RESEARCHES OF DIGITAL DESIGN SYSTEM OF RICE CULTIVATION BASED ON WEB AND SIMULATION MODELS

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Abstract: In order to integrate web with crop growth simulation and decision-making support system, the field experiment of different basal levels was carried out in experiment area of Jiangsu Academy of Agricultural Sciences in 2005 adopting 4 cultivars such as "Wuyungeng 7", "Yangdao 6", "Yueyou 948" and "Nangeng 41", which mainly were used in collecting cultivar parameters and updating database of them. The database of rice cultivars, soil and weather data were developed using SQL Server 2000. The pages of digital design system of rice cultivation based on web and simulation model (DDSRCBWSM) were designed using Visual Studio.Net, which included register, the main page, cultivar parameter management, site data management, parameter adjustment, decision making for rice cultivation, and so on. The DDSRCBWSM accorded with TCP/IP agreements, which could be installed and run in server (IIS5.0), and be browsed on internet, it inherited mechanism, universal adaptability and utility of rice cultivation simulation-optimization-decision making system(RCSODS), combined web techniques with research of rice growth models, set up web system of RCSODS, made agricultural technicians of main rice production area of china gain pre-sowing optimization cases and rice management suggestion of the current year with dynamic, goal and digital characteristic in accordance with soil, cultivar and weather conditions online, and to fulfill technical direction through many kind manner such as paper, internet, email, television, wall newspaper, and so on, eventually.

Key words: Web, Simulation model, Rice cultivation, Decision-making support system, Digital design

1. INTRODUCTION

China is the largest country of rice production and consumption in the world. Rice accounted for more than 50% of commodity food in China, its plant area was about from 28,000,000 to 31,000,000 ha and the total yield was from 120,000,000 to 180,000,000 ton in the normal year, which was 30% of total plant area and 43.6% of total yield of food crops in China, respectively. The matching of both good cultivars and its optimum cultivation techniques was an important scientific guarantee of steady increase for rice production in China; the Rice Cultivation Simulation-Optimization-Decision Making System (RCSODS) (Gao and Jin et al., 1992) provided an available way for the matching. However, RCSODS was still not integrating with web, and its extensive application was limited to some extent.

There were reports inland and overseas for studies on integrating database (DB), agricultural expert system (AES), decision-making support system (DSS), agricultural model, and so on with web. Many researchers integrated fertilization models, groundwater models, soil and water quality models, DSS or DB with web, respectively (Comis, 1999; Shaffer, 2002; McCown, 2002; Winston, 2002; Gunn et al., 2002; Bostick et al., 2004; Miller et al., 2004). Researches of integrating DB, AES, soil eroding models, DSS or GIS with web had also been reported (Shi et al., 1999; Yu, 2000; Gao et al., 2000; Liu et al., 2001; Yang et al., 2002; Liao et al., 2002; Li et al., 2003; Wang et al., 2003; Chu, 2003; Chen et al., 2003; Wang et al., 2004). However, the studies of integrating crop growth models and agricultural DSS with web were not reported in literature inland and overseas.

The objective of this research were integrating DB of rice cultivars, soil and weather data, rice growth models, rice optimization models with web platform, implementing internet running of rice growth models and optimization models based on RCSODS.

2. MATERIALS AND METHODS

2.1 Materials

In order to update cultivar parameter DB, WUYUNGENG 7, YANGDAO 6, YUEYOU948, and NANGENG 41 were adopted as experiment materials.

2.2 Methods

2.2.1 Field experiment

The trail was conducted in 2005 in experiment area of Jiangsu Academy of Agricultural Sciences, Nanjing, China, as split-plot arrangements (main plots were basals including 2 levels (fertilizer and no fertilizer(CK), thereinto, fertilizer included basals of nitrogen rate at 75 kg·ha^{-1}, P_2O_5 at 120 kg·ha^{-1},and K_2O at 45 kg·ha^{-1}, nitrogen rate during tiller period at 60 kg·ha^{-1}, and nitrogen rate during ear and grain period at 45 kg·ha^{-1}), sub-plots were cultivars with 4 levels) with 8 treatments, 3 replications, and 24 plots, each plot size was (10×3.029)m^2 , and there were 13 rows per plot.

The former crop of the experiment field was fallow, its soil fertility was at middling-crackajack, the soil from the topsoil (0-40cm depth) contained soil organic content at 19.8g•kg^{-1}, alkali soluble nitrogen at 138.6 mg•kg^{-1}, available phosphorus at 19.9 mg•kg^{-1}, available potassium at 141.9mg•kg^{-1} , and pH at 6.51. The deep plowing in the land preparation was conducted on May 18, planting date was on May 15, the basals was applied on Jun 15, transplant was conducted on Jun 16, urea 6.5kg (nitrogen rate 60 kg·ha^{-1}) was applied on Jun 21 and 4.65kg (nitrogen rate 45 kg·ha^{-1}) on Aug.17, the other field managements were the same as general rice field.

2.2.2 Data to be collected

They included phenology recordation, tagging and recording leaf age, investigating plant density, yield, and yield components. The shoot and tillering dynamic were investigated 1 time every 5 days, beginning from tillering date, 2 rows 30cm length each plot. LAI, the dry matter, population spectrum feature, plant nitrogen content and phosphorus content also were determined at rice main phenology period such as transplanting date, reviving date, tillering date, elongation date, heading date, anthesis, filling date, and mature date, sampling by the conventional means, thereinto, population spectrum feature was determined using EXOTECH100BX spectrum radiometer. Plant analysis (conventional items) at mature was conducted in laboratory.

3. DESIGN OF STRUCTURE AND FUNCTIONS OF THE SYSTEM

3.1 Design of DB

The DB of rice cultivars, soil, and weather data were developed by SQLServer2000. The rice cultivar DB included model parameters (rice phenology, leaf age, photosynthesis, yielding components, internode numbers, tillering rate, leaf area per plant, optimal season, and temperature index at all heading date), genetic characteristics of cultivars and knowledge DB of controlling pest and weed. The soil parameter DB involved soil types, texture, organic matter, total nitrogen, available phosphorus, available potassium, pH, ratio of volume to weight, saturation water content, field hold water content, and wilting point etc., the weather DB dealt with monthly or daily average temperature, maximum temperature, minimum temperature, sunlight time, precipitation, and raining days etc..

3.2 Design of The System's Functions

The system's functions mainly involved management of cultivar DB and site DB, cultivar parameter adjustment, and rice cultivation decision-making (see Fig. 1). The DB, knowledge DB and model class libraries, and functional modules accorded with TCP/IP agreements, which could be installed and run in server (IIS5.0), and be run on any browser of internet.

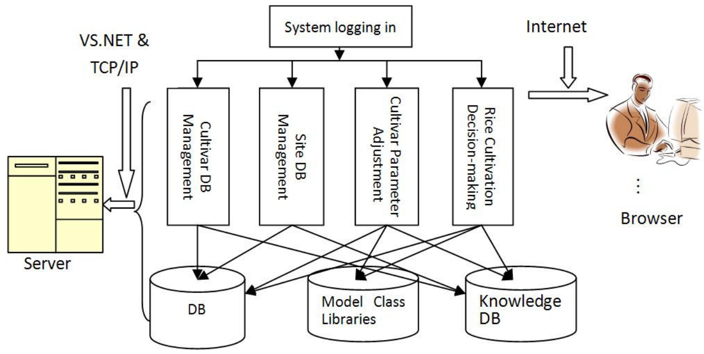

Fig.1 The function frame chart of the DDSRCBWSM

3.2.1 DB management

In order to fulfill appending, deleting and modifying of data online, the application program of ASP.NET Web in VS.NET needed to be run when calling cultivar and knowledge DB, and site DB of SQL Server, and weather simulator.

3.2.2 Cultivar parameter adjustment

In order to fulfill adjusting of cultivar parameters online, the application program of ASP.NET Web in VS.NET needed to be run when calling cultivar and knowledge DB of SQL Server, and model class libraries (rice growth models and optimum models).

3.2.3 Rice cultivation decision-making

In order to fulfill the normal and the current year decision-making of rice cultivation, show curves of the optimum LAI, shoot and tillering dynamic for rice, and build tables of cultivation case online, the application program of ASP.NET Web in VS.NET needed to be run when calling cultivar and knowledge DB of SQL Server, and model class libraries (rice growth models and optimum models).

3.3 Design of Web Pages of The System

They included enter page (Fig. 2), the main interface page of the system (Fig. 3), the cultivar DB management page (Fig.4), the site and weather DB management page (Fig.5), the parameter adjustment page (rice phenology, leaf age, photosynthesis, yielding components, node numbers and tillering rate, leaf area per plant, optimal season, and temperature index at all heading date) (Fig.6) and the rice cultivation decision-making page (Fig.7).

Fig.2 The enter page

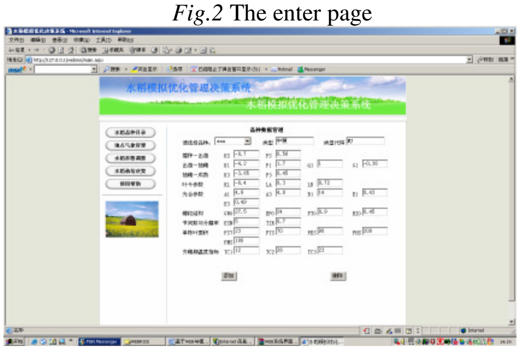

Fig.3 The main interface page of the system

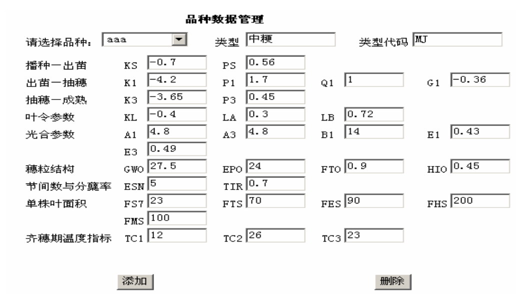

Fig.4 The cultivar DB management page

Fig.5 The site and weather DB management page

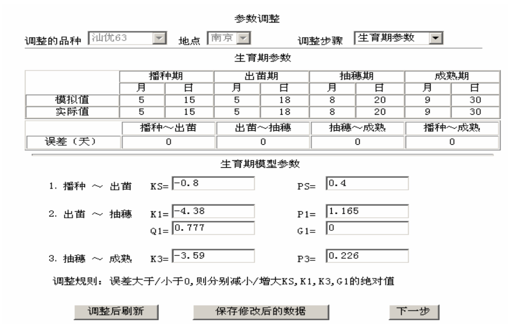

Fig.6 The parameter adjustment page

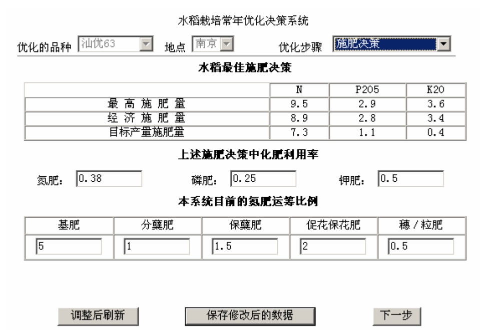

Fig.7 The rice cultivation decision-making page

3.4 The Run Environment of The System

It needed to install WIN2000Server or upward operating system, dot NET framework, SQLServer2000 or upward DB system, EXCEL5.0 or upward, and IE6.0 or upward software in server, WIN98 or upward operating system, EXCEL5.0 or upward, and IE6.0 or upward software in client.

3.5 The System Application Cases

The system may establish and down the optimum sheet of pre-planting for rice online by browser through selecting weather data in the normal year in Nanjing, cultivar data of XIANYOU 63, and soil nutrition etc., adjusting cultivar parameter of XIANYOU 63, and conducting the optimum decision-making sheet of pre-plant (Fig.8), which included the rice growth and development period, the optimum population dynamic, and the optimum fertilizer rate, the assign of nitrogen, and the control of pest and weed, and so on, with strong technique and maneuverability.

SHEET OF GOOD CULTIVARS AND ITS OPTIMUM CULTIVATION TECHNIQUES XIANYOU 63 IN NANJING REGION

ILLUMINATION- The case followed the principles of "high and stable yield, high benefit and agility", its main optimization steps were as follow: under precondition of adopting good cultivars, (1) choosing the optimum season; (2) cultivating strong seedling by suitable density; (3) deciding the optimum density in field; (4) increasing ratio from tiller to panicle by promoting valid tiller and controling invalid tiller early; (5) covering row space in optimum time to gain the optimum population; (6) gainning big ear by fertilizer in anthesis; (7) increasing grain ratio by delaying leaf function late; (8) fertilizing N, P and K according to soil and yield.

Cultivar: XIANYOU 63 | Rice crop type: Single season rice | Phenology (M-D): 05-15 | Seed yield (kg/666.7m²): 550

Cultivar type: Hybrid hsien Ting | Seedling and transplanting: Dryland, transplanting | Transplant (M-D): 06-16 | Life-cycle days (D): 138

Cultivar characteristic and cultivation outlines: Strong seedling and plant, purple sheath, deep leaf colour, middle tillering, more tighten plant type, big ear, high seed ratio, good disease resistance, and wide adaptability

Gaining ear number enough, big ear, sowing in the optimum date, wide row, the ratio to basal, tiller and ear fertilizer at 6:4

Actual season	Seedling age and density	Seedling age (D): 33				[illegible]: 30.5			[illegible]: 4				
	Period	From sowing to seedling				From transplant to elongation			From elongation to heading			From heading to mature		
	Phenophase	Sowing	Seedling	3-leaf	Draw seedling	Transplant	Re-growth	Valid tiller	Elongation	Flower step	flag leaf	Heading	Yellow	Mature
	Prediction date (M-D)	05-15	05-18	05-27	06-16	06-16	06-20	07-12	07-24	08-05	08-10	08-20	09-21	09-30
Leaf age (number)			1	3	4	4	4	12	14	16	17			
Main aims		Fostering heavy seedling				Valid tiller			Strong plant and big ear			High grains and 1000-grain weight		
[illegible]					148.1	4	4	16.1	28.2			16.1		16.1
The optimum LAI						0.1	0.1	1.5	4.8			7.6		4.1
The optimum biomass (kg/666.7m²)			0.1	25.6	333.3	23.4	23.4	70.8	186.3			630.3		1301.8
Water management		Wet, thin water				Thin water, little water			Thin water, dry and wet turning			Dry and wet turning, no water		
Soil nutrition		Fertilizing period				Basal	Tillering	Tillering	Anthesis			Ear or grain		
Organic matter (%)	1.5	Nitrogen rate (kg/666.7m²):	13.1			6.6	1.3	2	2.6			0.7		
Total nitrogen (%)	0.1													
P_2O_5 (ppm)	15	P_2O_5 rate (kg/666.7m²):	10			10								
K_2O (ppm)	138													
pH	6.5	K_2O rate (kg/666.7m²):	5			3.5			1.5			Ear number (10^4 Plant/666.7m²)		16.1
												Grains per ear (kernel)		170.5
Nitrogen rate with strong seedling						Dcreasing rate (−50~100%)			Dcreasing rate (−10~50%)			Ratio of valid grains		0.85
Nitrogen rate with weak seedling						Increasing rate (+20~40%)			Increasing rate (+20~30%)			Valid grains per ear (kernel)		145.3
Nitrogen rate under high temperature, more light						Dcreasing rate (−10~20%)			Increasing rate (+10~20%)			1000-grain weight (g)		26
Nitrogen rate under low temperature, less light						Increasing rate (+10~20%)			Dcreasing rate (−10~20%)			Yield in normal year (kg/666.7m²)		608.2
Main disease or insect		Planthopper				Sharp Eyespot			Rice Stripe Disease			Rice Blast Fungi		
1. Seed treatment: Control of bakanae diseas (Sporta 25% EC, 2000-3000 dilution).														
2. [illegible]														
3. [illegible]														
4. Control of weed in seedling bed: 42% Hanyangcaoning milk oil 1iml plus water 3-4kg/66.67m², spraying after sowing.														
Note		(1) [illegible]												
		(2) [illegible]												
		*Development unit:							Jiangsu Academy of Agricultural Sciences			May, 2006		

Fig. 8 The pre-plant optimum cases for XIANYOU 63 planted in Nanjing

4. CONCLUSIONS AND DISCUSSIONS

The DDSRCBWSM implemented integration of the rice growth models, the rice optimum models, and DB with web, developed internet platform of rice simulation-optimization-decision making, and provided basis for application of rice growth models online.

The DDSRCBWSM inherited mechanism, universal adaptability and utility of RCSODS, combined web techniques with research of rice growth models, can establish pre-sowing optimization cases and rice management suggestion of the current year with dynamic, goal and digital characteristic in accordance with soil, cultivar and weather conditions online, and to fulfill technical direction through many kind manner such as paper, internet, email, television, wall newspaper, and so on.

The DDSRCBWSM also provided internet platform combining with expert knowledge, images, video, and field task record and traceable management etc., can help to direct rice standardization production.

At present, the DDSRCBWSM has not integrated with GIS, however, the realization of region distributing and large-scale direction functions will require supports of GIS, it will need to be strengthened on this aspect.

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