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Estimating the effects of a conversion from submerged to aerobic rice: a case study on a district basis

Michele Rienzner, Arianna Facchi, Sandra Cesari de Maria, Enrico Antonio Chiaradia, and Claudio Gandolfi
Università degli Studi di Milano, Sezione di Idraulica Agraria, DiSAA, Milano, Italy (michele.rienzner@unimi.it)

Several studies report that the water use efficiency of irrigated rice can greatly improve at the field scale if continuously submerged rice is replaced with aerobic rice. However, the effects of a massive conversion on the groundwater resources of larger domains are much less investigated, even though several authors agree that a consequent drop of the groundwater table may have repercussions on the potential gains. Therefore, a case study was developed in order to assess the effects of replacing all the flooded rice fields (status quo) with aerobic rice (scenario) on both the groundwater level and the irrigation requirements at the scale of an irrigation district.
The investigated area is the San Giorgio di Lomellina-East district (Lombardia, Italy). Data available comprise: soil type (sandy soil according to the USDA classification), land cover of the status quo (200 ha of flooded rice, 105 ha of maize and 76 ha of non-irrigated crops), groundwater level measurements by a piezometer within the area, flow rates in the irrigation channels and meteorological data. First, the monthly percolations in the status quo were estimated by considering: i) percolations from flooded rice fields computed as the residual term of the district water balance, ii) percolations from fields with maize and non-irrigated crops obtained by parameterizing and running the model SWAP (boundary conditions given by the average groundwater level of the status quo), iii) percolation from the irrigation channels considering the efficiency of the irrigation network.
Then, an autoregressive model with exogenous input was calibrated in order to relate the district percolations and the groundwater levels in the status quo (P-GWL model). Finally, a set of SWAP simulation with increasing groundwater levels was run for each land use (i.e. aerobic rice, maize and non-irrigated crops) so as to find, within the set, the combination percolation-groundwater level which best responds to the P-GWL model.
The results obtained suggest that a conversion from flooded to aerobic rice in the investigated area might cause a significant decrease of percolation during the crop season with a summer groundwater level decreasing by around 0.75 m (from about -1.00 m in the status quo to about -1.75 m in the conversion scenario). The irrigation flow rates needed to satisfy the water requirements of aerobic rice would decrease by more than 60%, as huge irrigation amounts were required in the status quo in order to maintain continuous submergence in coarse textured soils. Some overestimation of the reduction is expected since the increase of percolation rates from the irrigation network that could occur with a lower groundwater table was neglected.
Despite the simplified approach adopted, the case study highlights the importance and the feasibility of estimating the potential effects of a widespread change in irrigation methods on both the field and the district water requirements.