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No-till and integrated crop-livestock system ensure high rice yield through soil fertility improvement of Brazilian lowlands

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Lowland soils represent 4 to 6% of the earth's surface, covering an area of 7 to 9 million km^2. Most of these areas can be used for flooded rice cultivation, as a paddy field. These soils commonly have low fertility due to the traditional flooded rice cultivation systems, which are based on intensive soil tillage and rice monocropping. On the other hand, soil conservation management systems, such as no-tillage and integrated crop-livestock systems (ICLS) may increase the soil fertility and consequently improve rice yield. In lowlands, these practices are contributing to sustainable soil management. Therefore, our study aimed to evaluate soil fertility properties by measuring soil organic matter (SOM) and soil available phosphorus (P) and potassium (K) contents, five years after the adoption of different paddy-farming systems in an Albaqualf soil. The long-term ICLS experiment is located in Cristal county, Rio Grande do Sul State, in Southern Brazil. The systems consisted of two ICLS under no-tillage (NT), in comparison to the traditional system (S1) of flooded rice cultivation under soil disturbance, rice monocropping, and winter fallow. The ICLS systems were based in: rice cultivation in summer season and pasture (annual ryegrass) with cattle grazing in winter season (S2), and crop rotation (rice and soybean) in summer season and livestock production in winter season (S3). In 2013, at the beginning of the experiment, and after five years (2018), soil samples were collected in the 0–10 and 10–20 cm layers, and then the SOM, and available P and K contents were analyzed. Regarding the rice yield, S2 and S3 always had higher rice yields than S1. The S2 and S3 showed increases in yields of 8.9 and 16.4% in relation to S1, with average yields of 11.3 and 12.1 Mg ha^{-1}, respectively. In addition to S3 having the highest rice yields, it also had high soybean yields for lowland environment in the period evaluated, with an average of 3.8 Mg ha^{-1}. After five years, S2 and S3 increased SOM contents by 27% and 50%, respectively, in the 0–20 cm soil layer. Similar behavior was verified in available P, with decrease of 4.6 mg dm^{-3} in S1 and increase of 16.0 mg dm^{-3} in the S3 compared to the initial evaluation. The available K content was higher in S3 (79.3 mg dm^{-3}), followed by S2 (68.1 mg dm^{-3}) and S1 (59.5 mg dm^{-3}) on average of two years evaluated, in the 0–10 cm soil layer. Therefore, the results shows that NT adoption, combined with crop rotation and ICLS, improve soil fertility attributes, which results in high rice yields over time, reaching the sustainable intensification of lowlands.