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

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Introduction

Rice ranks among the highest-imported staples in West African countries to make up for the shortfall in local rice production (Adjah *et al.*, 2022; Tondel *et al.*, 2020).

Despite conditions suitable for rice cultivation, yields are low due to poor water management and ineffective farming practices (Ibrahim *et al.*, 2021).

Improving paddy yields using optimal N-fertilizer doses and low water inputs enhances the efficiencies of water and N-fertilizer use.

Materials and Methods

The experiment was conducted during the rainy and dry seasons from 2023 - 2024 in the rice irrigation fields of Djagble, Togo.

A split-split-plot design was used, with irrigation regime as the main factor, nitrogen fertilization as the secondary factor, and rice cultivar as the third factor.

The irrigation regimen included the traditional method and three Alternate Wetting and Drying (AWD) practices involving fluctuations in the water depth above and below the soil surface.

N-fertilization was applied at four rates (0; 76; 114; 133 kg N/ha), including the recommended rate in Togo (76 kg N/ha) increased by 50% and 75%.

IR841, a locally cultivar, was compared with Jasmine85, a recently introduced cultivar from Ghana.

The CERES-Rice model (Jones & Kiniry, 1986), integrated into DSSAT 4.8.2 (Hoogenboom et al., 2023), was used to simulate paddy yield, water use efficiency, and nitrogen fertilizer efficiency based on soil data, daily weather data, and crop growth and yield parameters.

Data from the rainy season experiment were used to calibrate the model, and data from the dry season were used to evaluate the model through the root mean square error (RMSE) (Yang et al., 2014) and the d-statistic (d) (Willmott et al., 1985).

Model validation was performed over a 25-year period (2025–2050).

Results

Long-term paddy yields following water and nitrogen fertilizer management: CFI & 133 kg N/ha combination performed best (Fig.1).

Long-term water use efficiency (WUE) following water and nitrogen fertilizer management: During the rainy season, the combination of AWD & 133 kg N/ha gave the best WUE while, during the dry season, the most effective combinations were CFI & 133 kg N/ha (Fig.2).

Long-term crop water productivity (CWP) following water and nitrogen fertilizer management: The combination of AWD±5 with any nitrogen fertilizer rate produced the best CWP values during both growing seasons and for both cultivars (Fig.3).

Long-term partial factor productivity of Nitrogen (PFPN) **following water and nitrogen fertilizer management:** During the rainy season, no significant difference, whereas during the dry season, the combination of CFI & 76 kg N/ha yielded the highest PFPN (Fig.4).

Long-term Agronomic efficiency of Nitrogen (AEN) following water and nitrogen fertilizer management: no significant difference (Fig.5).

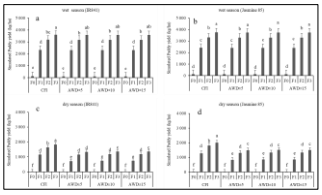

Fig.1: Simulated paddy yield

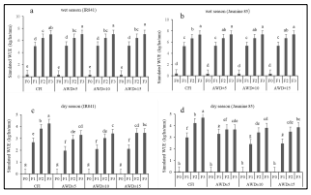

Fig.2: Simulated WUE

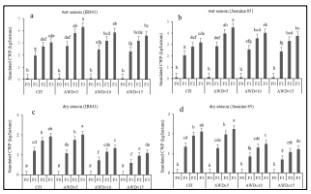

Fig.3: Simulated CWP

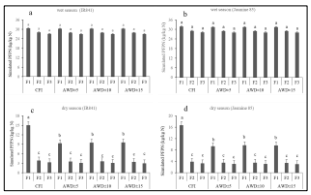

Fig.4: Simulated PFPN

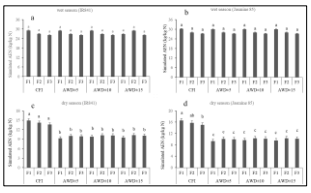

Fig.5: Simulated AEN

Conclusion

The prediction using biomass and physiology parameters showed the good accuracy of the model.

The effect of irrigation regimes was more noticeable in the dry season while the action N-fertilization was more essential.

High doses increased yields, WUE, and CWP, while low doses improved PFPN and AEN.

AWD±5 combined with 114 kg N/ha and Jasmin85 should be recommended.

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