Advances in Bioresearch
Adv. Biores., Vol 7 (1) January 2016: 113-120
©2015 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

Simulation of Yield and Yield Components of Rice (Hashemi c.v) at four Nitrogen Fertilizer levels using CERES Rice model in region Rasht

Maasoumeh Eliasi[1], Farzad Paknejad*[1], Mohammad Reza Ardekani[1], Ebrahim Amiri[2]
1. Department of Agronomy, Karaj Branch, Islamic Azad University, Karaj, Iran.
2. Department of Agronomy, Lahijan Branch, Islamic Azad University, Lahijan, Iran.
*Corresponding E-mail address: Farzadpaknejad@yahoo.com

ABSTRACT
Farm test was conducted in crop year 2013 in a randomized complete blocks design with four repeats in the country's Rice Research Institute to evaluate CERES-Rice model simulation in software DSSAT On yield and yield components of rice (Hashemi c.v) at four different levels of nitrogen fertilizer (N_1 = 0, N_2 = 30, N_3 = 60, N_4 = 90 kg N per ha) in Rasht. In this test, the simulation of grain yield traits, biomass, leaf dry weight, leaf area index were investigated for the Hashemi c.v. According to the simulated results, the model in the simulation of biomass trait (twenty days from planting to end of growth period) and grain yield has been successful from grain formation until the final yield of leaf dry weight at all stages of growth. But simulation was not carried out well on the leaf area index traits and due to Willmott index lower than optimal range (0.6) in all treatments. The Model simulated the grain yield with high power at each four levels of nitrogen fertilizer with Willmott index higher than 0.66 well. The Coefficient changes range of determining four different levels of nitrogen fertilizer (N_1 = 0, N_2 = 30, N_3 = 60, N_4 = 90 kg N per ha) became significant at 1% level as0.998, 0.996, 0.98, 0.953 respectively. Then the model can be used for research purposes, and programming management in Rasht climate conditions after calibrating and verifying the performance of this model and trial repetition and reduction of measured errors.
Keywords: *Simulation, Model CERES-Rice, Different levels of nitrogen fertilizer, Grain yield, Biomass, leaf area index.*

Received 09/10/2015 Accepted 27/12/2015

How to cite this article:
Maasoumeh E, Farzad P, Mohammad R A, Ebrahim A. Simulation of Yield and Yield Components of Rice (Hashemi c.v) at four Nitrogen Fertilizer levels using CERES Rice model in region Rasht. Adv. Biores., Vol 7 [1] January 2016: 113-120. DOI: 10.15515/abr.0976-4585.7.1.113120

INTRODUCTION

At the end of 1960_s, several computers have been developed sufficiently so that the possibility and even the motivations of first attempts were declared to incorporate the separate lessons learned in the multiple processes through mathematical equations and putting together the equations, the simulator models were developed. The Initial models were used to increase the understanding of behavior of crop plants via plant determination and growth based on the main physiological mechanisms.

Over the years, advances in plant science and different research inquiries led to the further development of plant simulator models. In addition to their determinative performance in prediction and extrapolation, the yield of models was tested as well recognized quickly and the more applied models were developed. For example, the consulting systems for farmers and studying the different scenarios for policy makers led to the evolution of some models that were used to help the management decisions [1,2]. Now the Crop growth modeling and simulation is accepted as an acceptable instrument of Agricultural Research [1]. Since the rice yield is strongly influenced by genotype, environment and their interactions and with regard to this reality that achieving the elimination methods of yield limiting factors needs high cost and a lot of tests in different areas, finding a way to reduce the number, time and cost of these tests can be considered as very useful. It is now possible to carry out this operation simulating the process of grain production and using the computer software based on mathematical equations and taking into account the many variables affecting the yield. Mousavi and colleagues [3], in a study on grain yield in the maize cultivars showed that a correlation between grain yield and plant height traits and weight of 1000 grain was significant and positive with inverse correlation between maize length traits and its diameter $p \leq 0.1$. Causality analysis results showed that the 1000 grains weight has the highest direct effect on grain yield, and the maximum indirect effect of this trait is applied through maize length .the Direct effect of plant height on grain yield and also indirect effect on trait were positive on 1000 grains weight. According to the results of Jones et al [4], crop plant models should be adjusted so that the addition, Changes and updates of new components are carried out with minimal effort, so that using this method increases the knowledge integration ability of various fields and it led the models towards a path that can predict the actual yields and potential as well. Falkner and colleagues [5] examined the effect of climate change on rice in Thailand. They combined the economic model with crop growth simulation model depended on soil conditions, climate-based simulated model and the world climate change models. To do so they looked at two different climate changes and analyzed their results with software DSATT.

MATERIAL AND METHODS

In order to evaluate the CERES-Rice model on rice (Hashemi c.v) under four different levels of nitrogen fertilizer, the farm trial was conducted in crop year 2013 at the Rice Research Institute in north latitude 37 degrees and 12 minutes and east longitude 49 degrees and 38 minutes.

This Test was conducted in a randomized complete block design with 4 repeats .in this experiment, Hashemi c. v was tested at four different levels of nitrogen fertilizer in amount of $N_1 = 0$, $N_2 = 30$, $N_3 = 60$, $N_4 = 90$ kg N per ha. Each experimental plot consists of six planting lines with a length of 4 m, distance between rows is 15 cm and plants distance is 15 cm too. Distance between the plots is 1.5 meters for non-mixing the nitrogen fertilizer rates. The distance between repeats is also 2 meters. Irrigation was carried out in flooding and phosphorus and potash fertilizers were used in the land and they were mixed thoroughly with the soil before planting based on soil test. Nitrogen fertilizer (based on test treatments in two periods i.e. first period 1.2 of plant time and other 1.2 time before flowering) was administered to the land. We're entering the measured data (the same data observed in the farm) into the model in order to implement the CERES-Rice model and the software does simulation using the input data that the ability of the model can be evaluated in the simulation eventually by comparing the observed and simulated data.

Data and information needed to run the CERES-Rice model in software DSSAT:

1- management Part in the farm consists of test plots' specification, planting spaces, planting depth, seed and plant density, method of testing, introduction of test treatments, introduction of cultivar, amount announcement and irrigation method, irrigation timing, fertilizer application methods and its amounts, date of planting and harvesting, soil texture and structure.

2- The soil information part of the farm contains the soil physical and chemical properties in 3 different depths of shallow, medium and deep soil such as soil color, soil texture, soil compaction, organic matter percentage, nitrogen, phosphorus and available Potassium, pH, electrical conductivity of soil.

3 -The experimental data part have been measured including the data for a minimum period of 6 stages and then the final harvest data which each of them has separate files. The weather data include the most important parameters effecting on plant growth such as minimum and maximum daily temperature (C°), daily precipitation (mm) and daily radiation or solar hours and from the beginning, each plot was divided into two areas sampled and planted. An area Equal to two square meters was chosen to determine grain yield and biomass And 10 plants were selected from each plot to determine the yield components and intended traits were measured on the 10 plants .Finally, data analysis was performed using the software SAS. Comparison of traits mean was performed using Duncan test at 5% probability level. Indicators of evaluation, Willmott agreement index (d) [6] and the coefficient of determination (R^2) obtained from linear regression analysis was used to compare simulated data with data obtained from farm experiments [7].

If d values are closer to 1 obtained by the model, it indicates that the model has been more successful in the simulation and it has been able to do the trait prediction rate with differences less than the observed values. According to some model makers, statistical results of the simulation with d values over 0.60 indicate the acceptable ability of the model to simulate. If values R^2 obtained from the linear regression analysis of the functions is closer to 1, it indicates a high correlation between the simulated values and describes the model better in the traits simulation. To assess the ability of models to predict the value r (given the number of sample (3 samples)) ($p \geq 0.95$) is significant at the level 5% and above from 0.99 at the level 1%. 66/0 and for 8 samples 0.66 to 0.79 at the level 5% and above 0.79 percent at the level 1 %.

RESULTS AND DISCUSSION

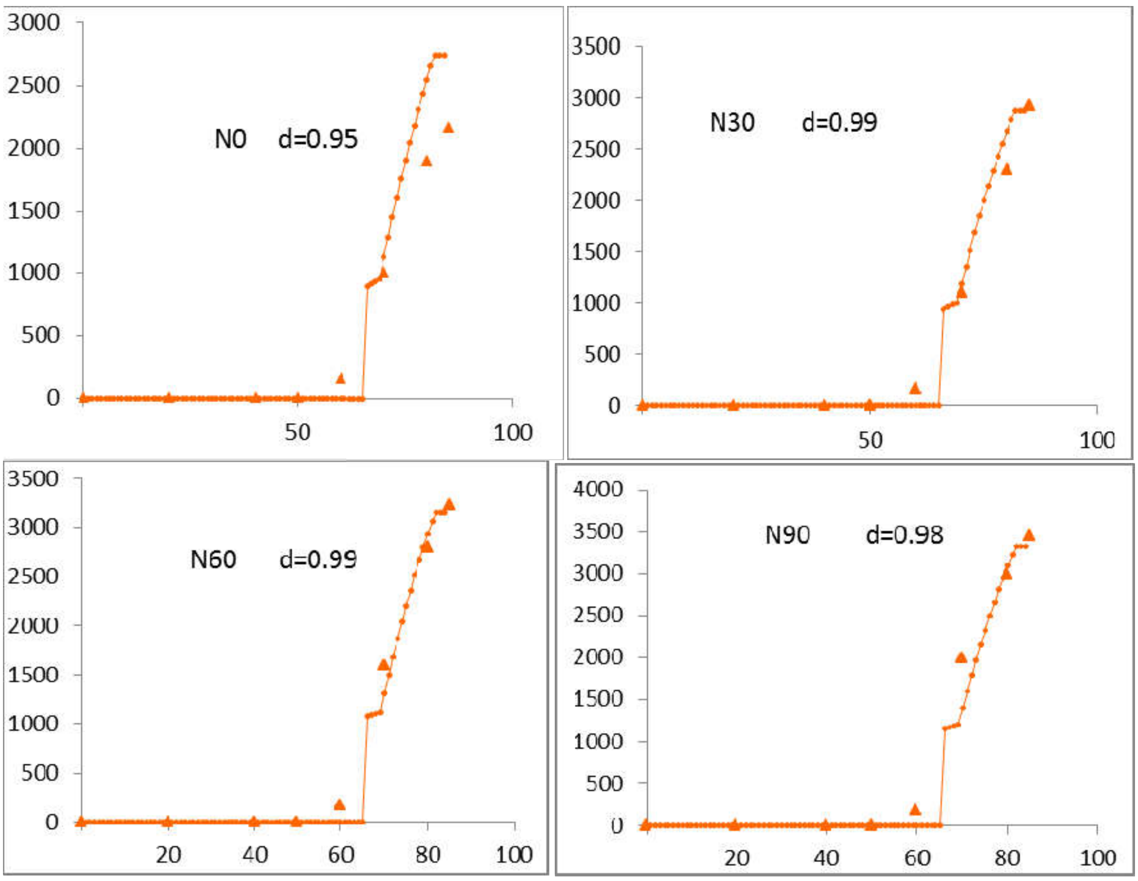
SIMULATION OF GRAIN YIELD

Comparing the coefficients of determination (Table 1) of grain yield was measured and Hashemi simulation at four different levels of nitrogen fertilizer showed the ability of the model to simulate the yield in this condition in Rasht region so that Willmott index for all treatments were successful (0.6) higher than Willmott index. The highest and lowest accuracy was found among treatments, for N2 = 30 and N1 = 0 with Willmott index of 0.95 and 0.99 respectively (Figure 1). Determination coefficient Scope was in the range of 0.95- 0.99 reviewing the determination coefficient (R^2) obtained from linear regression analysis of functions between measured and simulated values for grain yield, indicating that the grain yield changes process model has been described well . (Table 1).

Table 1. Comparison of simulated and measured yield values of grain

determination coefficient (R^2)	Willmott coefficient(d)	Nitrogen fertilizer levels
0.998**	0.95	control Kg per ha
0.999**	0.99	30 kg per ha
0.989**	0.99	60 kg per ha
0.953*	0.98	90 kg per ha

ns, *, **, respectively, with no significant difference , significant difference at the level 5 percent and 1 percent .



Days after Planting

Figure 1- simulated values (lines) and measuring the grain yield (▲) under the influence of four levels of nitrogen fertilizer in Hashemi c.v

As seen in Figure 1, the yield value has gone up in conditions of 90 kg N fertilizer and the model is well able to demonstrate the increased yield in these situations. In this study, Due to absence of proper environmental factors and Casualties caused by them and probably some factors from grain yield losses because of falling at harvest time, the simulated grain yield is estimated More than measured values via a management in the execution.

It seems that the strong management must be applied on the farm until we get better results. In an experiment Andarzian *et al* [1] also noted the CERES-Rice model in Shiraz region on rice, d and R^2 for yield are 0.88 and 0.85 respectively which shows the effectiveness of model in simulation and prediction of grain yield.

SIMULATION OF BIOMASS

Measured and simulated Biomass on the rice in condition of nitrogen fertilizer levels of nitrogen shows the high ability of the model in biomass simulations in this situation in Rasht region (Figure 2). Identification Coefficient ranges from 0.95 -0.98 which indicates the suitability of the model in biomass simulation in nitrogen levels condition (Figure 2) evaluating the coefficient of determination (R^2) obtained from linear regression analysis of functions between measured and simulated values of different levels of nitrogen fertilizer in rice.

Biomass simulated Changes process in the nitrogen fertilizer levels conditions in rice by CERES-Rice model in Rasht region (according to criteria of s Model evaluation in Table 2 like coefficient changes scope d in various cultivars in ranging from 0.99 to 0.98) shows that the model is successful in predicting the trend of biomass changes in nitrogen fertilizer levels conditions (Figure 2).

Table 2. Comparison of simulated and measured biomass values

determination coefficient (R^2)	Willmott coefficient(d)	Nitrogen fertilizer levels
0.953**	0.98	control Kg per ha
0.966**	0.99	30 kg per ha
0.98**	0.99	60 kg per ha
0.98*	0.98	90 kg per ha

ns, *, **, respectively, with no significant difference , significant difference at the level 5% and 1% .

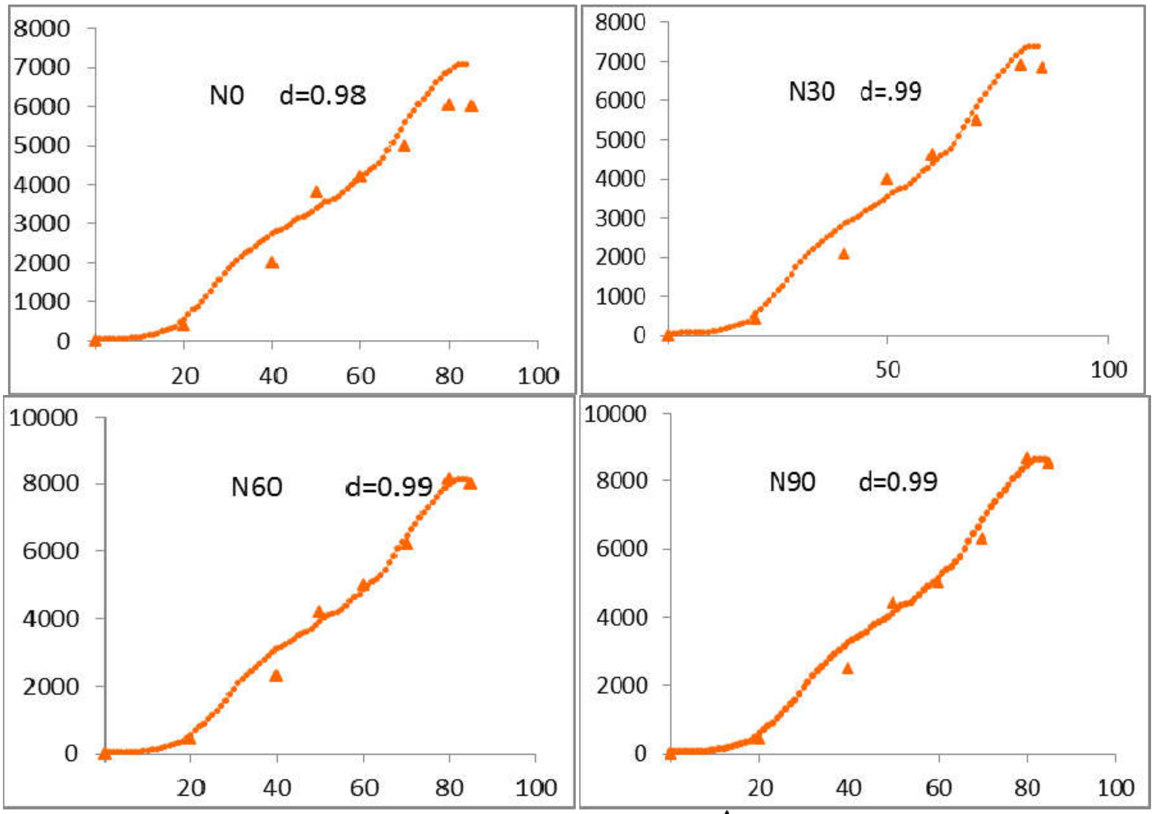


Figure 2- simulated values (lines) and measuring the biomass (▲) under the influence of four levels of nitrogen fertilizer in Hashemi c.v

As shown in the figures, the biomass production process model has been simulated well and Simulated biomass and nitrogen fertilizer is greater than the values measured in the farm at all levels , apparently It is the main cause of biomass imprecise simulation in mismatch of equations used in the model CERES-

Rice. To simulate the biomass with its production conditions in the farm , Or that managements used in the model were entered into the model with less precision, Measuring the amount of water in the farm faces the difficulties and errors of measurements such as difficult managements which appear in the model. Thus, the difference in the simulated and measured values may be due to errors in measurement of water used.

SIMULATION OF DRY MATTER

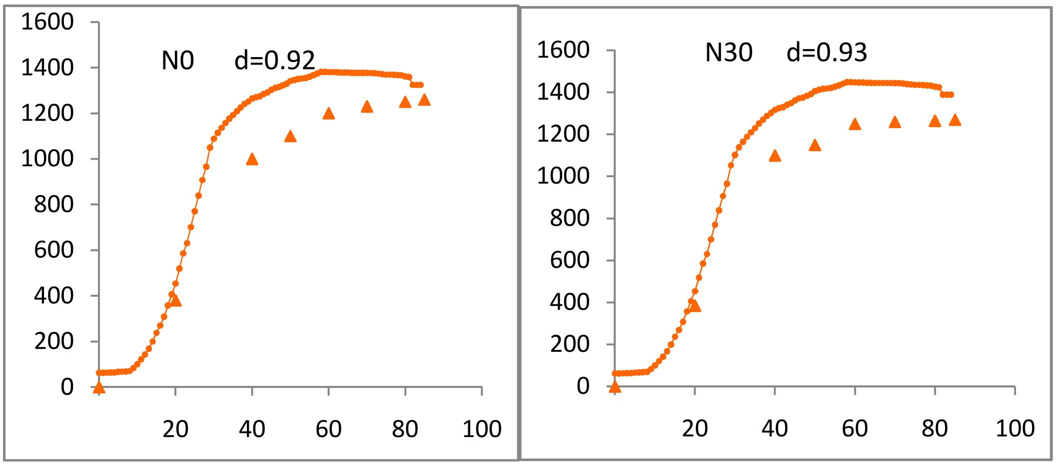
The Measured and simulated leaf dry matter in the rice in terms of nitrogen fertilizer levels, it shows the high ability of the model to simulate the leaf dry matter in the situation in Rasht region (Figure 3). Coefficient of determination is in the range of 0.96-0.98 investigating the coefficient of determination (R2) obtained from the linear regression analysis and the functions between measured and simulated values for leaf dry matter of rice. It shows the model suitability in simulation of leaf dry matter in nitrogen fertilizer levels.

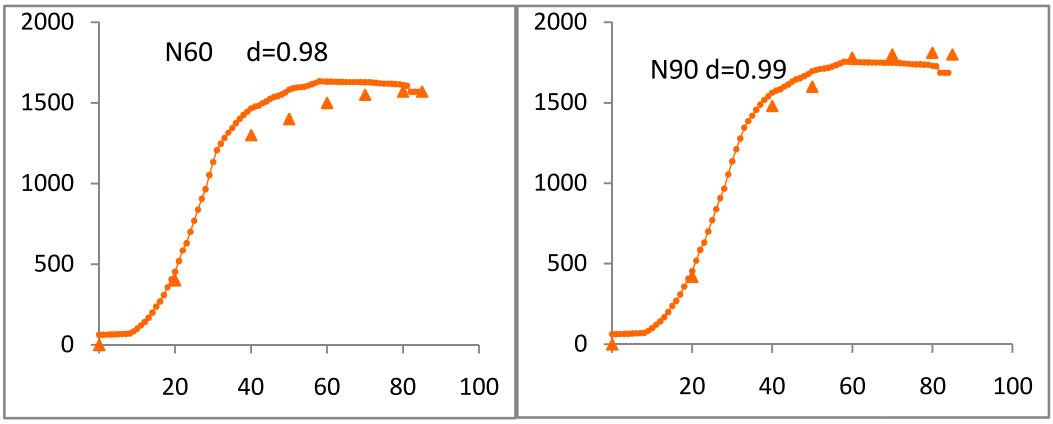
The simulated changes process of the leaf dry matter in the levels of nitrogen fertilizer condition in rice by the model CERES-Rice in Rasht region (according to Table 10-4 and changes range of coefficient d in different cultivars s ranging from 0.99 to 0.92) indicates that the model is successful in predicting the trend of leaf dry matter changes of nitrogen fertilizer levels (Figure 3). Simulation of leaf dry matter has been anticipated well in terms of nitrogen fertilizer levels which are probably due to the model ability to identify the leaf dry matter in different levels of nitrogen fertilizer that could be due to genetic traits precision or identification of Hashemi c.v for this trait via the model. It is worth noting that the simulation has made the biomass trait better than leaf dry weight. But it can be stated that according to d values, leaf simulation has been carried out well [11-14].

Table 3. Comparison of simulated and measured values of Leaf dry matter

determination coefficient (R^2)	Willmott coefficient(d)	Nitrogen fertilizer levels
0.960**	0.92	control Kg per ha
0.98**	0.93	30 kg per ha
0.98**	0.98	60 kg per ha
0.98*	0.99	90 kg per ha

ns, *, **, respectively, with no significant difference , significant difference at the level 5 percent and 1 percent .





Days After Planting

Figure 3: simulated values (lines) and measuring the biomass (▲) under the influence of four levels of nitrogen fertilizer in Hashemi c.v

In the first stage -As determined in Figure 3- the simulated leaf dry matter is placed in a level higher than the measured values that could be caused by the presence of weeds in farm and Plants competition with them led to leaf dry matter to be lower than the simulated values in early stages. But after removing the weeds, the measured values became closer to the simulated values.

SIMULATION OF LAI

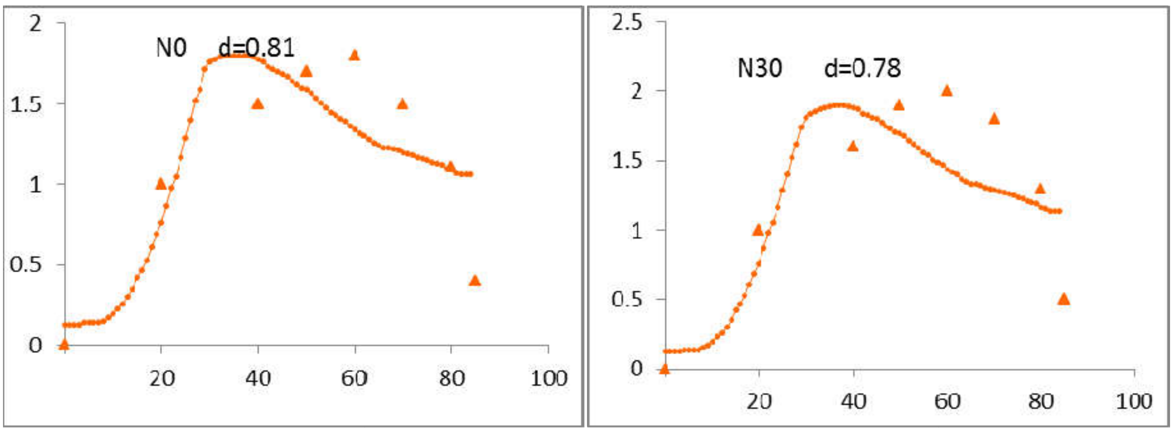
Comparison of measured LAI and simulated values in rice in terms of different levels of nitrogen fertilizer shows the high ability of the model to simulate LAI in Rasht region. (Figure 4).

Between LAI measured and simulated values of rice, the coefficient of determination ranges from 0.37-0.58 with reviewing the coefficient of determination (R2) obtained from linear regression analysis of functions. It shows the unsuitability of model in the simulation at LAI in the nitrogen fertilizer levels in relation to LAI simulated changes trend in the nitrogen fertilizer conditions in rice by the CERES-Rice in Rasht. According to Table 4 and the coefficient changes scope d in rice in the range from 0.75- 0.86 shows that the model has not been successful in predicting the trend of leaf area index changes in levels of N fertilizer [8, 9].

Table 4.comparsion of simulated and measured values of leaf area index (LAI)

determination coefficient (R^2)	Willmott coefficient(d)	Nitrogen fertilizer levels
0.994**	0.54	control Kg per ha
0.979**	0.70	30 kg per ha
0.998**	0.66	60 kg per ha
0.998*	0.53	90 kg per ha

ns, *, **, respectively, with no significant difference , significant difference at the level 5% and 1% .



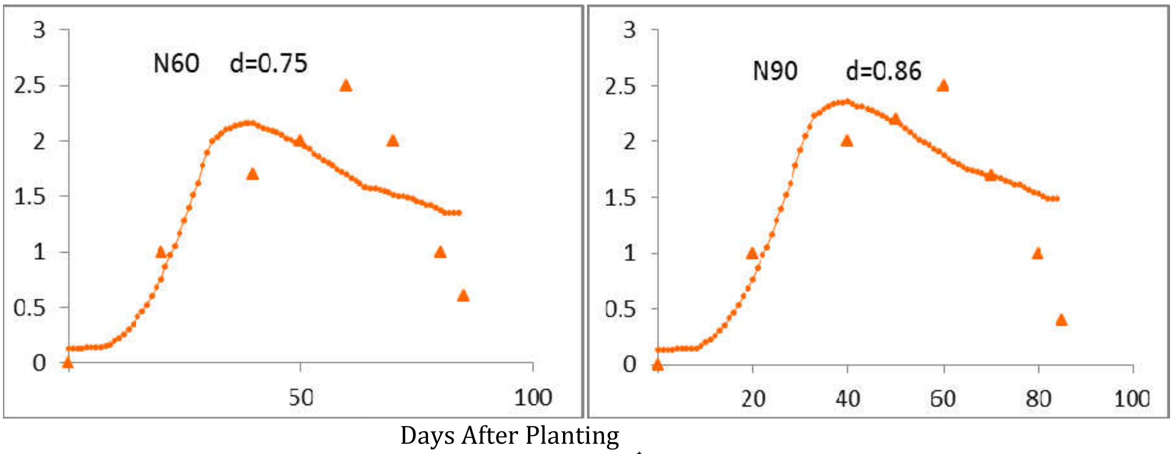


Figure 4: simulated values (lines) and measuring LAI (▲) under the influence of four levels of nitrogen fertilizer in Hashemi c.v

As you can see, the model in simulation of LAI has been more successful than the flowering stage on ward in terms of different levels of nitrogen. It could be due to lack of detection of rice cultivar because of inaccuracy in the used genetic characteristics or that the model has not been able to do the simulation for Hashemi c.v.

CONCLUSIONS

Due to the ability of the model CERES-Rice in the analysis of rice production systems which are capable of separating and simulating the impact of climate, soil, vegetation and management variables on plant growth and its yield, and also its ability in predicting the rice yield in the farm, regional, and national levels, at present the model is used as an important tool in decision making and management in the administrative and research aspects widely in different regions of the world. This model leads to dramatically reduce the research costs and time saving and it generalizes the results of research into other areas with acceptable accuracy. Given that this model requires the meteorological data such as minimum and maximum temperature, rainfall and sunshine hours or solar radiation to simulate the growth and yield. This data is also available in all weather stations and can be used in predicting the long-term performance and planning. Before using this model like other models, it should be evaluated in order to be used for other studies intended after verification of the model performance competency.

The results obtained from of this study's DSSAT software evaluation showed that the CERES-Rice model has good accuracy in terms of four different levels of nitrogen fertilizer simulated on the grain yield and biomass. But it could not well simulate LAI. High correlation and determination coefficient in four levels of nitrogen fertilizer has confirmed the issue. The model is used for research purposes, and even educational planning and management in Karaj climate conditions.

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