Application and Demonstration of Digital Maize Planting and Management System

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Abstract. Cooperating with Agriculture and Animal Husbandry Administrative Bureau of Dingxing County, Hebei province, we applied the agricultural information software of Digital Maize Planting and Management System to guide local maize production. This system can direct the maize production during the whole course including digital simulation and design of maize production, planting plan before sowing, optimal water and nitrogen operation, nitrogen pollution warning, economic benefits analysis and so on. This study tries to establish the foundation for information and digitalization of maize production and management.

Keywords: Maize; Digital management; Demonstration.

1 Introduction

Agricultural information technology is to collect, store, transmit, handle, analyze and utilize the natural, economic and social information in the course of agricultural production, management and decision-making [1]. Taking full advantage of agricultural information technology is an important and powerful measure to promote China agricultural modernization, and is the developing focus of the world agriculture. Now although the dazzling achievements have been acquired in China, the research on agricultural information is weaker and slower than developed countries [2]. The consciousness of agricultural informalization is not enough, and the information knowledge can't be spread better.

As the important content of agricultural information technology, crop simulation model has been becoming the core of agricultural production management and resource optimization management, and the basis of precision agriculture. After 50 years evolvement crop simulation model becomes more mature and possesses of more mechanism. America, Holand, England and Australia developed many crop models, some of which had been used in agriculture successfully such as DSSAT, SUCROS, EPIC, and RZWQM [3-5]. China started to study crop simulation model since 1980s. After introducing, analyzing and improving foreign crop models, researchers developed a lot of application systems [6-8].

Despite of the fast development of crop simulation model in foreign countries, only a few models can be applied to production successfully. At present its main function

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is to forecast yield. The rapid evolution and maturity of the technologies of GIS, RS, GPS, grid, computer provide better foundation and wider development prospect for the regional application of crop simulation model [9-12]. Relying on the task of "Key Technology Study on Crop Production Management and Application", combining with Agriculture and Animal Husbandry Administrative Bureau of Dingxing County, Hebei province, we studied the application and demonstration of maize production management system [13,14]. This system instructs maize production from sowing to development phases to harvest. It realizes the digital management for maize production, and will establish foundation for digital agriculture-based agricultural informalization and digitalization.

2 Brief Introduction of System

Based on the past studies, we collected related literatures and agronomic expert information in a large scale, then designed maize cooperative models in accordance with the relationship among crop, environment and management, then combined the models with corresponding database and repository, and constituted Digital Maize Planting and Management System by using technologies of system engineering theory, software engineering theory, computer and model simulation. Therefore, this software system based on simulation model serves for maize production management and scientific experiment.

The system simulates maize production process and yield of different varieties under different location with one day as time step. It has the following functions: 1) It simulates yield and yield components, main quality formation, dynamic change of soil water and N, water and N uptake and utilization by maize, N leaching, and shows the simulation results with form and chart directly. 2) It gives anticipative target yield and quality, variety choose, sowing date and density determination, fertilizer and water management according to user's requirement and biological environment of decision location. Based on simulation model, system analyzes maize variety, water and nutrition status, weather resource and offers assistant decision-making, such as the suggestions on optimal variety, sowing date and density, the amount and time of irrigation and fertilizer. 3) Maize 3D visualization shows maize growth vividly, and it is the real reflect of simulation results from model.

System application covers the whole production process. Before sowing it makes digital simulation and design for maize production, and provides the planting scheme such as optimal sowing date and cultivar. In the course of production, it can provide the reasonable water and N fertilizer application rate, and present warning for N fertilizer pollution. After harvest the production benefit analysis can be done. The user can consult the massive information about maize production and view the 3-dimension growth process visually at any time.

3 System Optimality and Simplification

This universal system can be used to most areas which grow food crops. Hebei province is a vital demonstration base for us. When we communicated with the technicians working in Dingxing county, they considered the system was too professional to satisfy the demand of plentiful and complicated parameters. They don't know the special meaning of some parameters at all. According to the demand of demonstration region, we redesigned the model framework to improve the practicability and maneuverability under the premise of retaining the model precision to the full. Fig. 1 showed the part of system interfaces. Data collection and analysis which drive the model are another important question, and model calibration and validation need a great deal of observed data. But there's no agricultural experiment on demonstration station before, so the lack of data accumulation prevents the simulation model application.

On the basis of enough demand investigation and local production analysis, we collected, sorted out and analyzed information required by model system such as the meteorology material (daily maximum temperature, daily minimum temperature, solar radiation, precipitation), soil property, variety characteristic (name, yield, spike number, kernel number, kernel weight and management).

In order to reduce the experimental cost, we collected the data which were useful for model calibration from the other tasks conducted on demonstration station. For example, the partial data of local formula fertilization experiment can be used to modify and check parameters of maize simulation model in order to get the variety characteristic parameters. At the same time, for the necessary data which can't be acquired directly, we arranged the detailed experiment to get managed by special technician. According to above data the database of six characteristic parameters for local common varieties was constructed with the identification program. With the work of the staffs engaging in computer, agronomy and the local extension department, system localization was done and the Digital Maize Planting and Management System for demonstration region was built and applied in practice. The relative validation items were set such as growth stages, yield, grain quality, irrigation, fertilizer application. The simulated and observed data were compared again and again until the model system can make prediction and decision accurately. Then the large-scale extension and application were carried out.

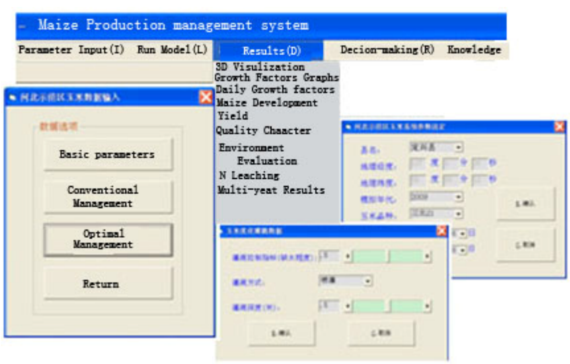

Fig. 1. System interface

4 Application Case in Dingxing County, Hebei Province

4.1 Design of Experiment

2.7 hectares located in Hebei Changli Technological Zone were chosen as demonstration area to test the optimal irrigation and fertilization function of model system. This module provides the corresponding management after running the model according to the given irrigation and fertilization indexes. The former index means the ratio of practical transpiration to potential transpiration. The latter means the ratio of N demand to N supply. We presumed all of these two indexes were 0.5, i. e. in the simulation process system recorded once irrigation or fertilization if only the index was less than 0.5.

The selected field with homogeneous property possessed 1.1% organic matter, 94 kg/mg alkaline hydrolysis nitrogen, 32 kg/mg available P content, 147 kg/mg available k content. One convenient weather station named Weatherhawk made in America collected the real-time meteorology data for instance daily maximum temperature, daily minimum temperature, precipitation and solar radiation which are the drive factors of model system.

Half of the area was taken as regulation field which was managed in terms of local measures, i. e. all of the 600kg/ha fertilizer was applied as base manure; maize was irrigated at jointing stage and tasselling stage respectively. The other half was used to demonstrate the model system, i. e. maize was irrigated or fertilized according to the recommendation measures offered by system. Maize production process was simulated at three stages of before sowing, jointing and tasselling. Before sowing maize yield and the rate and time of irrigation and fertilization were simulated on the basis of the basic data about perennial meteorology, soil property and variety characteristic. At jointing stage maize yield and the amendatory irrigation and fertilization application were provided on the basis of the basic data of the real weather material between sowing and jointing, perennial meteorology after jointing, soil property and variety characteristic. At tasselling stage the simulation was done again by using the real meteorology data between sowing and tasselling. The first simulation result meant 450 kg/ha and 300 kg/ha N fertilizer would be applied as base manure and top-dressing in jointing stage respectively; irrigation of 90mm in jointing stage and 70mm in tasselling stage would be needed. The second recommended management was that 225 kg/ha N fertilizer should be applied as top-dressing in jointing stage and no irrigation. The third recommended result indicated there were no need for fertilizer and irrigation.

The local conventional irrigation management is irrigating maize twice in jointing and tasselling stages. The precipitation was enough for maize growth in 2009, so above two stages needed no irrigation. For demonstration field the simulation result before sowing indicated the demand of irrigation in jointing stage, yet the second predicting result showed there's no need for irrigation. Here we adopted the latter simulation result because it was based on partial practical meteorology data. Therefore in this study there was no irrigation whether for regulation field or for demonstration field.

The other materials and production manner were same for these two treatments. The maize with variety of Sanbei 21 and density of 57 000 plants per hectare was sowed in 18th June, 2009, and was harvested in 10th October, 2009. The fertilizer used was special manure for formula fertilization (N:P:K=26:10:6).

4.2 Yield Comparison

Every treatment had been harvested individually. Then the yield and kernel weight were measured. We chose 20 spikes to account the kernel number per spike stochastically. The fertilizer applied in jointing stage acts on maize growth mainly from jointing to tasselling, which is the key period to decide kernel number. Below table showed the kernel number was increased distinctly and the kernel weight was a little improved in demonstration field compared with conventional field. Using this software to guide maize production indicated that adding N fertilizer 75 kg/ha resulted in a 768 kg/ha yield increase, and had significant enhancement on economic benefit.

Table 1. Yield and yield components for conventional field and demonstration field

	Spike number per ha	kernel number per spike	100 kernel weight(g)	Yield (kg/ha)
conventional field	57 000	434.3	33.4	7110.0
demonstration field	57 000	459.2	35.0	7878.0

5 Conclusion

The agricultural software based on simulation model of Digital Maize Planting and Management System was well-done in theory. This system can instruct maize production from sowing to development phases to harvest. In order to verify and perfect it we applied it in maize production management process in Dingxing county, Hebei province. The system predicted that the maize growth needed more N fertilizer than conventional N management. The results indicated that adding N fertilizer 75 kg/ha resulted in a 768 kg/ha yield increase, and had significant enhancement on economic benefit.

The performances of currency and universality for model system can be explained difficultly because of the small demonstration area and only one-year experiment result. So we intend to enlarge the extension region and increase the demonstration content to promote the application of crop simulation model.

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