ABSTRACT

Flooding-induced phosphorus (P) dissolution causes favorable P regimes in lowland rice soils, but non-flooded rice production systems would reduce the P bioavailability that may have yield-limiting impacts. The present study aimed to evaluate the effect of different system-based sole fertilizer and integrated P management in improving productivity, economics, and P use efficiency of the non-flooded rice-lentil systems in tropical alkaline soil. Field experiments involving two non-flooded rice production techniques with seven different system-based P management treatments were conducted during 2015-2018 at Kanpur, India. The non-flooded rice cultivation techniques were direct seeded rice (DSR) and system of rice intensification (SRI). The system-based P treatments [subscript value represents fertilizer-P rate (kg P ha^{-1}) to rice and lentil, respectively] were P control ($P_{[0-0]}$), three sole fertilizer-P treatments with variable rate ($P_{[22-22]}$, $P_{[33-11]}$, $P_{[11-33]}$), and three integrated treatments ([P_{11-11}+phosphate solubilising bacteria (B)], [$P_{16.5-5.5}$+rice residue recycling (RR)+B], [$P_{5.5-16.5}$+lentil residue recycling (LR)+B]). The yield potential of DSR was lower than SRI crop, attributed to the reduced root growth, suboptimal N nutrition, and sink inefficiencies. The DSR system favoured lentil performance over the SRI system. The non-flooded rice production significantly reduced P availability (6-9%) in rice season compared to the flooded-rice production. The integrated P management involving suboptimal P rate with rice residue recycling and bacterial inoculation treatment ($P_{16.5-5.5}$+RR+B) significantly increased Olsen-P in the rice (6-8%) and lentil (10%) crop seasons over the recommended sole fertilizer-P treatment ($P_{[22-22]}$), leading to higher system productivity (8%), agronomic P use efficiency, fertilizer-P recovery efficiency, and net return (15%). The integrated treatment '$P_{16.5-5.5}$+RR+B' resulted in higher soil $NaHCO_3$-extractable P (11%), dissolved non-reactive P (6%), macro-aggregates (13%), active carbon pools (8%), and water holding capacity (6%) over the treatment '$P_{[22-22]}$'. The positive correlations of soil aggregation, labile C pools, and microbial biomass carbon with Olsen-P demonstrated their significance in P cycling. The marginally negative P balance in the crop residue recycling integrated treatments suggested that fertilizer-P rate needs to be precisely adjusted to ensure a positive balance. Hence, rice residue recycling integrated P management could improve soil P availability, system productivity, and profitability in the non-flooded rice-lentil systems, and save costly fertilizer-P.

Key words: Alkaline soil, Apparent P balance, Crop yields, Non-flooded rice, P pools, P use efficiency