THE PARAMETERS STUDY ON RICE GROWTH SIMULATION FOR FERTILIZER MANAGEMENT IN ACID SOIL PADDY RICE

[1]PITCHAYASINEE ARIYATANAKATAWONG, [2]WATCHARAKORN PHAHANICH, [3]PANNAVICH ARIYATANAKATAWONG

[1,2]Rajabhat Rajanagarindra University, [3]Silpakorn University,Thailand
E-mail: pitchayasinee.ari@gmail.com, phahanich@hotmail.com, apannavich@gmail.com

Abstract- Rice is one of staple foods for human and serving for the world's population. Although global production has excess demand in the last 20 years, food security problems still facing and need to be manage based on early and reliable recommendation for all activities of paddy rice. The important attempt for manage and prediction the rice crop yield based on simulation models was developed. However, sample of operation systems implementing models is suitable for reproducing the peculiarities of paddy rice, especially on site-specific or small rice farm was missing recognize such as in acid soil area, In this study Oryza2000was used for evaluation and optimum fertilizer in acid soil paddy rice. The experiment was based on acid soil paddy field in two district name Bangkha and Banpho district of Chachoengsoa province Thailand. The most relevant model parameter was identified through sensitivity analysis carried out using the manually and calibrated using linear model method. The data from published experiments in 2 locations and 3 years were used. Our result from new framework was able to report a optimum parameters with Oryza2000 in case fertilizer management at both districts. Specifically, the average of relative root mean square error calculated on leaf area index curves was 22.5% for the calibration and 25.8% validation and productivity curves was 28.2% for the calibration and 31.1% validation. The parameters of the linear regression equation between measurement and simulation values were always satisfy. Indeed, intercept and slope were always close to their optimum and R^2 was always higher than 0.78. Therefore, efforts to find the optimum parameters in acid soil, while keeping a high level of yield from fertilizer management, are of great significance in the rice-based cropping systems. Modeling is an important and effective tool for explicitly describing the relationships among the components of complex system in paddy rice. Modeling method is provides insight into relevant processes and their interactions, and can should be applied to study the effects of crop management under water-limited and fertilizer-limited conditions as an alternatively for submerging and no-submerging of field experiments in acid soil, Thailand.

Index Terms- Rice Growth Simulation, Acid Soil, Optimum of fertilizer, Parameters.

I. INTRODUCTION

Rice is the most important food crop worldwide, representing the staple food for more than three billion people. Since problems with food security still persist in many areas of the world where rice is one of the most important sources. The robust and reliable tools for early forecasting of rice yields were needed. Especially, the

Weather is related to decision the affect of final yield and the prediction.

Crop models have been increasingly used since the 70 centuries to analyze the interactions between plants and external factors as weather, soil and management practices. In the first years loads and more frequent thermal shock than their aircraft counterparts. In addition, many of these focused on formal the knowledge and different physiological processes into integrated systems [14].

Crop simulation models can dynamically describe the biophysical and physiological processes of growth, development and yield, and provide a quantitative tool for predicting the productivity level of crop in relationship to genotype, environment and management. Several growth simulation models have been developed for rice including SIMRIW, CERESS-Rice, ORYZA and DSSAT etc. Each of performing is well, these models use development stage or a development index to predict morphological, and use partitioning coefficients to estimate organ biomass. Some of coefficients have different values at different a stage which complicates their application.

Oryza2000 is the most important grain crop in Thailand, it's planting area accounting for 30% of all grain crops, and it's yield for 40% of the grain yield in the institute of rice research center. More than half of world's population relies on rice as its primary food staple, Thailand and other rice producing countries face problem of feeding an increasing population, Global warming and a reduction in rice planting area. Accurate prediction of rice growth and productivity under vary environmental conditions will be helpful in developing appropriate agricultural policies and ensuring adequate food production precision [3].

Central Plan of Thailand is the center of rice plantation for export. This century, the rice production was reduced due to climate change, lack of farmer's knowledge management and rice simulation tool to solve the problem in acid soil. The acid soil area has been effected to low yield and high cost of cultivation. Some of crops has reduced productivity because of acid soil level. The acid soil area may not be only one

province but also the areas that close to the river side in Thailand. This problem needs to create a system or model to learn and find the root of problem and to be success in a solving [18].

In this study, the model growth of rice (Oryza2000) was implementing in acid soil condition in BanPho and BangKhla district Chachoengsao province, Thailand. The experimental were investigated on appropriate planting, water management, fertilizer management and rice morphological with the worst and the best conditions to provide the optimum range. The result will benefit for farmers and related organization that to be a monitor in using information for experimental. Base on the measuring network performance in Total Bio Mass, LAI to determine the nature of growth and performance management model [4]. According to the results from the model there was a production cost and a reasonable profit for comparison in this study.

II. DETAILS EXPERIMENTAL

A. Location

This study was investigated on optimal nitrogen scheduling under nitrogen balancing condition was applied on cultivate command area of Bangkha (13° 43'42 "N 101° 12'30" E) district and Banpho district (3° 35'59 "N 101° 4'43" E), Chachoengsao province, central of Thailand in Bangpakong river basin, which is the main river at the east area of Thailand. This area effected from disaster every year (flooding and drought). The overall area was high acid soil and low productivity.. In Banpho district, there was 972.32 hectare (6,077 rai) and Bangkha district; there was 1,701.76 hectare (10,606 rai) for rice plantation in acid soil area [18].



Fig.1 Map of experimental at Bangkha and Banpho district, Chachoengsao, Thailand. (Red Color)

B. Materials and Methodology of Simulated

1) Rice Varieties

Based on the survey data in 2014, KD 41 varieties is the most popular of rice in these areas. The Characteristic of KD 41 varieties is 120 day-old rice, 25 plants per panicle, resistance to the brown plant hopper, and yield of 4,875 kg. per hectare (780 kg. per rai) [19].

2) Oryza2000

Oryza2000 is an eco-physiological crop growth model that simulates the growth, development t and water balance of rice in situations of potential, water limited, and nitrogen limited conditions on a daily basis. Since rice is the major crop cultivated in the study area, we selected this model for our study. While there were a few other crop growth for rice that are available, the Oryza2000 has extensively used and testing for it's efficiency in fertilizer and water limited conditions, and the results were encouraging and therefore is considered in the current study [6].

A detailed explanation of the model with the program source code was given by Bouman. The model assumes that the crop is well protected against disease, pests and weeds, and consequently the model does not consider the yield reduction due to these factors. The model computes the rate of phonological development of rice on a daily time scale based on the daily average temperature and photoperiod. The dry matter at plant organs is computed considering the daily heat units. The matter production can be detailed scientific description of dry matter is partitioned by the model among various parts of the crop (roots, leaf, stems, and panicles) using partitioning factors that was determined through calibration [7] [11].

The environment of this study, we have been leaned more details of IR64 and Oryza2000 format. And Selected the modes of running is RICETYPE = 'LOWLAND', choice of water balance we define WATBAL = 'PADDY' for lowland soils, method for evapotranspiration calculation is Penman based also ETMOD = 'PENMAN'. All of parameter from observed suitable environment data, Weather station and climatically data for simulation we use parameter from CLIMWAT 2.0 for CROPWAT of prior data, Establishment data is ESTAB='DIRECT-SEED' and Management parameters from prior experiment test from pitchayasinee in 2003 [18][19] also number of plants per hill NPLH= 2.5, number of hills NH= 44 and last is number of plants/m2 direct-seeded NPLDS = 200 and the last one is irrigation we used Irrigation supplied as input data from weather of previous data [8].

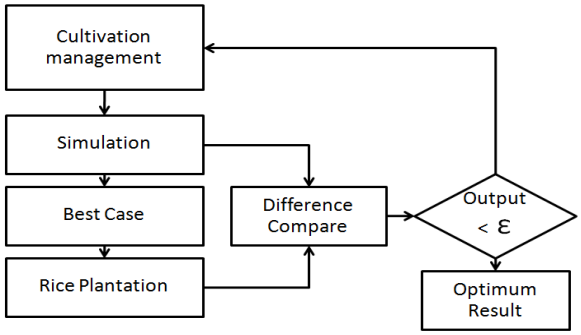


Fig.2 Methodology of Simulated and Observed Calibration and Validation of Parameters

3) Experiment Test

3.1) Simulation Test

In terms of system cybernetics theory, the processes of rice production can be considered as a dynamic feedback system. Factors that input to the system are distinguished as controlled and uncontrolled. The controlled usually refers to artificial activities or cultivation management, such as variety selecting, showing date, rate of seeding, density of transplanting, rate of fertilization, irrigation schedule, etc. The uncontrolled factors are basically natural conditions, including weather and soil.

Results that outputs from the system have two parts. One is the growth and development of crop canopy, expressed as predicted and desired dynamics of biomass, leaf area and tiller. The other is a feedback output or decision output by means of a cultivation decision-making model, which is then turned into the controlled input. The target of this system for a stable and high grain yield. The foundation of optimum canopy dynamics is the high-yielding cultivation theory developed by scientists.

During the procedures of dynamic simulation, prediction ad decision-making, the system, according to the inputs of weather, soil, fertilizer application canopy appearance, etc. by manually, first estimates the future dynamics of rice growth and developed by running a series of responsive simulation models. Then it makes a comparison between predicted and desired canopy dynamics and sends the compared results into several responsive cultivation decision-making models. Lastly, the decision to make the canopy growth 'approach' the desired one is made as a feedback output, which can be put into practice by the controller or the farmer as the controlled input of the system. Fig.2 is showed the framework of basic principle on the combination of rice crop simulation with cultivation decision-making for finding the optimum parameters in acid soil area.

3.2) Rice Plantation

The experiment was conducted in 3 treatments: (I) control or no fertilizer, (II) single fertilizer by applied chemical fertilizers as 16:20:0 ratio with urea and (III) single fertilizer by applied chemical fertilizers with absorbent. The rice growth morphological was collected data in triplicate during growth date on 5, 15, 25, 45, 70, 95 days after showing date. And the data is calculated for find the optimum parameters of simulation model in acid soil [14] [15].

3. 3) Measurement

The agreement between measured and simulated valued was quantified by using the flowing indices: relative root mean squared error, minimum and optimum equal to 0%; maximum equal to infinity , the modeling efficiency equal to minus infinity within 1 percent and optimum equal to one, if positive, indicates that the model is a better coefficient of predictor than the average of measured values, the coefficient of residual mass, optimum equal to zero, if positive indicate model underestimation and the parameters of the linear regression equation between observed and predicted values [2] [8].

$$RRMSE = 100 \cdot \frac{\frac{\sum_{i=1}^{n}(D_i)^2}{n}}{\overline{M}} \quad (1)$$

$$EF = 1 - \frac{\sum_{i=1}^{n}(D_i)^2}{\sum_{i=1}^{n}(M_i - \overline{M})^2} \quad (2)$$

$$CRM = \frac{\sum_{i=1}^{n} M_i - \sum_{i=1}^{n} S_i}{\sum_{i=1}^{n} M_i} \quad (3)$$

D_i Is the difference between S_i and M_i with S_i and M_i being, respectively, the ith measured values, n is the number of pairs S_i-M_i, $\overline{S}$ and $\overline{M}$ are the average of simulated and measured values.

Within each group of varieties, the same values for the parameters involved in growing dgree-day accumulation and thermal limitation to photosynthesis were used both for flooded and unfolded experiments of acid soil. In order to verify the presence of possible differences in model performances under fertilizer applied and unfertilized condition due to the simulation of the acid soil effect on fertilizer, we compared the means of each index of agreement. For both the variables (aboveground biomass and leaf area index) and each index, the two groups to compare were defined by including all the metrics calculated for calibration and validation: the factor was the type of fertilizer application. F-ratio and Student-t tests were performed to investigate if variances and means between groups were similar. When the F-test revealed significant differences ($P < 0.05$), a Student-t test assuming unequal variances was performed, using the Welch-Satterthwaite equation [10] to the effective degree of freedom. Otherwise, two-sided student-t tests assuming equal variances were used to investigate if the differences between groups were not significant [2] [8].

III. RESULTS AND DISCUSSION

The aim of the study was evaluation the adequacy of the Oryza2000 model for simulating rice in Thailand. We used data from experiments field for carried out characteristic of parameter in acid soil area of Chachoengsao, Thailand between 2013 and 2015.

The data used, collected under optimal condition for water and nitrogen availability, were split in to two

independent datasets for the calibration and validation activities.

1) Analysis Rice of Parameters

The Sobol' method [13] requires the distributions of the different factors in order to manage the q priority knowledge about factors in a more effective way. The distributions were retrieved from the literature, The Shapiro-Wilk test allowed one never to reject the hypothesis of normality of the distribution. Average and Standard deviation were: 3 and 0.51 for RUEmax ; 0.52 and 0.03 for k; 12 and 0.005 for LAIini ; 26 and 2.1 for SLAini ; 18 and 2 for SLAtill ; 0.65 and 0.12 for RipL0; 710 and 70 for LeafLife ; 101 and 22 for Hmax.

For each location, the sample of combinations and number of simulation run using average weather data near by the experiment area.

2) Calibration and validate of crop model with Graph

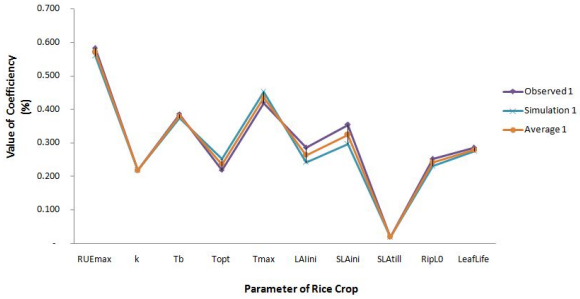


Fig.3 Parameters calibration involved with crop Growth.

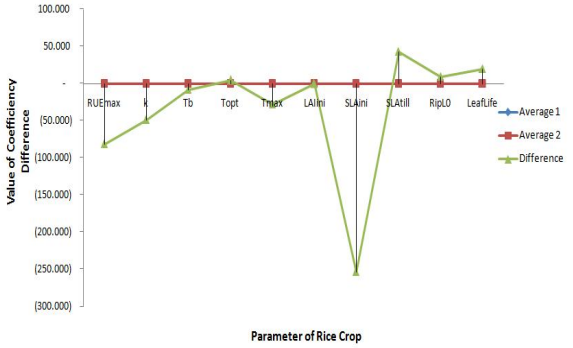


Fig.4 Calibration involved with crop growth

3) ***Comparison the costing of Observed and Simulated fertilizer scheduling of Rice Crops in Acid Soil Area by Oryza2000 model***

Table 1. Calibration Involved

	RUEmax	k	Tb	Topt	Tmax	LAIini	SLAini	SLAtill	RipL0	LeafLife
Observed1	0.583	0.353	0.253	0.353	0.387	0.320	0.387	0.187	0.320	0.153
Simulation 1	0.561	0.298	0.198	0.331	0.342	0.253	0.342	0.176	0.287	0.164
Average 1	0.572	0.326	0.226	0.342	0.364	0.287	0.364	0.181	0.303	0.159

Table 2. Validation

	RUEmax	k	Tb	Topt	Tmax	LAIini	SLAini	SLAtill	RipL0	LeafLife
Observed 2	0.350	0.220	0.253	0.353	0.320	0.320	0.120	0.320	0.320	0.187
Simulation 2	0.283	0.220	0.164	0.364	0.253	0.253	0.087	0.320	0.353	0.209
Average 2	0.317	0.220	0.209	0.359	0.287	0.287	0.103	0.320	0.337	0.198

Table 3. Difference calibration and validation were compared between Simulated and measured

	RUEmax	k	Tb	Topt	Tmax	LAIini	SLAini	SLAtill	RipL0	LeafLife
Average 1	0.572	0.326	0.226	0.342	0.364	0.287	0.364	0.181	0.303	0.159
Average 2	0.317	0.220	0.209	0.359	0.287	0.287	0.103	0.320	0.337	0.198
Difference(%)	(80.70)	(47.98)	(7.98)	4.64	(27.13)	-	(252.69)	43.40	9.90	19.66

Cost and productivity of post harvesting were compared between simulation and measurement, In addition, the plots of observed and simulated crop yield as well as biomass during the data used for validation of the model are presented in Fig.3 and Fig.4 compares between dry weight of storage organs with kilogram per hectare result of simulation schedule pattern with original application

Discussion, it is clear that the calibration with Oryza2000 model were capable of simulation the nitrogen balancing condition with the simulation of rice crop effectively, but it not impression for output. It

more useful for set up to be used our parameter to find the nitrogen application or other management schedules in acid soil of Bangkha and Banpho district, Chachoengsao Province, Thailand.

The results shown on Table 5, the simulated yield was better than the observed yields. So, the observed yield was considered as the average yields for rice yield in this study area.

Therefore, the optimum parameters with used a model for fertilizer management, it was appropriate for acid soil. This framework was promising to give appropriate yield for rice crop in this study area. However, the result in Table 5 was only simulated of our experiment. In the future, if we can use this framework of all acid soil areas, it should be more useful and accuracy in a optimum morphological of rice parameters. Other one this is a study for finding a optimum rice parameter in acid soil with a simulation (Oryza2000) or other software.

Table4. Index of agreement between measured and simulated aboveground biomass (AGB;t ha^{-1}) and leaf area index (LAI; m^2 m^{-2})

	Variable	Calibration	Validation	RRMSE	EF	CRM	Slope	Intercept	R^2
Banpho	*AGB*	x		20.78	0.89	-0.13	0.97	-0.79	0.91
			x	14.98	0.93	-0.12	1	-1.01	0.95
	LAI	x		37.58	0.5	0.22	0.85	1.17	0.71
			x	25.08	0.87	-0.2	0.84	-0.14	0.95
Bangkha	*AGB*	x		23.68	0.91	0.05	0.86	0.81	0.94
			x	13.98	0.94	-0.1	0.86	0.41	0.97
	LAI	x		22.78	0.89	-0.15	0.94	-0.33	0.92
			x	14.98	0.93	-0.12	1	-1.01	0.95

Table5. Observed and simulated crop y ld for calibration validation for different use simulation for nitrogen scheduling (kg ha^{-1}) Chachoengsao Province,Thailand.

	Banpho District		Bangkha District	
Crop Yields	Calibrate	Validate	Calibrate	Validate
Prior Data	4,646	4,646	4,316	4,316
Simulated	5,323	6,273	4,688	6,511
Difference (%)	12.7	25.94	7.94	33.71

Summary of Table 5 is shown that the calibrate simulation at Banpho was better than previous data 12.7 percent; validate simulation was better than previous data 25.94 percent; and then Bangkha area is calibrated simulation was better than previous data 7.94 percent; simulation validate was better than previous data 33.71 percent. And the last one at Bakha area the grain yield was better than Banpho because of simulation can be improved and finding the parameter of acid soil with this method.

IV. SUMMARY AND CONCLUSION

The current study, use a simulation to finding the optimum parameter in acid soil of Chachoengsao province is proposed to develop optimal fertilizer and water schedule for rice crop in acid soil area. This method utilizes a rice crop growth simulation model to identify the critical periods of growth that are highly sensitive to the reduction in final crop yield, and model based can be optimal development the nitrogen and water providing during the crop growing period in acid soil. The nitrogen provided by the model selection was performed that reduced in total crop yield is minimal during the crop.

The Oryza2000 model, which is employed as the crop growth simulation model, is calibrated and validated using previous field experimental data to corporation in the proposed methodology. This method can be accuracy with more experimental of rice fields plantation in acid soil area.

DESCRIPTION

Table 6. Parameters Validate

Parameters	Detail
RUEmax	radiation-use efficiency
k	extinction co eff. for solar radiation
Tb	base T for growth
Topt	optimum T for growth
Tmax	maximum T for growth
LAIini	initial leaf area index
LSAini	specific leaf area at emergence
SLAtil	specific leaf area end tillering
RipL0	AGB partition to leaves at emerg
LeafLife	leaf duration

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