pBulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 3 [6] May 2014: 184-193
©2014 Academy for Environment and Life Sciences, India
Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

ORIGINAL ARTICLE

Calibration and Evaluation of the rice growth ORYZA 2000 model under nitrogen fertilizer Management in paddy fields of Iran

Ebrahim Azarpour[1], Maral Moraditochaee*[2] and Hamid Reza Bozorgi[1]
[1]Young Researchers and Elite Club, Rasht Branch, Islamic Azad University, Rasht, Iran
*[2]Departmentof Agriculture, College of Agricultural Science, Takestan Branch, Islamic AzadUniversity,Takestan, Iran.
*Corresponding Author: Maral_Moraditochaee@yahoo.com

ABSTRACT

ORYZA2000 model, a crop model for rice, has been calibrated and validated across world with reliable ability to predict rice growth and yields. Therefore, it is also used to identify and evaluate the nitrogen fertilizer management options in various rice production systems. For the evaluated ORYZA2000 model in Iran, a study was carried out in a RCBD with three replications was conducted during 2009 year in the Rice Research Institute, Iran, and Rudsar, East of Guilan. Factors were cultivar (Khazar, Ali Kazemi and Hashemi), and nitrogen fertilizer levels (0, 30, 60, and 90 Kg N/ha). Evaluation assimilate and measured total biomass, grain yield, partitioning factors to leaves, stems, storage and above ground total (FLV, FST, FSO and FAGT respectively) and leaf area index (LAI) by R2, p(t), α, β, CRM, RMSE, RMSEn and line 1:1. Results indicated that, Researchers can use ORYZA2000 model to support in studies under the management nitrogen fertilizer conditions and investigate optimum nitrogen fertilizer.

Keywords: Rice, Model, Evaluation, Calibration, Nitrogen.

Received 19.03.2014 Revised 02.05 .2014 Accepted 10.05.2014

INTRODUCTION

Rice is most important food crop and a major food grain for more than a third of the world's population [26]. Judicious and proper use of fertilizers can markedly increase the yield and improve the quality of rice [1]. Fertilizer is very important input for intensive rice production the profitability of rice production systems depends on yield and input quantities. So the appropriate fertilizer input that is not only for getting high grain yield but also for attaining maximum pro fertility [13]. Rice plants require large amounts of mineral nutrients including N for their growth, development and grain production [15]. Given the importance of nitrogen fertilization on the yield in grain from the rice plant, it is necessary to know what the best dose is for each variety as well as its influence on components of yield and other agronomic parameters such as the cycle, plant height, lodging and moisture content of the grain, in order to obtain better knowledge of said productive response. Rice production in much of the world increasingly focuses on optimizing grain yield, reducing production costs, and minimizing pollution risks to the environment [14].

Many of the currently used crop growth models are highly complex and are generally characterized by a multitude of parameters [23]. Due to the variability in agro-climatic zones and the specific cultivars, the value of many of these parameters will not be exactly known. Further, many of them may not be directly measurable. Therefore, in most cases model calibration is necessary. Model calibration helps reduce the parameter uncertainty, which in turn reduces the uncertainty in the simulated results. During a model calibration, selected parameters are allowed to vary within predefined bounds, until a sufficient correspondence between the model outputs and actual measurements are obtained. The actual measurements for calibration of crop growth models come from the field level experiments. However, generally the experimental data may not be long enough, for accurate estimation of model parameters, because experimentation on crop systems is necessarily lengthy and expensive in terms of land, equipment, and manpower. In addition, when the number of parameters in a model is large (either due to large number of sub-processes being considered or due to the model structure itself) the calibration process becomes complex and computationally extensive [8]. ORYZA2000 model is an eco-physiological crop growth model that simulates the growth, development, and nitrogen balance of rice in situations of potential, nitrogen-limited and nitrogen-limited conditions on a daily basis. 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 predefined 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 phenological 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 (6). Actual crop N uptake is restricted by a maximum physiological uptake rate of the plant and available mineral N in the soil. Available soil N is calculated through a simple bookkeeping routine of both indigenous soil N and fertilizer N, without simulating the dynamics of N transformation processes in the soil. Indigenous supply is defined as a constant daily rate. Available fertilizer N is calculated as application rate multiplied by a potential (or maximum) recovery fraction, defined as a function of crop development stage, with relatively low values at transplanting and high values at panicle initiation. Actual seasonal-average fertilizer N recovery thus depends on the day-to-day balance between supply (timing of fertilizer application) and crop demand. Leaf N concentration affects leaf photosynthesis rate and leaf expansion rate, and the total amount of N in the crop affects the rate of leaf senescence after flowering [11]. The ORYZA2000 was evaluated under nitrogen limited conditions in the Philippines [7], Iran (3), chile (4) and China [12]. The objectives of this study were to (i) study the phenological development, crop duration, and yield of rice varieties in response to nitrogen management, (ii) calibrate and validate the ORYZA2000 model based on experimental data, and (iii) explore the value of the model for improving breeding programs and field management of rice in the Caspian Sea coastal area and extend it for optimizing rice crop phenology in rice growing areas in north of Iran.

MATERIALS AND METHODS

Field experiment

The experiment was conducted at Rice Research Institute, Rasht, Guilan, Iran, and Roudsar, East of Guilan; during the growing season 2009. The experiment was laid out factorial in randomized complete block design with three replications of four nitrogen fertilizers levels (N1: control (no N fertilizer), N2: 30 kg N/ha, N3: 60 kg N/ha and N4: 90 kg N/ha). Three different cultivars were examined (V1: Hashemi, V2: Alikazemi and V3: khazar). The N fertilization was applied as single incorporated application of urea (46% N). Tillage operations were done according to typical practices of the region and needed notes such as sowing time, transplanting, flowering, harvesting, the amount and the date of nitrogen fertilizer application, the number of seedling per hill and the number of hill per square meter were recorded at two locations. In order to establish of weather file of two locations, daily data related to the minimum and maximum of temperature, rainfall, sundial and relative humid of the Rasht and Roudsar weather station was used.

For the studying of growth analysis, sampling of each plot was done with 15 days intervals, after removing border rows as marginal effect with selection of 4 plants, randomly. Leaf area was measured with leaf meter (GA-5 model produced by Japan OSK Company). After that different parts of rice dried in an oven at 70ºC for 48 h to weight dry matter.

ORYZA2000 model

ORYZA2000 model uses a daily computed plot for simulating the production of plant parts dry matter and physiological growth rate and with the completion of this process over time dry matter production is simulated during the season.

Data required running the ORYZA2000 model:

1- Location: latitude, longitude and altitude

2- Meteorological data: sun hour, maximum and minimum air temperature, vapor pressure, wind speed, and rainfall for the crop season.

3- Soil data: native soil nitrogen.

4- Plant information: sowing time, transplanting, flowering, harvesting, the amount and the date of nitrogen fertilizer application, the number of seedling per hill and the number of hill per square meter, leaf area index sampling during the growth season, dry matter sampling of plant parts (leaf, stem and panicle) during the growth season and grain yield.

ORYZA2000 Calibration

In ORYZA2000 model, rice life cycle based on time-temperature is divided on four phonological stages:1- basic vegetative phase (DVRJ), 2- photoperiod-sensitive phase (DVRI), 3- panicle formation phases (DVRP) and 4- grain filling phase (DVRR). In ORYZA2000, the rice crop has four phonological phases, viz.,

juvenile phase from emergence (development stage [DVS]= 0) to start of photoperiod-sensitive phase (DVS= 0.4), photoperiod-sensitive phase from DVS= 0.4 until panicle initiation (DVS= 0.65), panicle development phase from DVS= 0.65 until 50 % of flowering (DVS= 1.0), and grain-fill phase from DVS= 1.0 until physiological maturity (DVS= 2.0) (6). For the calibration of ORYZA2000 plant parameters, two different programs (DRATES and PARAM) were applied. The result of DRATES was computing the rate of phonological development at four deferent basic vegetative phases (DVRJ), photoperiod-sensitive phase (DVRI), panicle formation phases (DVRP) and grain filling phase (DVRR). With running the PARAM program and other parameters such as maximum relative growth rate of leaf area (RGRLMX), fraction of stem reserves (FSTR), Relative death rate of the leaves as a function of development stage (DRLVT), specific leaf area (SLA), assimilate partitioning factors to leaves, stems, storage and above ground total (FLV, FST, FSO and FAGT respectively) were calculated (6).

ORYZA2000 evaluation

Since any particular criteria did not show the accuracy of models simulation, statistical and graphical values combination was used (6). In graphical form, comparing of measured and simulated value for each cultivar with determination of R2, and was done. For statistical evaluation of simulation results, t-test P (t) and below statistic parameter were used (6, 19).

(1) Root Mean of Square Error (RMSE)

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

(2) Normalized Root Mean Square Error ($NRMSE_n$)

$$NRMSE = 100\,(\sum_{I=1}^{n} (P_i - O_i)^2 / n)^{0.5} / \overline{O}$$

(3) Coefficient of residual mass (CRM)

$$CRM = (\sum_{i=1}^{n} O_i - \sum_{i=1}^{n} P_i) / \sum_{i=1}^{n} O_i$$

p_i = simulated values, O_i = measured values, n = samples no. and $\overline{O}$ = mean of measured values.

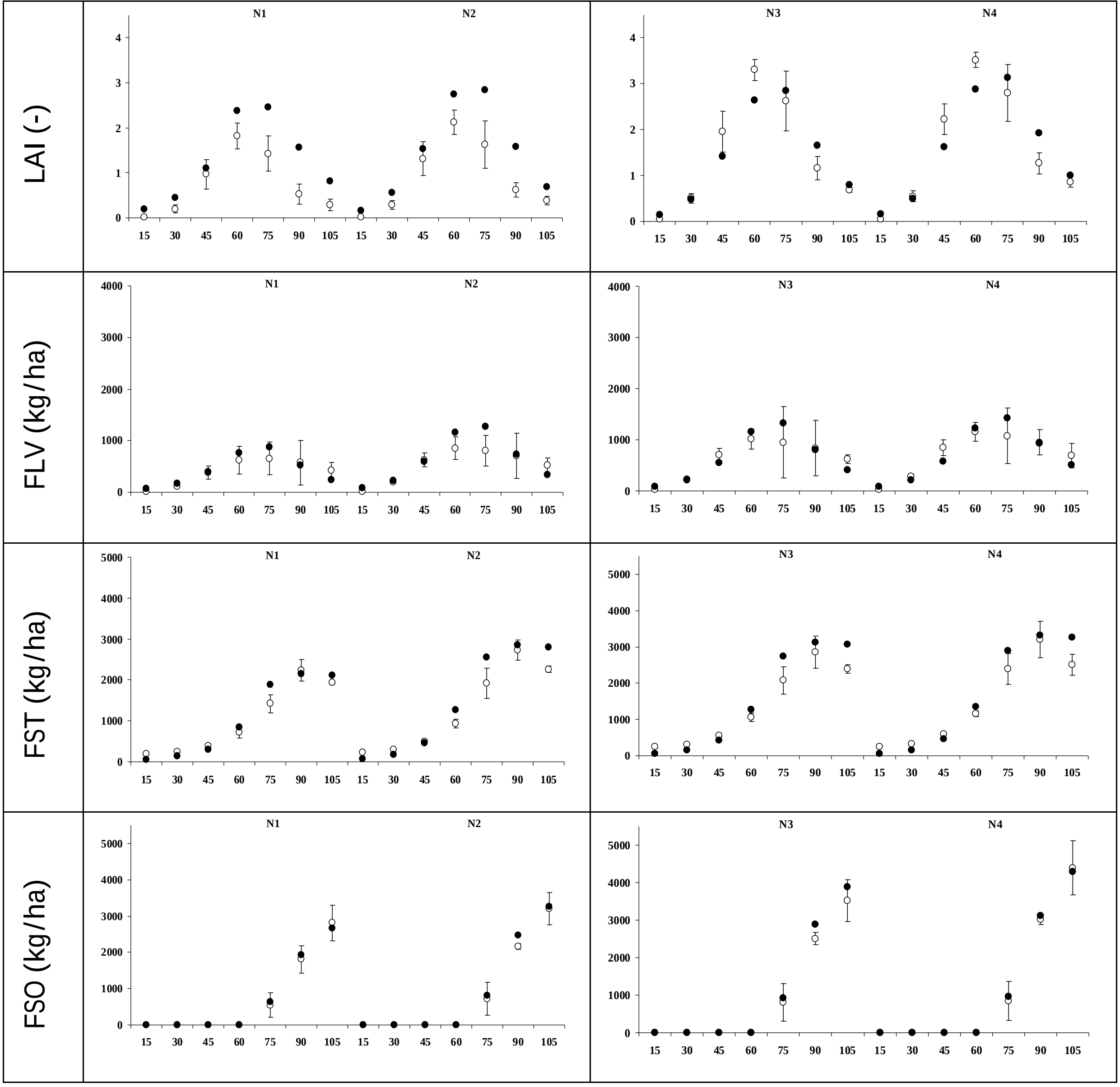
RMSE, NRMSE and CRM values at optimum condition or the state of equality between simulated and measured values are 0. The negative value of CRM shows that the mode had more estimated simulated values than measured ones and the positive value means that it had less estimated simulated values compared to measured values. If the t-test result is greater than 0.05, it reveals that the simulated and measure values of parameter has not significant difference at 95% level of possibility. RMSE indicates the amount of overestimation or less of model compared to observations (measurements) and it should be less than or equal to the value of standard error. If the NRMSE value is less than 10, 10-20, 20-30 and more than 30 it shows excellent, good, fair and weak form of simulation, respectively. In computed functions of the parameters, the best condition is that the values of R2and coefficients are equal to 1.

RESULTS AND DISCUSSION

Leaf Area Index (LAI)

The comparison of the simulated and measured LAI trends under different nitrogen fertilizer at Rasht and Roudsar is demonstrated in figures 1 and 2. LAI changes in nitrogen fertilizer contents have a similar trend. The trend of measured LAI values reveals that at early growth stages, LAI was increased over the time slightly and in later stages, it was further increased. The maximum LAI of rice was occurred at flowering stage and later due to the wilting and falling of lower leaves, it was decreased. Simulated and measured LAI value at lower levels of nitrogen (0 and 30 kg/ha nitrogen) is less than higher levels (60 and 90 kg/ha nitrogen). Nitrogen impacts gibberellin hormone indirectly through cytokinin and increases the growth of young leaves (9, 16). Simulated trend of LAI by the ORYZA2000 model at Rasht and Roudsar revealed that the model has an appropriate efficiency for LAI trend simulating at 60 and 90 kg/ha nitrogen treatments but it simulated LAI more than actual value at 0 and 30 kg/ha nitrogen treatments (Figures 1 and 2). The maximum difference of LAI simulated and measured was recorded for 0 and 30 kg/ha nitrogen treatments and the minimum one was recorded for 60 and 90 kg/ha nitrogen (Tables 1 and 2). Bouman and Van Laar 7) indicated that at lower contents of nitrogen fertilizer, simulated LAI was more than actual value. According to the t-test (Tables 1 and 2), LAI simulated values at evaluation condition had not significant difference with measured ones at 95% possibility level. Negative CRM of LAI at calibration and evaluation conditions means that the model has estimated simulated values more than measured ones (Tables 1 and 2). NRMSE of LAI at 0 and 30 kg/ha nitrogen treatments (70 and 78%) is indicative of undesirable simulation of this parameter and NRMSE of LAI at

60 and 90 kg/ha nitrogen treatments (35 and 27%) implies better simulation of LAI by the model compared to low fertilizer application during the growth season (Tables 1 and 2). Bouman and Van Laar [7] obtained NRMSE of LAI at different nitrogen fertilizer contents, at model calibration (67-120%) and at model evaluation (17-107%). Amiri and Rezaee (2), Belder et al. (5), Jing et al. [12] and Xue et al. [24] computed at interaction of irrigation management and nitrogen fertilizer, at model calibration, NRMSE of LAI (38, 45, 28, 37%) and at model evaluation (23, 45, 32, 32%). In real conditions, low fertilizer content leads to SLA (Specific Leaf Area) and LAI reduction while the model is not able to decrease these parameters but at higher fertilizer contents, SLA is changed by the model well which resulted in appropriate simulation of LAI. LAI trend in all the nitrogen contents is increased until flowering stage and then it is decreased and the model also follows this trend. α, β, R2 coefficients and RMSE of LAI in rice cultivars different under nitrogen fertilizer management in paddy fields of Guilan were fair (Tables 1 and 2).



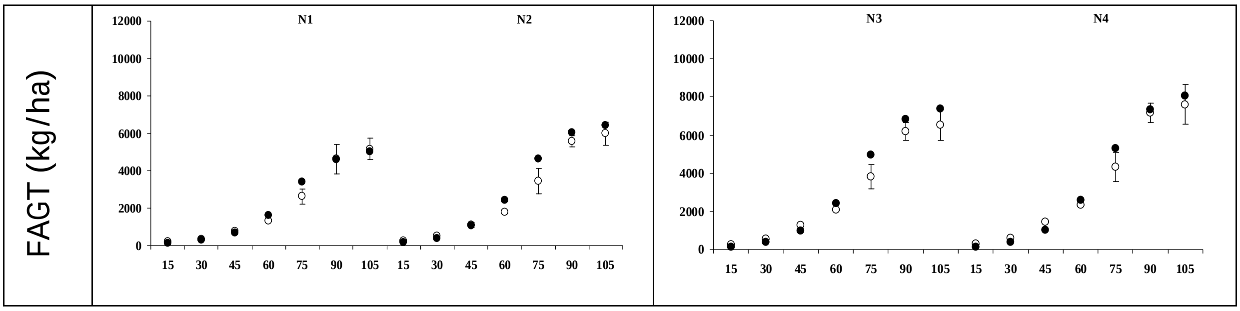
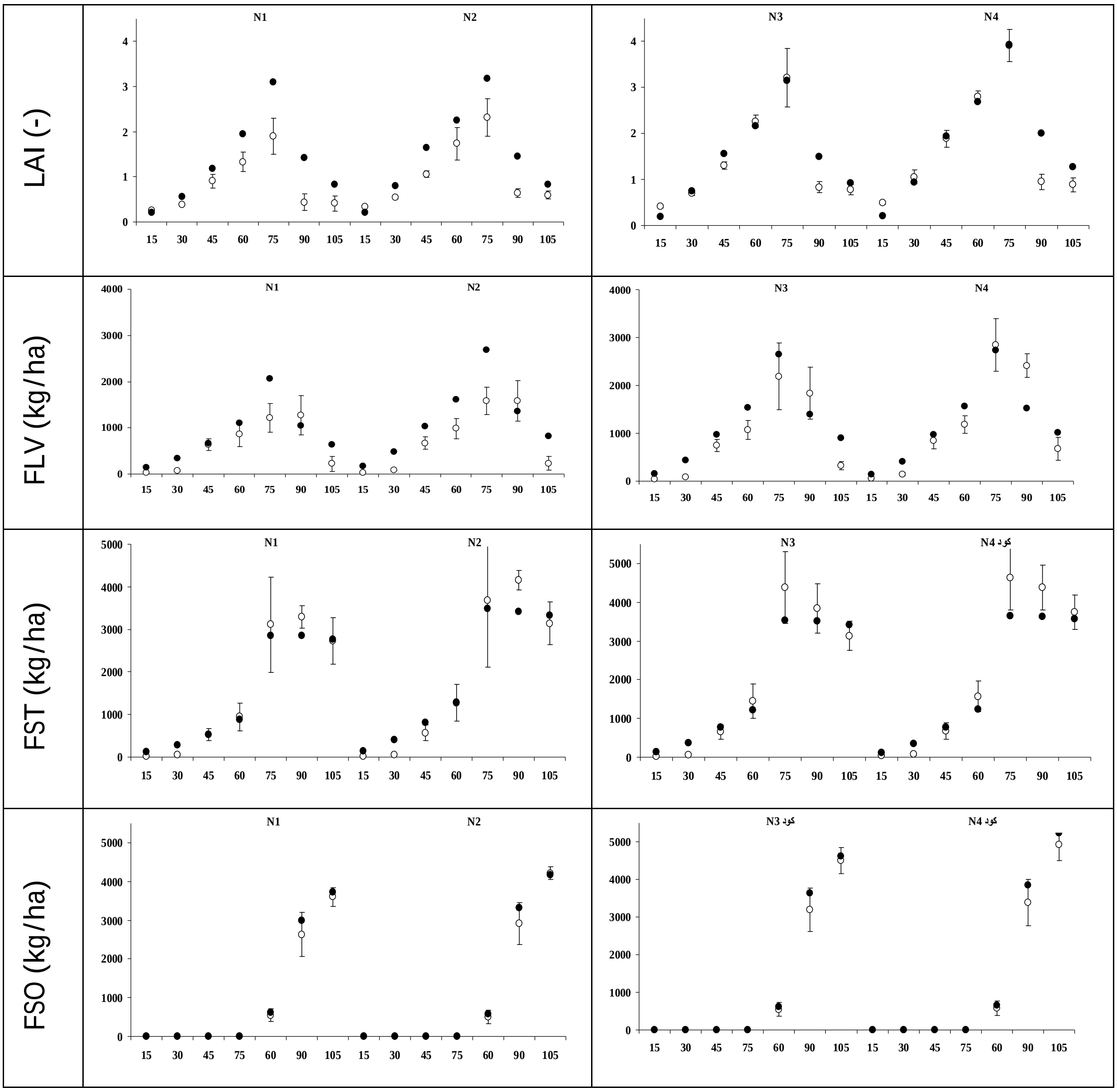


Fig. 1. Simulated (●) and measured (○) LAI, FLVG, FST, FSO and FAGT of rice cultivarsin Rasht
Note: assimilate partitioning factors to leaves, stems, storage and above ground total (FLV, FST, FSO and FAGT respectively), LAI= Leaf Area Index.



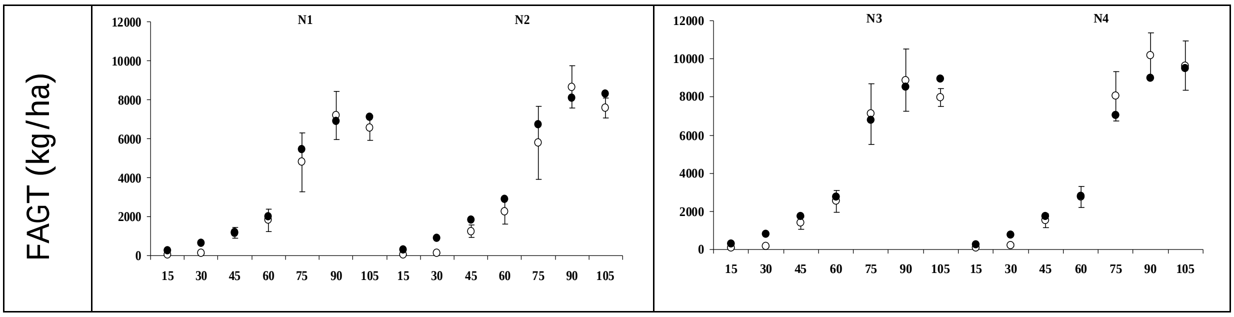


Fig. 2. Simulated (●) and measured (○) LAI, FLVG, FST, FSO and FAGT of rice cultivarsin Roudsar
Note: assimilate partitioning factors to leaves, stems, storage and above ground total (FLV, FST, FSO and FAGT respectively), LAI= Leaf Area Index.

Table 1. Evaluation results of ORYZA2000 simulations of crop parameters under calibration condition

Crop parameters	$RMSE_n$	RMSE	CRM	$P(t^*)$	β	α	R^2	Variance (%)	X_{obs} (SD)	X_{sim} (SD)	N
					Rasht						
FLV Kg/ha	47	219	-0.14	0.19	138	0.61	0.77	+14	532 (412)	465 (288)	42
FST Kg/ha	29	332	-0.10	0.29	135	0.80	0.94	+10	1262 (1087)	1142 (895)	42
FSO kg/ha	10	198	-0.05	0.40	6.93	0.95	0.92	+5	1963 (1065)	1877 (1063)	18
FAGT kg/ha	22	537	-0.09	0.32	44	0.90	0.96	+9	2636 (2305)	2411 (2115)	42
LAI -	87	0.75	-0.65	0.003	0.05	0.64	0.80	+65	1.43 (1.06)	0.87 (0.76)	42
Yield Kg/ha	7	204	-0.05	0.27	719	0.71	0.64	+5	2979 (446)	2829 (395)	6
Biomass Kg/ha	8	559	-0.05	0.28	1042	0.79	0.59	+6	6663 (1109)	6287 (1134)	6
					Roudsar						
FLV Kg/ha	75	506	-0.49	0.12	29	0.70	0.73	+50	1010 (732)	675 (600)	42
FST Kg/ha	30	516	0.01	0.46	204	1.14	0.91	-2	1653 (1341)	1683 (1606)	42
FSO kg/ha	10	246	-0.06	0.38	18	0.94	0.95	+7	2548 (1554)	2388 (1506)	18
FAGT kg/ha	22	744	-0.11	0.29	425	0.01	0.96	+11	3756 (3105)	3381 (3213)	42
LAI -	70	0.64	-0.53	0.004	0.01	0.64	0.17	+53	1.40 (0.97)	0.92 (0.66)	42
Yield Kg/ha	8	289	-0.07	0.07	1257	0.59	0.33	+8	3816 (329)	3518 (337)	6
Biomass Kg/ha	9	82	-0.10	0.07	2190	0.66	0.57	+1	9242 (1091)	8303 (952)	6

Note$_1$: Note: assimilate partitioning factors to leaves, stems, storage and above ground total (FLV, FST, FSO and FAGT respectively), LAI= Leaf Area Index.

Note$_2$: N, number of data pairs; Xmea, mean of measured values; Xsim, mean of simulated values; SD, standard deviation; P(t*), significance of paired t test; α, slope of linear relation between simulated and measured values; β, intercept of linear relation between simulated and measured values; R2, adjusted linear correlation coefficient between simulated and measured values; RMSE (%) normalized, normalized root mean square error (%); RMSE absolute, absolute root mean square error; CRM, Coefficient of Residual Mass.

* In a column, * means simulated and measured values are the same at 95% confidence level.

Assimilate partitioning factors to leaves, stems, storage and above ground total

Figures 1 and 2 illustrated that at both locations, the patterns of simulated and measured values of assimilate partitioning factors to leaves, stems, and storage has a harmony. Since at early growth the most photosynthesis assimilates reserve in leaves and stems, assimilate partitioning factors to leaves, stems are at highest rate (Figures 1 and 2) but over the time and in reproductive stage, photosynthesis assimilates are assimilate partitioning factors to storage. The trend of simulated and measured assimilate partitioning factors to above ground total at Rasht and Roudsar implies that this physiological index is increased due to the accumulation in different parts over the time and at early

stages, it's increased by the less gradient and at later stages it further increases until assimilate partitioning factors
to above ground total reaches its maximum (grain filling) (Figures 1 and 2). The maximum assimilate partitioning factors to leaves, stems, and storage was obtained at higher contents of nitrogen fertilizer and consequently maximum assimilate partitioning factors to above ground total was observed at higher nitrogen fertilizer treatments (Figures 1 and 2). Nitrogen because of having a role in production and translocation of cytokinin from root to the shoots, increases cell division rate and rice growth (16, 20). Photosynthetic rate per leaf area unit is correlated with the amount of nitrogen available and with increasing nitrogen application photosynthesis rate is increased per unit area (21).Also, application of different nitrogen fertilizer values impact on photosynthesis exchange and plants growth and higher nitrogen stimulates vegetative growth, reduces storage of hydrate carbon and increases allocation dry matter to the leaves and reduction of nitrogen fertilizer increases dry matter allocation to the root (10).

Table 2. Evaluation results of ORYZA2000 simulations of crop parameters under evaluation condition

Crop parameters	$RMSE_n$	RMSE	CRM	P(t*)	β	α	R^2	Variance (%)	X_{obs} (SD)	X_{sim} (SD)	N
					Rasht						
FLV Kg/ha	37	252	0	0.47	214	0.67	0.74	+1	677 (496)	671 (387)	42
FST Kg/ha	30	425	-0.12	0.26	192	0.77	0.95	+12	1595 (1370)	1422 (1085)	42
FSO kg/ha	8	216	-0.06	0.37	66	0.96	0.96	+6	2676 (1442)	2515 (1421)	18
FAGT kg/ha	20	644	-0.07	0.35	194	0.81	0.97	+8	3419 (3039)	3173 (2677)	42
LAI -	35	0.40	-0.02	0.43	0.06	0.91	0.81	+3	1.17 (0.90)	1.14 (0.92)	42
Yield Kg/ha	7	296	-0.08	0.06	878	1.12	0.71	+9	4140 (314)	3774 (418)	6
Biomass Kg/ha	2	233	-0.02	0.22	2563	0.68	0.75	+2	8812 (536)	8596 (423)	6
					Roudsar						
FLV Kg/ha	41	424	-0.13	0.23	217	1.06	0.82	+13	1171 (811)	1032 (954)	42
FST Kg/ha	26	544	0.08	0.32	172	1.18	0.94	-8	1876 (1527)	2047 (1860)	42
FSO kg/ha	8	229	-0.08	0.35	49	0.94	0.98	+8	3096 (1921)	2852 (1815)	18
FAGT kg/ha	17	740	0	0.49	380	1.08	0.97	+1	4352 (3639)	4323 (3993)	42
LAI -	27	0.40	-0.08	0.30	0.03	0.94	0.87	+8	1.66 (1.80)	1.53 (1.09)	42
Yield Kg/ha	6	288	-0.03	0.28	1859	1.36	0.55	+3	4666 (322)	4503 (589)	6
Biomass Kg/ha	5	544	-0.05	0.09	661	0.88	0.51	+5	10804 (635)	10223 (784)	6

Note$_1$: Note: assimilate partitioning factors to leaves, stems, storage and above ground total (FLV, FST, FSO and FAGT respectively), LAI= Leaf Area Index.

Note$_2$: N, number of data pairs; Xmea, mean of measured values; Xsim, mean of simulated values; SD, standard deviation; P(t*), significance of paired t test; α, slope of linear relation between simulated and measured values; β, intercept of linear relation between simulated and measured values; R2, adjusted linear correlation coefficient between simulated and measured values; RMSE (%) normalized, normalized root mean square error (%); RMSE absolute, absolute root mean square error; CRM, Coefficient of Residual Mass.

* In a column, * means simulated and measured values are the same at 95% confidence level.

Maximum difference of simulated and measured assimilate partitioning factors to leaves, stems, storage and above ground total (FLV, FST, FSO and FAGT respectively) at calibration condition was related to the leaf dry matter (+14% at Rasht) and (+50% at Roudsar). Difference of FLV simulated and measured values at evaluation condition was (+1% at Rasht) and (+13% at Roudsar) (Table 1).

It can be due to more simulation of LAI at low values of fertilizer, when the model simulates LAI more than measurement, it leads to further simulation of dry matter but with increasing nitrogen fertilizer, FLV is simulated well. Difference of simulated and measured values of assimilate partitioning factors to leaves, stems, storage and above ground total (FLV, FST, FSO and FAGT respectively) at evaluation condition was +1 to +13 (Table 2). T-test results (Tables 1 and 2) showed that simulation values of all the plant parameters at model calibration and evaluation condition under nitrogen fertilizer management had not significant difference with measured values at 95% possibility level. CRM of accumulate partitioning parameters in different parts was negative in most conditions and implies that the model has estimated simulation values more than measured ones (Tables 1 and 2). RMSEn of assimilate partitioning factors to leaves, stems, storage and above ground total (FLV, FST, FSO and FAGT respectively) under calibration condition at Rasht was computed (47, 29, 10 and 22% respectively) and at Roudsar (75, 30, 10 and 22% respectively) (Table 1). RMSEn of assimilate partitioning factors to leaves, stems, storage and above ground total (FLV, FST, FSO and FAGT respectively) under evaluation condition at Rasht was calculated (37, 30, 8 and 20% respectively) and at Roudsar (41, 26, 8 and 17% respectively) (Table 2). So based on RMSEn it can be concluded that has an appropriate efficiency to simulate assimilate partitioning factors to leaves, stems, storage and above ground total (FLV, FST, FSO and FAGT respectively). Bouman and Van Laar (2006) obtained showed that RMSEn of FLV, FST, FSO and FAGT under calibration condition was computed (23-59, 13-57, 9-32 and 5-21 respectively) and under evaluation condition was calculated (10-37, 13-35, 3-16 and 9-31 respectively). With increasing nitrogen levels in the experimental site values FSO and FAGT increases; values FLV and FST Initially increases and then decreases in the reproductive stage, the model also obeys the same for both locations. α, β, R2 coefficients and RMSE of FLV, FST, FSO and FAGT in rice cultivars different under nitrogen fertilizer management in paddy fields of Guilan were fair (Tables 1 and 2).

Total Biomass and Grain Yield

Tables 1 and 2 illustrated that maximum grain yield (3374 and 4503 kg/ha) and total biomass (8596 and 10223 kg/ha) was produced under high fertilizer application, minimum grain yield (2829 and 6287 kg/ha) and total biomass (3518 and 8303 kg/ha) was related to the low fertilizer application. Nitrogen providing for the plant leads to growth increment, photosynthesis and dry matter accumulation and increases production per unit area. With increasing nitrogen content to a certain extent, grain yield and total biomass are raised significantly (17, 18, 22, 25). In this experiment, ORYZA2000 model was able to simulate grain yield and total biomass under nitrogen fertilizer different content. Furthermore, NRMSE of grain yield at calibration condition was obtained (Rasht: 7% and Roudsar: 8%) and total biomass (Rasht: 8% and Roudsar: 9%). NRMSE of grain yield at evaluation condition was computed (Rasht: 7% and Roudsar: 6%) and total biomass (Rasht: 2% and Roudsar: 5%) (Tables 1 and 2).

Rinaldi et al. (19) stated that if RMNSE is less than 10 indicate excellent form of simulation. According to the t-test it can be concluded that simulation values of grain yield and total biomass at model evaluation under nitrogen fertilizer management had not significant difference with measured ones at 95% possibility level (Tables 1 and 2). CRM index of the grain yield, model total biomass and field results was negative in all the treatments which indicate that the model has estimated grain yield and total biomass more than actual conditions for all the cases (Tables 1 and 2). α, β, and RMSE of rain yield and biomass in rice cultivars different under nitrogen fertilizer management in paddy fields of Guilan were fair (Tables 1 and 2).

The results of linear regression analysis (Figure 3) between simulated and measured grain yield values of rice cultivars under nitrogen fertilizer management at Rasht and Roudsar revealed that coefficient of determination (R2) was 0.83 and also 87% of the points was fell within in the range 1:1 line and standard error (±SE= 108) lines of measured grain yield. In addition, linear regression analysis (Figure 3) between simulated and measured total biomass values of rice cultivars under nitrogen fertilizer management at Rasht and Roudsar revealed that coefficient of determination (R2) was 0.87 and also 92% of the points was fell within in the range 1:1 line and standard error (±SE= 219) lines of measured total biomass. Bouman and Van Laar (2006), Belder et al. (2007), Jing et al. (2007) and Xue et al. (2008) computed NRMSE of total biomass at calibration condition (7, 19, 9 and 11%) and at evaluation condition (9, 13, 11 and 11%). In these experiments, NRMSE of grain yield was reported (13, 13, 16 and 18%) and (11, 13, 11 and 10%) at calibration and evaluation conditions, respectively.

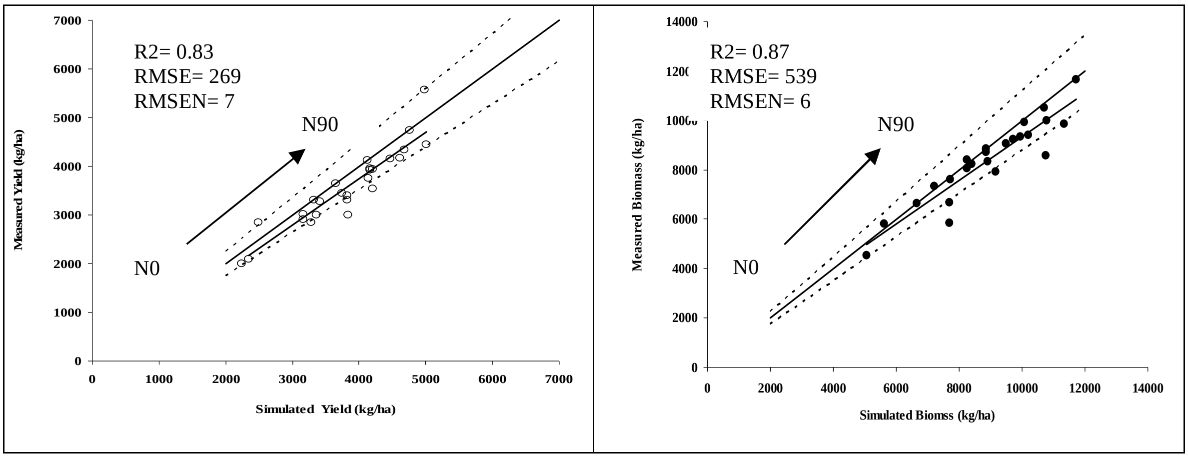


Fig. 3. Comparison simulated and measured yield (○) and biomass (●)

CONCLUSION

There are no absolute criteria to classify a model as good or bad. Strictly speaking, models cannot be validated; only invalidation is possible on the basis of empirical evidence. However, repeated and well-documented comparisons between model simulations and experimental measurements increase the confidence in the suitability of a model for a specific purpose (6). The results of this experiment showed that the model has a capability to simulate of growth aqnd yield of rice varieties (Hashemi, Ali-Kazemi and Khazar) under nitrogen fertilizer management in Gilan rice paddy fields. So that it predicts grain yield and total biomass of rice varieties with less than 10% error. Thus, according to the excessive use of nitrogen fertilizer in Gilan province paddy fields, the application of this model is necessary in order to optimization of nitrogen fertilizer application and prevention of field trials. It is suggested that future researches for model application in nitrogen losses through leaching, the amount of residual nitrogen in soil and crop nitrogen use efficiency in rice varieties specifically those with higher nitrogen consumption should be focused. Therefore, researchers can use the ORYZA2000 model to support the results of studies under nitrogen fertilizer management and optimization of nitrogen fertilizer in rice.

REFERENCES

1. Alam, M.M., Hassanuzzaman, M. Nahar, K. (2009). Tiller dynamics of three irrigated rice varieties under varying phosphorus levels. American Eurasian Journal of Agronomy., 2(2): 89-94.
2. Amiri, E., Rezaee, M. (2009). Testing the modeling capability of under water-nitrogen limit condition in northen iran. World applied sciences journal., 8: 1113-1122.
3. Amiri, E., Rezaee, M. (2013). Evaluation of Water-Nitrogen Schemes for Rice in Iran, Using ORYZA2000 Model. Communications in Soil Science and Plant Analysis., 41(20): 2459-2477.
4. Artacho, P., Meza, F. Alcalde, J.A. (2011). Evalution of the oryza20000 rice growth model under nitrogen-limited conditions in an irrigated mediterranean environment. Chilean journal of agricultural research., 71(1): 23-33
5. Belder, P., Bouman, B.A.M. Spiertz, J.H.J. (2007). Exploring option for water savings in lowland rice using a modeling approach. Agriculture Systems., 92: 91-114.
6. Bouman, B.A.M., Krop, M.J. Tuong, Y.P. Wopereis, M.C.S. Ten Berge, H.F.M. Van Laar, H.H. (2001). ORYZA2000: Modelling Lowland Rice. International Rice Research Institute, Wageningen University and Research Centre, Los Ban os, Philippines, Wageningen, Netherlands.
7. Bouman, B.A.M., Van Laar, H.H. (2006). Description and evaluation of the rice growth model ORYZA2000 under nitrogen-limited conditions. Agricultural Systems., 87: 249-273.
8. Cibin, R., Sudheer, K.P., Chaubey, I. (2010). Sensitivity and identifiability of stream flow generation parameters of the SWAT model. Hydrol Process., 24(9): 1133–1148.
9. Dasilva, P.R.F., Stutte, C.A. (1981). Nitrogen loss in conjunction with translocation from leaves as influenced by growth stage, leaf position and N supply. Agronomy Journal., 73: 38-42.
10. Dingkahn, M. (1996). Modeling concepts for the phenotypic plasticity of dry matter and nitrogen partitioning in rice. Agriculture System., 52: 383-397.
11. Drenth, H., ten Berge, F.F.M. Riethoven, J.J.M. (1994). ORYZA simulation modules for potential and nitrogen limited rice production. Wageningen, The Netherlands: IRRI/AB-DLO. SARP Research Proceedings. 223 pp.
12. Jing, Q., Bouman, B.A.M. Hengsdijk, H. Van Keulen, H. Cao, W. (2007). Exploring options to combine high yields with high nitrogen use efficiencies in irrigated rice in China. European Journal Agronomy., 26: 166-177.
13. Khuang, T.Q., Huan, T.T. Hach, C.V. (2008). Study on fertilizer rates for getting maximum grain yield and profitability of rice production. Omonrice., 16: 93-99.
14. Koutroubas, S.D., Ntanos, D.A. (2003). Genotype differences for grain yield and nitrogen utilization in indica and japonica rice under Mediterranean conditions. Field Crop Research., 83: 251-260.

15. Ma, J.F. (2004). Role of silicon in enhancing the resistance of plants to biotic and abiotic stresses. Soil Science and Plant Nutrition., 50: 11-18.
16. Marschner, H. (1995). Mineral Nutrition of higher plants. Academic Press London.
17. Pramanik, K., Bera, A.K. (2013). Effect of Seedling Age and Nitrogen Fertilizer on Growth, Chlorophyll Content, Yield and Economics of Hybrid Rice (Oryza sativa L.). International journal of Agronomy and Plant Production., 4: 3489-3499.
18. Qiao-gang, Y., Jing, Y.Shao-na, Y. Jian-rong, F. Jun-wei, M. Wan-chun, S. Li-na, J. Qiang, W. Jian-mei, W. (2013). Effects of Nitrogen Application Level on Rice Nutrient Uptake and Ammonia Volatilization. Rice Science., 20(2): 139-147.
19. Rinaldi, M., Losavio, N. Flagella, Z. (2003). Evaluation of OILCROP-SUN model for sunflower in southern Italy. Agricultural Systems, 78: 17-30.
20. Takada, T. (1961). Studies on the photosynthesis and production of dry matter in the community of rice plant. Japanese Journal of Botany., 17: 403-407.
21. Timothy, W., Joe, E. (2003). Rice tertilization. Mississippi agricultural and forestry experiment station 13(48): 1-4.
22. Uddin, S., Sarkar, M.A.R. Rahman, M.M. (2013). Effect of nitrogen and potassium on yield of dry direct seeded rice cv. NERICA 1 in aus season. International journal of Agronomy and Plant Production., 4(1): 69-75.
23. Varella, H., Guerif, M. Buis, S. (2010). Global sensitivity analysis measures the quality of parameter estimation: the case of soil parameters and a crop model. Environ Model and Software., 25(3): 310-319.
24. Xue, C., Yang, X. Bouman, B.A.M. Deng, W. Zhang, Q. Yan, W. Zhang, T. Rouzi, A. Wang, H. (2008). Optimizing yield, water requirements, and water productivity of aerobic rice for the north China plain. Irrigation Science., 26: 459-474.
25. Yoseftabar, S. (2013). Effect Nitrogen Management on Panicle Structure and Yield in Rice(Oryza sativa L.). International Journal of Agriculture and Crop Sciences., 5(11): 1224-1227.
26. Zhao, L., Wu, L. Wu, M. Li, Y. (2011). Nutrient uptake and water use efficiency as affected by modified rice cultivation methods with irrigation. Paddy Water Environment., 9: 25-32.