while bulk density (1.52 g cc^{-1}) and particle density (2.65 g cc^{-1}) were found highest in the control. In this way the results clearly suggested that integrated use of balanced synthetic fertilisers in combination with organic manure in a rice-wheat cropping system improves soil physico-chemical properties and thereby has the potential to enhance soil sustainability.

Keywords: Integrated nutrient management, organic fertilisers, physico-chemical properties, rice-wheat cropping system, soil nutrient status.

ACROSS South Asia, particularly in India, Pakistan, and Bangladesh, the rice–wheat (RW) cropping system is extensively practised and forms the backbone of regional agriculture. It occupies more than 13.5 million hectares, with a significant share located in the Indo-Gangetic Plains (IGP) of India, which contributes nearly one-third of the country's cereal production[1]. Due to its vast coverage and importance, it is regarded as the leading cropping system in the region. The emergence of this system can be linked to the Green Revolution, when rice cultivation was expanded into traditional wheat-growing areas of northwestern India, eventually making RW the dominant production system by the mid-1960s (ref. 2). In recent years, however, the RW system has shown signs of stagnation in both productivity and overall output. Indian agriculture is currently facing multiple constraints, including declining yields and the degradation of soil fertility coupled with escalating production costs[3]. Moreover, questions have been raised regarding its long-term sustainability due to intensive input use, declining factor productivity, and environmental concerns. A key factor contributing to reduced productivity is the improper and imbalanced use of fertilisers in nutrient-exhaustive cropping systems, which has resulted in gradual depletion of soil fertility[4,5]. Although fertilisers are essential for enhancing crop productivity, their excessive or mismanaged application can negatively impact soil health and long-term productivity. Continuous and imbalanced nutrient supply under intensive cultivation can adversely influence soil physicochemical properties, biological processes, and nutrient-use efficiency. This situation is further aggravated by insufficient incorporation of organic nutrient sources into the system[6]. Several studies have suggested

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