Advances in Bioresearch
Adv. Biores., Vol 7 (5) September 2016: 209-213
©2016 Society of Education, India
Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
ICV Value 8.21 [2014]

Advances in Bioresearch

ORIGINAL ARTICLE

Validation of the ORYZA2000 model to simulating rice yields under interval irrigation

[1]Raheleh Jenabi Haghparast, [2]Ebrahim Pazira, [3]Ebrahim Amiri, [4]Hossain Babazadeh
[1]Ph.D. student of soil science, Department of soil science, faculty of Agriculture and natural Resources, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[2]Department of soil science, faculty of Agriculture and natural Resources, Science and Research Branch, Islamic Azad University, Tehran, Iran.
[3]Department of Agriculture, Lahijan Branch, Islamic Azad University, Lahijan, Iran
[4]Department of Water Sciences and Engineering, faculty of Agriculture and natural Resources, Science and Research Branch, Islamic Azad University, Tehran, Iran.

ABSTRACT
The ORYZA2000 model was tested in Iran for simulating the response of two rice genotypes to water management. Study was carried out in a Randomized Complete Block Design between 2012 and 2013, with 3 replications at Rice Research Institute of Iran, Rasht. Irrigation management (4 regimes) was the main plot and rice genotypes were the sup-plot. Evaluation simulated and measured final biomass and yield, by adjusted coefficient of correlation; T test of means; and by absolute and normalized root mean square errors (RMSE). Results show, with normalized root mean square errors (RMSEn) of 6–10%, ORYZA2000 satisfactorily simulated final biomass and yield. Grain yields and biomass of genotypes rice were adequately simulated by the model (differences between simulated values and observations were less than 10%).
Keywords; *biomass, Genotypes, Irrigation, ORYZA2000, Rice*

Received 28/04/2016 Accepted 04/07/2016

How to cite this article:
Jenabi Haghparast, R. Pazira, E. Amiri E. and Babazadeh. H. Validation of the ORYZA2000 model to simulating rice yields under interval irrigation. Adv. Biores. Vol 7 [5] September 2016: 209-213. DOI: 10.15515/abr.0976-4585.7.5.209213

INTRODUCTION

Rice (*Oryza sativa L.*) is produced in at least 95 countries across the globe and provides a staple food for more than half of the world's current population. In addition, Rice is the second largest produced cereal in the world [2]. Crop growth simulation models are recognized as valuable tools in agricultural studies. They can help compare experimental research findings across sites, extrapolate experimental field data to wider environments, develop management recommendation and decision support systems, explore effects of climatic changes, and make yield predictions [9].

In the 1990s the Wageningen group focused more on applications in research, agronomic practice. In a major project (Simulation and Systems Analysis for Rice Production, SARP) of Wageningen and the International Rice Research Institute (IRRI) in Asia, The MACROS [17] model was developed to facilitate the transfer of simulation and systems analysis methodologies to researchers in Southeast Asia. The ORYZA model series [15] evolved from MACROS and SUCROS in that project to serve specific applications. The first model was ORYZA1 for potential production [15], followed by ORYZA_W for water-limited production and by ORYZA-N and ORYZA1N [1] for nitrogen-limited production. For all production situations, optimal control of diseases, pests, and weeds is assumed. In 2001, a new version in the ORYZA model series was released that improved and integrated all previous versions into one model called ORYZA2000 [11]. The ORYZA2000 was evaluated under potential, water-limited, and/or nitrogen (N)-limited conditions in the Philippines [9], India [6], Indonesia [7], Iran [4] and China [7; 14; 10; 13; 24].

The present study was carried out with the main objective of validation and performance evaluation of the ORYZA2000 model under interval irrigation.

MATERIALS AND METHODS

Field experiments

Field experiments were conducted in 2012 and 2013 at Rice Research Institute of Iran, Guilan province, located in the north of Iran (37°12' N, 49°38' E), at the rice cultivation season. The experimental design was split plot with complete randomised block and three replicates. The main plots were four irrigation regimes:

I_1: continuous irrigation (standing water was maintained 30-50 mm throughout crop growth),
I_2: irrigation 5 day interval
I_3: irrigation 8 day interval and
I_4: irrigation 11 day interval.

The subplots (12 m^2) consisted of 2 rice genotype (Hashemi and Gohar).

Seedlings were grown in wet beds for approximately 30 days and transplanting was done at 3 plants per hill with a spacing of 25×25 cm. A mixed commercial fertilizer was applied at the rate of 25 kg P ha^{-1} and 75 kg K ha^{-1}: all of phosphorous, potassium, half of nitrogen fertilizer were applied at basal and other 50% nitrogen fertilizer has applied as a top dressing at maximum tillering. For each treatment, the dates of emergence, panicle initiation, flowering, and physiological maturity were recorded.

Grain yield and final biomass was measured from a central 5 m^2. The amount of irrigation water applied was monitored at each plot from transplanting till maturity, by using flow meters installed in the irrigation pipes.

The Model ORYZA2000

In ORYZA2000, under optimal crop management, light and temperature are the main factors determining crop growth. The light profile within the canopy is calculated from total leaf area and its vertical distribution. When the canopy is not yet closed, leaf area development is calculated from mean daily temperature, and after closure from the increase in leaf weight, using a development stage-dependent specific leaf area. On the basis of single leaf photosynthetic characteristics, defined as a function of incident radiation, air temperature, and leaf N concentration, instantaneous canopy photosynthesis rates are calculated for pre-defined combinations of time-of-day and depth-in-the-canopy. Integration over total leaf area and over the day yields daily total assimilation rate. Daily dry matter accumulation is calculated by subtraction of maintenance and growth respiration requirements from the total assimilation rate. The dry matter increment is partitioned among the various plant organs as a function of phonological development stage, which is tracked as a function of mean daily air temperature. Spikelet density at flowering is derived from total dry matter accumulation over the period from panicle initiation to flowering [11]. Drought stress affects leaf expansion, leaf rolling, leaf senescence, photosynthesis, assimilate partitioning, root growth, and spikelet sterility. For these processes, stress factors are calculated as a function of the soil water tension in the root zone. The water dynamics in the ORYZA2000 model is accounted by using a soil water balance module (PADDY) [11]. In PADDY, a lowland rice soil is modeled as a layer of muddy topsoil overlying a 3–5cm plough sole and no puddled subsoil. With ponded water on the surface, vertical water flow is either a fixed percolation rate. The water retention and conductivity characteristics are expressed by Van Genuchten parameters [19].

ORYZA2000 input data and parameterization

Model calibration or parameterization is the adjustment of parameters so that simulated values compare well with observed values. About 10% of the crop parameters are expected to be variety-specific and need empirical derivation. These parameters are development rates; assimilate partitioning factors, specific leaf area, relative leaf growth rate, leaf death rate, fraction of stem reserves, and maximum grain weight. ORYZA2000 was parameterized for the rice cultivar, starting with the standard crop parameters for cultivar IR72 and following the procedures set out by [11]. First, development rates were calculated using observed dates of emergence, Transplanting, panicle initiation, flowering, and physiological maturity. Next, specific leaf area was calculated from the measured values of leaf area and leaf dry weight. The partitioning of assimilates was derived from measured data on the biomass of leaf, stem, and panicles.

Weather data on sun hour, maximum and minimum air temperature, vapor pressure, wind speed, and rainfall for the crop season was obtained from Rasht meteorological station. Soil water content and Van Genuchten parameters of different soil layers were described whit Amiri and Rezaei [4]. Crop parameters were obtained from a combination of measurements and model fitting (matching simulated and measured variables by adapting model parameters).

Model evaluation

Several statistical methods were used to compare the simulated and observed results. In this paper used a combination of graphical analyses and statistical measures, graphically compared the simulated and measured \ final biomass and yield. In this paper evaluated model performances using the absolute root mean square error (RMSE) and root mean square error normalized (RMSEn). RMSE and RMSEn characteristics are common tools to test the goodness of fit of simulation models [9].

$$\text{RMSE} = \left(\sum_{I=1}^{n} (P_i - O_i)^2 / n\right)^{0.5} \qquad (1)$$

$$\text{RMSEn} = 100 \left(\sum_{I=1}^{n} (P_i - O_i)^2 / n\right)^{0.5} / O_{mean} \qquad (2)$$

Where Pi is the simulated value, O_i is the measured value, and n is the number of measurements. Paired t-tests and linear regression analysis were also used to assess the goodness-of-fit between the observed and simulated results. If the P-value (P (t)) from the paired t-test was greater than 0.05, it was concluded that no significant differences existed between the measured and simulated values.

RESULTS AND DISCUSSION

Model calibration

The model was calibrated using data for 2012 growing season, while the data for 2013 growing season was used for model validation. The ORYZA2000 model was evaluated in respect of simulation of grain yield and final biomass in variable irrigation regimes. Table 1 shows the goodness-of-fit parameters for grain yield and final biomass at harvest of the calibration data set. The root mean square error (RMSE) was between 383-458 kg ha^{-1} and normalized RMSE was 8-10% for measured yields varying between 3691 and 5917 kg ha^{-1}. Final biomass was predicted with a RMSE of 692-768 kg ha^{-1} and normalized RMSE between 6 and 7% for measured final biomass ranging between 9748 and 14505 kg ha^{-1}. Paired t-test showed no significant differences between the measured and simulated yield and final biomass values.

Amiri et al. [5], Jing et al. [14], and Bouman and Lar [9] have obtained normalized root mean square error of grain yield as 7, 13, and 11% for calibration conditions, respectively. Amiri Larijani et al. [3] calculated coefficient of determination (R^2) as 0.83% for estimating grain yield in calibration conditions. Amiri and Rezaei [4] found coefficient of determination (R2) of 0.88% for estimating grain yield in calibration conditions. Bouman and Lar [9], Bolder et al. [7], Jing et al. [14], and Xue et al. [24] have obtained normalized mean square errors of biological yield as 7, 19, 9, and 11% in calibration. Amiri Larijani et al. [3] reported coefficient of determination (R^2) as 0.91% for estimating biological yield in calibration conditions. Amiri and Rezaei [4] calculated this coefficient (R^2) as 0.76% for estimating biological yield.

Model validation

The root mean square error (RMSE) was 389 kg ha-1 and normalized RMSE was 9% for measured yields varying between 2956 and 5206 kg ha^{-1}. Final biomass was slightly under predicted with a RMSE of 784 kg ha^{-1} and normalized RMSE 9 for measured final biomass ranging between 6840 and 10916 kg ha^{-1} (Table 2). Paired t-test showed no significant differences between the measured and simulated yield and final biomass values (at P=0.05 confidence level). The linear regression between simulated and measured values had an R^2 larger than 0.72 for all variables, indicating a close correlation between the simulations and the measurements. Figure 1 compares simulated with measured yield and final biomass for all data of the calibration and validation set. For reference, the 1:1 line plus and minus the SE of the measured variables is also shown. Nearly 95% biomass and 88% yield data points fell within the plus and minus SE lines of measured biomass. In validation conditions, results of Amiri et al. [5], Xue et al. [24], Fang et al. [13], Boling et al. [8], Bolder et al. [7], and Bouman and Lar [9] have demonstrated that normalized root mean square error of grain yield was 6, 11, 19, 16, 13, and 11% , respectively. Bouman and Lar [9], Bolder et al. [7], Jing et al. [14], and Xue et al. [24] have obtained normalized mean square errors of biological yield as 9, 13, 11, and 11% in validation conditions. Amiri Larijani et al. [3] reported coefficient of determination (R^2) as 0.78% for estimating biological yield in validation conditions. Amiri and Rezaei [4] calculated it (R^2) as 0.93% for estimating biological yield. Figure 1, compares simulated with measured crop growth variables for all data of the calibration and validation set. For reference, the 1:1 line plus and minus the Standard Error of the measured variables was also shown. Nearly 80% final biomass and 90% yield data points fell within the plus and minus SE lines of measured biomass.

The results from this study showed that the ORYZA2000 generally predicted grain yield and final biomass fairly satisfactorily across a range of data sets covering varying levels of irrigation management at two years in Iran. Based on our results, the calibrated ORYZA2000 model was found to be quite efficient in the simulation of yield and biomass can be successfully applied to consideration the effects of irrigation management in similar regions.

Table 1. Evaluation results of ORYZA2000 simulations of crop parameters, for the calibration conditions (2012)								
genotype	crop variable	N	X_{obs}	X_{sim}	R^2	P(t)	RMSE	$RMSE_n$ (%)
Hashemi	Yield (Kg ha^{-1})	4	3691	3611	0.96	0.26	383	10
	Final biomass (Kg ha^{-1})	4	9748	10732	0.97	0.12	575	6
Gohar	Yield (Kg ha^{-1})	4	5917	6192	0.92	0.39	458	8
	Final biomass (Kg ha^{-1})	4	14505	14459	0.99	0.49	975	7
N, number of measured/simulated data pairs; Xobs, mean of measured values in whole population; Xsim, mean of simulated values in whole population; R^2, adjusted linear correlation coefficient between simulated and measured values; RMSE, absolute root mean square error; $RMSE_n$ (%), normalized root mean square error.								

Table 2. Evaluation results of ORYZA2000 simulations of crop parameters, for the validation conditions (2013)								
genotype	crop variable	N	X_{obs}	X_{sim}	R^2	P(t)	RMSE	$RMSE_n$ (%)
Hashemi	Yield (Kg ha^{-1})	4	3806	3979	0.93	0.31	334	9
	Final biomass (Kg ha^{-1})	4	9470	8903	0.78	0.20	692	7
Gohar	Yield (Kg ha^{-1})	4	7216	7118	0.72	0.39	517	7
	Final biomass (Kg ha^{-1})	4	14171	12880	0.98	0.14	768	9
N, number of measured/simulated data pairs; Xobs, mean of measured values in whole population; Xsim, mean of simulated values in whole population; R^2, adjusted linear correlation coefficient between simulated and measured values; RMSE, absolute root mean square error; $RMSE_n$ (%), normalized root mean square error.								

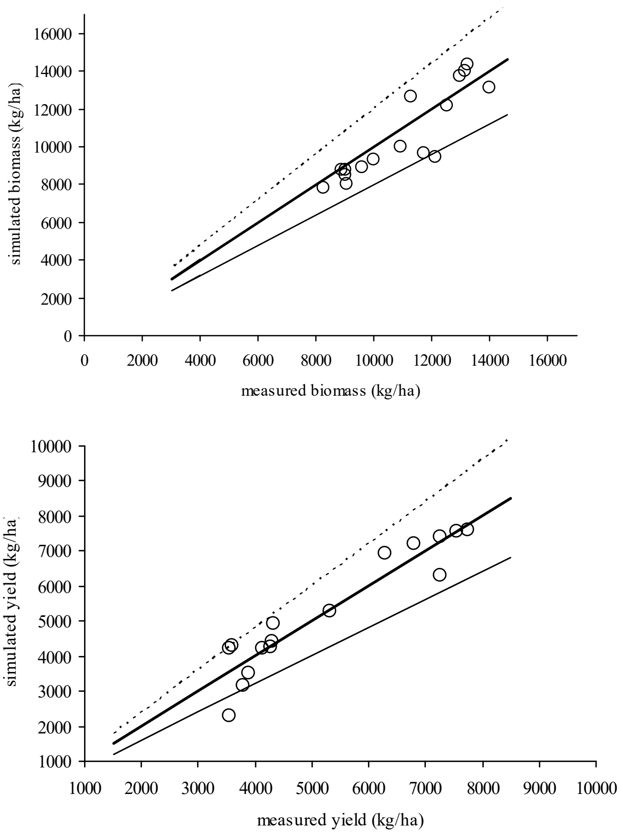

Figure 1- Simulated versus measured final biomass and yield. Solid lines are the 1:1 relationship; dotted lines are plus and minus standard error around the 1:1 line as derived from a data set

CONCLUSION

With the above description it is clear that a dengue fever can causes a variety of neurological manifestations in endemic countries. Our case report highlights the potential danger of dengue fever, so treating physician must be aware of the development of atypical neurological manifestations. Early diagnosis and management with prompt supportive care can reduce the morbidity and mortality of the patients by preventing neurological disabilities.

REFERENCES

1. Aggarwal, P.K., Kropff M.J., Cassman K.G., ten Berge H.F.M., (1997). Simulating genotypic strategies for increasing rice yield potential in irrigated tropical environments. Field Crops Res. 51:5-17.

2. Ainsworth, E.A., (2008). Rice production in a changing climate: a meta-analysis of responses to elevated carbon dioxide and elevated ozone concentration. Glob Change Biol. 14, 1642-1650.
3. Amiri Larijani, B., Sarvestani, Z.T., Nematzadeh Gh., Manschadt, A.M., & Amiri, E. (2011). Simulating phenology, growth and yield of transplanted rice at different seedling ages in Northern Iran using ORYZA2000. Rice Science, Volume 18 (Issue 4), 321-334.
4. Amiri, E., & Rezaei, M. (2010). Evaluation of water–nitrogen schemes for rice in Iran, using ORYZA2000 model. Communications in Soil Science and Plant Analysis, 41, 2459–2477.
5. Amiri, E., Razavipour, T., Farid, A., & Bannayan, M. (2011). Effects of crop density and irrigation management on water productivity of rice production in Northern Iran: Field and Modeling Approach. Communications in Soil Science and Plant Analysis, 42 (17), 2085-2099.
6. Arora, V.K. (2006). Application of a rice growth and water balance model in an irrigated semi-arid subtropical environment. Agric Water Manage. (83): 51–57.
7. Belder, P., B.A.M. Bouman, and J.H.J. Spiertz (2007). Exploring option for water savings in lowland rice using a modeling approach. Agric Syst. (92): 91–114.
8. Boling, A.A., B.A.M. Bouman, T.P. Tuong, M.V.R. Murty, and S.Y. Jatmiko. (2007). Modelling the effect of groundwater depth on yield increasing interventions in rainfed lowland rice in Central Java. Indonesia. Agric Syst. (92): 115–139.
9. Bouman, B.A.M, and H.H. Van Lar. (2006). Description and evaluation of the rice growth model ORYZA2000 under nitrogen-limited conditions. Agric Syst. (87): 249–273.
10. Bouman, B.A.M., L. Feng T.P. Tuong, G. Lu H., Wang, and Y. Feng. (2007). Exploring options to grow rice under water-short conditions in northern China using a modelling approach. II: Quantifying yield, water balance components, and water productivity. Agric Water Manage. 88, 23-33.
11. Bouman, B.A.M., M.J. Kropff, T.P. Tuong, M.C.S. Wopereis, H.F.M. Ten Berge, and H.H. Van Laar. (2001). ORYZA2000: modeling lowland rice. International Rice Research Institute, Los Banos.
12. De Wit, C.T., (1965). Photosynthesis of Leaf Canopies (Agricultural Research Report 663). Pudoc, Wageningen, the Netherlands.
13. Feng, L.P., B.A.M. Bouman, T.P. Tuong, R.J. Cabangon, Y.L. Li, G.A. Lu, and Y.H. Feng. (2007). Exploring options to grow rice under water short conditions in northern China using a modeling approach. I: Field experiments and model evaluation. Agric Water Manage. (88): 1–13.
14. Jing, Q., B.A.M. Bouman, Hengsdijk, H. Van Keulen and W. Cao (2007). Exploring options to combine high yields with high nitrogen use efficiencies in irrigated rice in China. European Journal of Agronomy. (26): 166–177.
15. Kropff, M.J., H.H. van Laar and R.B. Matthews. (1994). ORYZA1: an ecophysiological model for irrigated rice production. SARP Research Proceedings. Wageningen (Netherlands): IRRI/AB-DLO. 110 pp.
16. Noisakran S, Chokephaibulkit K, Songprakhon P, Onlamoon N, Hsiao HM, Villinger F, *et al*. (2009). A re-evaluation of the mechanisms leading to dengue hemorrhagic fever. Ann N Y Acad Sci 2009;1171:E24-35
17. Penning de Vries, F.W.T., Jansen, D.M., Ten Berge, H.F.M., Bakema, A., (1989). Simulation of ecophysiological processed of growth in several annual crops. Simulation Monographs, Pudoc, Wageningen, Netherlands, 271.
18. Rinaldy, M., N. Losavio and Z. Flagella. Evaluation of OILCROP-SUN model for sunflower in southern Italy (2003). Agricultural Systems. 78: 17-30.
19. Van Genuchten, M.Th., (1980). A closed form equation for predicting the hydraulic conductivity of unsaturated soils. Soil Sci. Soc. Am. J. 44, 892–898.
20. Van Ittersum, M.K., Leffelaar, P.A., Van Keulen, H., Kropff, M.J., Bastiaans, L., Goudriaan, J., (2003). On approaches and applications of the Wageningen crop models. European Journal of Agronomy .18, 201-234.
21. Van Keulen, H., Penning de Vries, F.W.T., Drees, E.M., (1982). A summary model for crop growth. In: Penning de Vries, F.W.T., Van Laar, H.H. (Eds.), Simulation of Plant Growth and Crop Production. Pudoc, Wageningen, The Netherlands, pp. 87–97.
22. Van Keulen, H., Wolf, J. (Eds.), (1986). Modelling of Agricultural Production: Weather, Soils and Crops. Simulation Monographs. Pudoc, Wageningen, The Netherlands, p. 479.
23. Van Laar, H.H., Goudriaan, J., Van Keulen, H. (editors), (1997). SUCROS97: simulation of crop growth for potential and water-limited production situations. Quantitative Approaches in Systems Analysis 14. C.T. de Wit Graduate School for Production Ecology and AB-DLO, Wageningen, The Netherlands, p. 52.
24. Xue, C, X. Yang, B.A.M. Bouman, W. Deng, Q. Zhang, W. Yan, T. Zhang, A. Rouzi and H. Wang., (2008). Optimizing yield, water requirements, and water productivity of aerobic rice for the North China Plain. Irrig Sci. 26 (6), 459-474.