Experiments and demonstrations on the rapeseed cultivation simulation-optimization decision support system

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Abstract

Three experiments and demonstrations had been carried out for the system during 2004/05 in Mianyang, Wuxue and Wuhu, all of which locate in the reaches of Yangtze River. After inputting local climate data in normal year and soil nutrient data etc., and modifying some parameters, the system generates a table of rapeseed cultivation and management case, which including the density and sowing rate, leaf area index, the number of ramifications, silique per unit area, dry matter accumulation, a proper target yield and nutrition accumulation according with the high yield population quality dynamic growth indices. Results from the field experiments and demonstrations shows that those data narrows in the diversification extension of farmers practice. As for development stages of rapeseed, their date of emergence, 5 leaves stage, initial flowering stage, final flowering stage, mature stage are believable according to the expert knowledge and farm practice. And the yield increase scope is 18%–25%, economizes cost for at least 10%, and saves farmer 15–25 labour force per ha. The system has been verified and some parameter updated using the data through the experiments and demonstrations.

Key words: Rapeseed; production; decision support system; experiment and demonstration

The Rapeseed Cultivation Simulation-Optimization Decision Support System (Rapeseed-CSODSS) was developed by the Institute of Oil Crops Research, Chinese Academy of Agricultural Sciences associated with Jiangsu Academy of Agricultural Sciences. It integrated crop-growing simulation and Optimization management with expert experience to make rapeseed management for growers. The System contains Rapeseed -growing Simulation Model and Rapeseed Optimizing cultivation Model, provides functions such as parameter adjustment, normal year cultivation decision making, current year cultivation decision making, model constructing and so on, offers corresponding cultivation projects and digital decision supports for rapeseed grower based on planting site, climate, soil, variety, planting model, cropping and target yield etc. Besides the advantages of reasonable design and good maneuverability, it has achieved the domestic leading level.

China possesses the longest history and has been one the largest country for rapeseed production, accounting for a quarter of the world's rapeseed planting area and yield. The reaches of the Yangtze River is not only the concentrate production region of rapeseed in China, taking about 40% of total planting area, but also one of the three largest rapeseed production belts all over the world. Demonstration and application of the Rapeseed-CSODSS in three experiment sites, Mianyang City in Sichuan Province, Wuxue City in Hubei Province and Wuhu City in Anhui Province, in the reaches of the Yangtze River, aimed to make full use of it in the large-scale planting and standardized management in rapeseed production, to promote the development China's rapeseed production.

1 Structure and Function of the Rape-CSODSS

The structure of the Rape-CSODSS mainly consists of principle hierarchy, model layer, database hierarchy, system hierarchy and function hierarchy. System analysis method and mathematical model had been used in the rapeseed management. Through analyzing the relationship among indexes relation to rapeseed growth and environmental components, several models has been built and integrated in the DSS, which can predict the rapeseed yield and growth status at different stages in normal and current year. Fig.1 shows the structure and function of the Rape-CSODSS.

2 Demonstration Research

2.1Collecting data of weather, soil and genetic parameters

Using weather data in 2004-2005 as current year's data (Table 1), The long duration weather data is from 1971 to 2000 (Table 2), soil nutrition (Table 3) and parameters of the tested varieties in demonstration areas were collected. The data of varieties referred include the basic biology and yield components in main growth stages, such as five-leaf stage, bolting stage, flowering stage and mature stage.

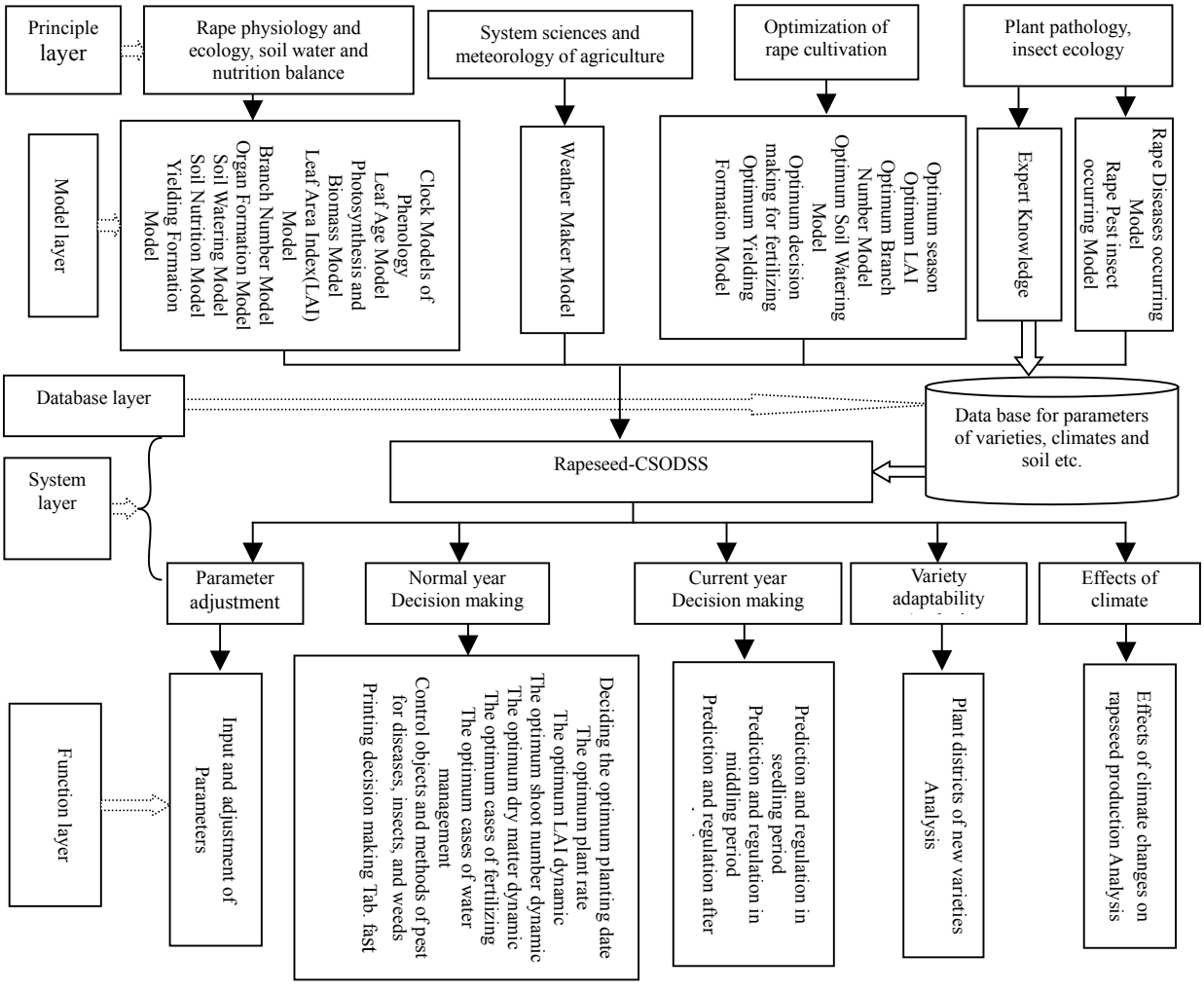

Fig.1 The Structure and Function of the Simulation and Optimization Management &Decision-making system for rapeseed

Table1 Wuxue's climate data in 2004-2005

Month	Mean Monthly Temperature(℃)			mean monthly maximum temperature(℃)			mean monthly minimum temperature(℃)		
	Mianyang	Wuxue	Wuhu	Mianyang	Wuxue	Wuhu	Mianyang	Wuxue	Wuhu
Data not shown									
Month	Mean monthly sunshine hours(h)			Mean daily precipitation(mm)					
	Mianyang	Wuxue	Wuhu	Mianyang	Wuxue	Wuhu			
Data not shown									

Table 2 Wuxue's Climate data in normal year

Month	Mean Monthly Temperature(℃)			mean monthly maximum temperature(℃)			mean monthly minimum temperature(℃)		
	Mianyang	Wuxue	Wuhu	Mianyang	Wuxue	Wuhu	Mianyang	Wuxue	Wuhu
Data not shown									
Month	Mean monthly sunshine hours(h)			Mean daily precipitation(mm)			Monthly numbers of precipitation days(d)		
	Mianyang	Wuxue	Wuhu	Mianyang	Wuxue	Wuhu	Mianyang	Wuxue	Wuhu
Data not shown									

Note: Mianyang City is at latitude 31°2′North, longitude 103°East and altitude 471 meters; Wuxue City is at latitude 29°5′North, longitude 115°22′East and altitude 12 meters; Wuhu City is located at latitude 31°09′North, longitude 118°35′East and altitude 21.1 meters.

Table 3 Soil Nutrient in demonstration areas

sites	PH	Organic matters(%)	Total N(%)	Available N(mg/kg)	Available P_2O_5(mg/kg)	Available K_2O(mg/kg)
Qingyi town,Mianyang City	5.89	2.38	0.173	88.6	40.2	40
Fulin district,Mianyang City	6.62	2.57	0.172	100.1	45	89.2
Huaqiao Town, Wuxue City	4.56	2.46	0.157	98.2	89.2	56.5
Liulang Town, Wuhu City	6.05	3.35	0.241	147.2	16.8	56.7

2.2 System adjustment

2.2.1 Variety parameters adjustment

According to the data from cultivation experiments and experiences for different varieties in the local sites, it adjusts parameters to predict characters such as growth stages, leaf age, photosynthesis, and yield, so that to simulate and optimize the management and decision making for the tested varieties.

2.2.2 Decision making in normal year

It mainly makes use of the climate data in normal year (mean value of 30 years) at the local site to optimize and make management for grower before sowing.

2.2.3 Current year decision making

It takes advantages of the weather data in different growth stages at the local sites to predict the growth trend of rapeseed in the current year, which was also compare with cultivation projects in past years, supplying the current year making decision. And this decision making also enriches and adjusts the normal year decision making project reasonably.

2.2.4 Effects of climatic change analysis

The System can analyze the effects of climatic change on rapeseed production, and proposed solutions.

2.2.5 Growth simulation

The System can simulate the growth of new rapeseed cultivars in different areas and work out the suitable planting area.

2.3 Patterned decision making

Using the climate, soil, variety and expert knowledge in Wuxue City in Hubei Province and Mianyang City in Sichuan Province and Wuhu City in Anhui Province, the System output the pattern of perennial decision making model quickly. The result of decision making, corresponding to cropping, soil and yield level, has the advantages of goal-oriented and good maneuverability, and could be adjusted dynamically.

2.4 Demonstration results

The application of the Rapeseed-CSODSS in the three demonstration fields in Mianyang, Wuxue and Wuhu showed, the yield increased 21.3% compared with CK. Wuxue got the best result in yield increasing by 27% compared with CK, whose yield increasing is the highest one among the three demonstration fields.

Table 4 Yield of demonstration and CK fields in Wuxue City

Treatment	Variety	Planting density(10^4 plant/ha)	No. of pods per plant	Seeds. per pod	Weight of 1000-seeds(g)	Yield per plant (g)	Yield (Kg/ha)
Demonstration field	Zhongyouza No.11	50.9	114.03	19.0	3.1	5.2	2710.5
CK	Zhongyouza No.11	47.0	60.0	19.8	3.72	4.42	2646.0

Taking the Wuxue demonstration sites in the year of 2004/2005 for example, the System provides the rapeseed suitable variety and optimized cultivation project pattern (Fig.2) by making use of the current year climate and variety information.

As shown in table 4, the expecting yield 2710.5kg/ha given by computer was very close to the field yield 2646.00kg/ha (Actual yield). And there is no significant difference between the Rapeseed-CSODSS output and field survey in the number of green leaves, leaf area index, dry matter weight etc. during all the rapeseed growing stages. Table 4 shows the yield and yield components of demonstration field and CK. The increment of yield in demonstration field was 555kg/ha compared with CK.

3 Discussions

Combined with rapeseed growth simulation, cultivation optimization and expert knowledge, the Rape-CSODSS has the abilities of decision making in normal year, decision making in current year, effects of climatic change on rapeseed growing analysis and suitability analysis of new variety and efficient cultivation decision making etc. For its characters of currency, practicability and explain-ability, the System can make oriented, dynamic, quantified and optimized management decision based on different climates, soils, varieties, yield levels and cropping and output the rapeseed growing pattern. Experiments showed that usually it made the yield increase 10%-21% N fertilizer using decrease 18%-28% and save cost 10% under the guidance of the Rape-CSODSS compared with CK.

The Rape-CSODSS make full use of modern high-tech method and information technology to spread rapeseed cultivation technology, which acts as an expert to instruct farmers and makes it easier to obtain obvious effect on increasing yield, quality and benefits and be accepted by farmers.

As an important part of information technology applied in agriculture, development of the Crop Management Decision Making System filled up fill up the blank of Hubei province in rapeseed management decision making system research. It will be served for the Departments of agricultural management and technology extension to realize such objects as high yield, quality and benefits for rapeseed production. Dr. Zhang Chunlei expressed that the next object of his research group was to build network Decision Making System, and the rapeseed farmers could visit the System by internet, which will increase the number of users and promote the development of rapeseed production. Therefore, it will advance China's rapeseed throughput necessarily.

Computer output pattern of No.11 Zhongyouza in Wuxue City

Explain: The Decision making is based on the cultivation principle of high yield, steady yield, high quality, and high

efficiency. Preconditioned by selecting well-bred varieties, the mainly optimization measure are: (1)Choose suitable season; (2)Control rapeseed growth, breeding strong seedlings; (3)Promote available branches and decreasing unavailable branches as soon as possible; (4)Close fields off timely (10-15d after bolting), build high yield and lodging resistant population; (5)Prolong the leaf functional period to improve setting pod rate and weight of 1000-seeds; (6)Increase organic fertilizing according to soil and yield, irrigate in time. When the measures above taken, it can increase the yield 10% compared with traditional cultivation.

Variety: Zhongyouza No.11; Type: winter rape; Sowing date (Month/day); 6th Oct, Target yield (kg/ha): 2700
Variety type: *Brasscia napus*; Sowing manner: direct seeding; Growth period (days): 224; Base seedlings (10^4/ha):27.0

Variety character and cultivation requirement: Semi-winter rapeseed, high yield, widely adaptable, high resistance for white rust disease and enduring Downy Mildew.

Planting season	Sowing date		Earliest sowing date:20th Sep.		Suitable sowing date:28th Sep.	Latest sowing date:10th Oct.	Sowing Rate(kg/mu): 7.5
	Planting date Growing stages Date(Month/day)		Sowing date—winter sowing seedling five leaf 9/28 10/5 10/8		winter—Bolting period winter 12/31	Bolting—Initial flowering period Bolting 1/23	Initial flowering period—maturation period Initial Green Yellow flowering mature mature 3/11 4/26 5/8
Leaf age			1 5		22	27.6	30.6
Main target			Cultivate strong seedlings before winter		Promote available branches while control unavailable branches	Increase the dry matter accumulation	Improve Setting Fruit Rate and Weight of 1000-seeds
Suitable population dynamics	Branch numbers(10^4/ha) Leaf area index Dry matter weight(kg/ha)		27.0 27.0 0.001 0.004 1.5 15		194.9 2.0 558.0	41586.2 2.8	214.1 214.1 6.5 1.3 624.0 5254.5
Watering management			70-80%field moisture capacity		70-80%field moisture capacity	60-70%field moisture capacity	65%field moisture capacity
OPT amount of fertilizer	Characters of soil		Fertilizing date		Base fertilizer seedling fertilizer mid-December fertilizer	Flower Fertilizer at the beginning of Bolting	
	Organic matters(%) Total N(%) Available N (ppm) Available P_2O_5(ppm) AvailableK_2O(ppm) PH	2.64 0.15 6 4.91 70 5.6	Total field fertiliz-ing	Net N:225.0 P_2O_5:198.0 K_2O:168.0 Cake fertilizer:750	112.5 67.5 45.0 198.0 168.0 750	Foliage spray with Boron	
	Unit: kg/ha						
N fertilizer regulation	(1)Seedling condition	excessive growing seedling	Field number of branches/OPT number of branches	>110%	-50—100%	-10—50%	Structure of pod: No. of pods per ha(10^4) 6000
		Weak seedlings		60—80%	+20—40%	+20—30%	Seeds. Per pod 16.3 Weight of 1000-seed(g) 3.9
	(2)Climate(compared with normal year)		A little higher temperature and more sunshine		-10—20%	+10—20%	
			A little lower temperature and less sunshine		+10—20%	-10—20%	Yield in normal year(kg/ha) 2710.5
Disease and Insect Pest Prevention			Budworm, Green worm		Budworm	Budworm, Sclerotinia disease	Budworm, Sclerotinia disease
Pest, Disease, weed Prevention	1.seed treatment: prevention of Sclerotinia disease(using 10% salt water solution to screen seeds or dipping in warm water of 50°C for 5min). Weed prevention: using herbicide; 2. Sclerotinia disease prevention; 3.Virus disease prevention; 4.Downy Midder prevention: rotation and selecting disease resistant varieties						
Note	(1) This computer pattern was corresponding to planting area, variety, soil, sowing date and yield level; (2)No of base seedlings: it should be more when sowing late or poor soil conditions; (3)N fertilizer regulation: if normal(the field branch number is 95-110% of OPT branch number), you can fertilize as usual; otherwise, you must adjusted it according the range above.						
	*Development units: Bureau of Agricultural of Wuxue City; Institute of Oil Crops Research, CAAS September,2004						

Fig. 2 Computer output pattern in Wuxue City