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Modelling the effects of water and nitrogen fertiliser management on irrigated rice production

Alfassassi Arouna[1,3], Israel Kwame Dzomeku[2], Eliasu Salifu[3], Nurudeen Abdul Rahman[4]

[1] *School of Agronomy, University of Lome, Department of Agricultural Engineering and Mechanization, Togo*

[2] *University for Development Studies, Department of Crop Science,*

[3] *University for Development Studies, Department of Agricultural Engineering,*

[4] *International Institute of Tropical Agriculture, Tamale Station, Ghana*

Abstract

This study assessed the effect of climate change on grain yield, water and nitrogen use efficiencies in rice production using DSSAT-CERES-Rice model. The experiment was conducted on-farm during wet and dry seasons using a split-split-plot design with three replications. The main plots were four irrigation regimes including continuous flooding (CFI), alternate wetting and drying (AWD) method with a water depth fluctuating above and below the soil surface at 5 cm (AWD ± 5 cm), at 10 cm (AWD ± 10 cm), and at 15 cm (AWD ± 15 cm). The sub-plots were 4 nitrogen (N) fertiliser rates (kg N/ha: 0, 76, 114 and 133). The sub-sub-plots included 2 cultivars (IR841 and Jasmin85). Wet season data were used for model calibration while that of the dry season were used for model validation. Model performance was evaluated using Root Mean Square Error (RMSE) and d-statistics (d). The validated model was used to assess long term (2025–2050) effects of the above treatments on grain yield, water and nutrient use efficiency. The model accurately simulated straw, grain yield, total biomass (RMSE = 492.65–2550.00 kg ha^{-1}, d = 0.60–0.91) but performed fairly good for leaf area index (RMSE = 1.82–2.27, d = 0.35–078), water use efficiency (WUE) and crop water productivity (CWP) (RMSE = 1.41–5.53 kg ha^{-1} mm^{-1}, d-stat = 0.35–0.88), partial factor N productivity (PFNP) and agronomic N efficiency (ANE) (RMSE = 3.76–17.87 kg kg^{-1}, d-stat = 0.35–0.89) for both cultivars. The long-term simulation results revealed that the AWD methods, especially ±5 cm with increasing N fertiliser rate recorded higher ($p < 0.01$) CWP relative to that of CFI in both seasons. However, there was no significant effect of the irrigation regime on grain yield, WUE, PFNP, ANE during the wet season. In the dry season, the CFI with increasing N fertiliser rate recorded higher ($p < 0.05$) grain yield, WUE, PFNP and ANE compared to the AWD methods. The results suggest that smallholder rice farmers in Togo and similar agro-ecology could use the AWD ± 5 cm with 114 kg N/ha in the wet season and CFI with 114 kg N/ha in the dry season for improved grain yield, water and nutrient use efficiency.

Keywords: Nitrogen use efficiency, oryza sativa, Togo, Water productivity, Yield

Contact Address: Alfassassi Arouna, School of Agronomy, University of Lome, Department of Agricultural Engineering and Mechanization, 01p. O. Box 1515 lome -Togo, Lome, Togo, e-mail: arounafazaz@yahoo.fr