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Short Comminucation

Simulating the yield attributes of *Boro* rice under nitrogen and irrigation management at Mohanpur, West Bengal using ORYZA2000

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India is the second largest producer of rice in the world after China. India produces about 152.6 million tons of rice from 42.5 million ha with an average productivity of 3.57 t ha^{-1} (FAOSTAT, 2014). Rice cultivation through out the world paying deep attention on: i) optimizing grain yield ii) reducing production costs, and iii) minimizing pollution risks to the environment (Koutroubas *et al.,* 2003). The crop growth models can be used to predict crop performance over an agro-climatological regions where the crop has not been grown before nor it have been cultivated under optimal conditions. Crop models can also be used to quantify effects of climate variability on yield and to explore options for coping with this variability (Akponikpea *et al.,* 2011). ORYZA 2000 has been calibrated and validated for almost 18 popular rice varieties in 15 locations throughout Asia. The ability of ORYZA2000 has not been studied to judge the performance of rice yield particularly under different nitrogen doses and irrigation regime under Mohanpur region although Das *et al.* (2007) had used the model for climate change impact study. Thus the present work is carried out to judge it's ability in simulating the yield attributes of *Boro* rice under nitrogen and irrigation management over the Mohanpur region of West Bengal.

A field experiment was conducted during 2013-14 with Boro rice variety 1R-72 at D block farm of Bidhan Chandra Krishi Viswavidalaya, Kalyani, West Bengal having geographical positions of 22°9' N latitude and 88°43' E longitude. The field trial was designed with randomized block design with three replications four different doses of nitrogen application namely, N_1 (150.0 kg N ha^{-1}), N_2 (112.5 kg N ha^{-1}), N_3 (75.0 kg N ha^{-1}) and N_4 (120.0 kg N ha^{-1}) and three irrigation regimes I_1 (continuous ponding of 5 cm of water throughout), I_2 (irrigation applied 1 day after complete disappearance of water) and I_3 (irrigation applied 2 days after complete disappearance of water) with three replications.

As per the requirement of heat energy of rice at different growing stages estimated through growing degree days (GDD) on the basis of daily variation of temperature, Bouman *et al.,* (2001) classified the following four major phenological stages of rice which has been incorporated in the ORYZA 2000 are: i) basic vegetative phase or juvenile phase from emergence (development stage [DVS] = 0) to start of photoperiod-sensitive phase (DVS = 0.4), ii) photoperiod-sensitive phase from DVS = 0.4 until panicle initiation (DVS = 0.65), iii) panicle development phase from DVS = 0.65 until 50 per cent of flowering (DVS=1.0), and iv) grain-filling phase from DVS= 1.0 until physiological maturity (DVS= 2.0). For the calibration of ORYZA 2000 plant parameters, two different programs (DRATES and PARAM) were applied incorporating the field data. For the present experiment, we ran those routines using initial values of development coefficients for different parameters and updating those with simulated values. The graphical analysis and statistical measures has been carried out following Jing *et al.* (2007). Simulated and measured total biomass, biomass of individual organs, crop N uptake, and N uptake of individual organs has been compared graphically. All the required input parameters are provided in the basic input data files viz. weather, crop and experimental data from the data generated from the field experiment. In bried, the developmental rate constants were obtained after running the DRATES programme as depicted in Table 1. All these values were then incorporated into the crop data file and finally the programme was run again to obtain the simulated results.

It was observed that under the nitrogen dose of 150 kg ha^{-1} (N_1) along with continuous ponding of 5 cm water level throughout the season produced the highest grain yield of 6.8 t ha^{-1} at 14 per cent moisture level, while least yield was recorded under the combination of N_3I_3 (Table 2). The plants were exposed to high temperature especially during the later growth stages (Fig 1) i.e, flowering stages (95 days after sowing), which resulted in poor yield (4.4 t ha^{-1}). Similar results were obtained for total dry weight of

Table 1: Developmental rate coefficients at various developmental stages

Developmental Coefficient	Descriptions	Developmental Rate
DVRJ	Development rate constant at basic vegetative phase (BVP)	0.000773
DVRI	Development rate constant at photoperiod-sensitive phase (PSP)	0.000758
DVRP	development rate constant at panicle formation phase (PFP)	0.000784
DVRR	Development rate constant at grain-filling phase (GFP)	0.001784
TSTR	Temperature sum for phenological development at transplanting (°Cd)	202.6
TSF	Temperature sum for phenological development at flowering (°Cd)	374.9
TSM	Temperature sum for phenological development at maturity (°Cd)	1935.6

Table 2: Observed and Simulated values of yield parameters for *Boro* Rice during 2013-14

Treatments	WRR14 (kgha^{-1})		WSO(kgha^{-1})		WAGT(kgha^{-1})		ANCR(kgha^{-1})	
	Observed	simulated	Observed	simulated	Observed	simulated	Observed	simulated
N_1I_1	6830.6	8640.0	6326.1	8144.0	21500	24377	470.6	484.4
N_1I_2	6345.2	8408.8	5782.6	7872.6	20758	23658	441.8	459.8
N_1I_3	5703.6	6763.6	4390.0	6390.0	20097	22997	426.4	444.9
N_2I_1	6563.5	8863.5	6047.3	8287.3	21221	24058	465.3	470.3
N_2I_2	6163	8183.0	5573.5	7663.5	20428	23428	429.4	455.2
N_2I_3	4465.6	6525.6	4091.2	6191.2	19210	22310	419.6	425.8
N_3I_1	6423.1	8723.1	5917.1	8157.1	20680	23680	457.8	460.8
N_3I_2	5809.2	7969.2	5400.6	7490.6	20096	23096	431.5	447.7
N_3I_3	4598.2	6658.2	4178.3	6278.3	19428	22311	422.8	434.4
N_4I_1	6562.3	8962.1	6104	8366.7	21684	24984	469.0	485.9
N_4I_2	6013.0	8000.8	5573.5	7514.5	20220	23120	434.7	463.8
N_4I_3	4698.4	6758.0	4287.5	6387.5	19550	22650	424.2	444.0

Where WRR14 – grain weight at 14% moisture, WSO – weight of storage organ, WAGT – weight of above ground dry matter, ANCR – accumulated nitrogen concentration

storage organs (WSO), total above ground dry matter (WAGT) and accumulated nitrogen concentration (ANCR). However, no significant differences in yield parameters were observed under the condition of 112.5 kg ha^{-1} (N_2) along with continuous ponding water and under the condition of 120.0 kg ha^{-1} (N_4) with continuous ponding (I_1) throughout the season. In both cases the amount of yield was ~6.5 t ha^{-1}.

To judge the performance of the ORYZA2000, the model-simulated results were compared with the experimental results obtained through field experiment. It was notice that the highest rice yield of 8.9 t ha^{-1} was simulated under the combination of N_4I_1 while the combination N_2I_3, where irrigation was applied after 2 days of complete disappearance of water, reproduced the lowest yield of 6.5 t ha^{-1}. As pre-monsoonal rainfall is quiet uncertain during the *Boro* season hence irrigation is an essential criterion for assured paddy production. The linear relationship between observed and simulated yield components of total above ground dry matter, total dry weight of storage organs and nitrogen content are shown in the Fig. 1(a-d) which indicated a strong dependency reflected through their high positive correlations of R^2=86.8 for grain yield, R^2=97.7 for total dry weight of storage organs and R^2=97.3 for total above ground dry matter and R^2=83.0 for nitrogen accumulation. The RMSE calculated for the above parameters i.e grain yield, total dry weight of storage organs, total above ground dry matter and nitrogen accumulation were 2049.8, 2092.8, 2985.7 and 17.1; which shows that the model can be satisfactorily be utilized for predictions of rice yield provided the model should be fine tuned in order to remove the initial

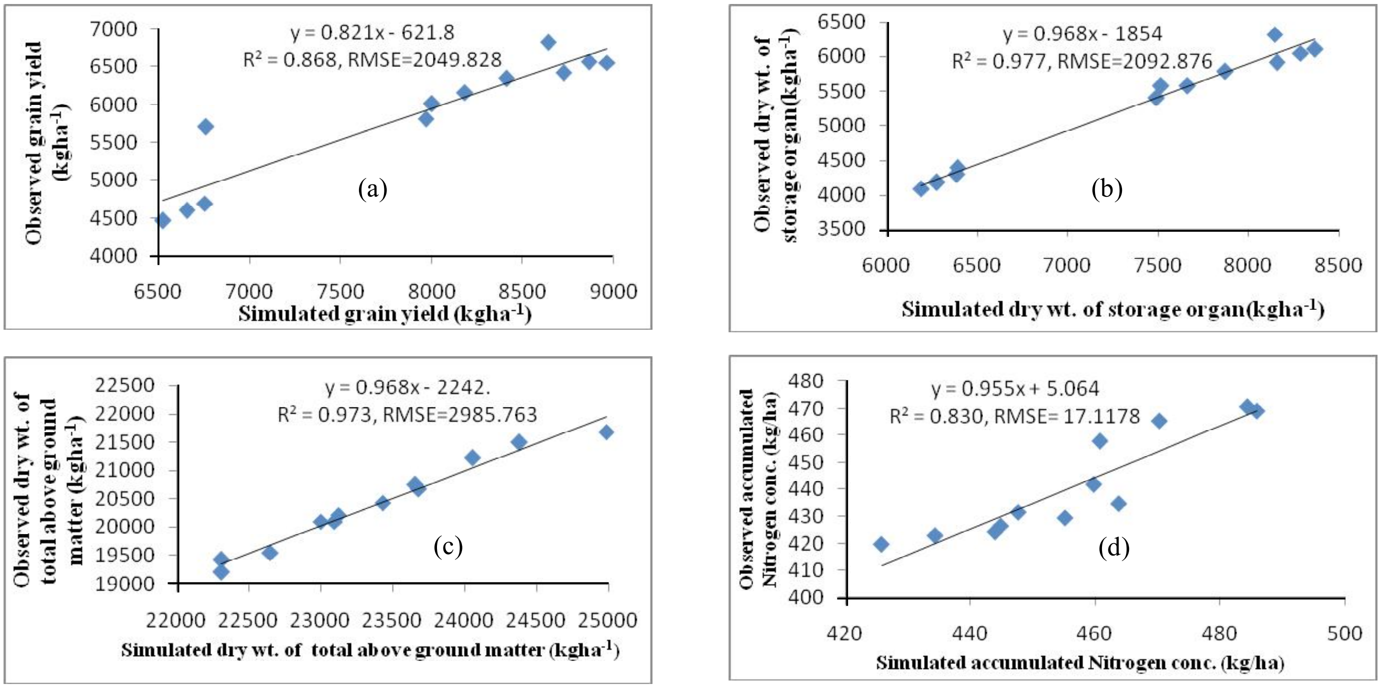

Fig 1 (a-d): Relationship between simulated and observed (a) grain yield, (b) dry wt. storage organs, (c) total above ground matter and (d) accumulated nitrogen concentration.

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