THREE-DIMENSION VISUALIZATION FOR PRIMARY WHEAT DISEASES BASED ON SIMULATION MODEL

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Abstract: Crop simulation model has been becoming the core of agricultural production management and resource optimization management. Displaying crop growth process makes user observe the crop growth and development intuitionisticly. On the basis of understanding and grasping the occurrence condition, popularity season, key impact factors for main wheat diseases of stripe rust, leaf rust, stem rust, head blight and powdery mildew from research material and literature, we designed 3D visualization model for wheat growth and diseases occurrence. The model system will help farmer, technician and decision-maker to use crop growth simulation model better and provide decision-making support. Now 3D visualization model for wheat growth on the basis of simulation model has been developed, and the visualization model for primary wheat diseases is in the process of development.

Keywords: 3-dimension, visualization, wheat diseases, simulation model

1. INTRODUCTION

Growing with the development of computer technology, system analysis theory and agricultural scientific research, crop simulation model has been becoming the core of agricultural production management and resource optimization management, and the basis of precision agriculture which is implemented now in China. After 50 years evolvement crop simulation model and becomes more mature 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 series models, RZWQM and APSIM etc. Now crop simulation model mainly is used to forecast yield with typical application such as studying world food and agri-ecological belt, forecasting regional yield, evaluating the effects of environment and social economy changes on agriculture.

China started crop simulation model study since 1980s. After introducing, analyzing and improving foreign crop models, researchers developed a lot of application systems. Some units exploited their own crop simulation model. For example, Zhao chunjiang et al constructed wheat management expert system based model for Beijing (Zhao Chunjiang et al., 1997); Soil and Fertilizer Institute of Chinese Academy of Agricultural Sciences developed wheat and maize optimal fertilization expert system of Yucheng county on Huanghuai Plain; Nanjing Agricultural University integrated wheat growth model and expert system to wheat intelligent management and decision-making system (Zhu Yan et al., 2004); Jiangsu Academy of Agricultural Sciences constructed rice cultivation simulation-optimization-decision making system (Gao Liangzhi et al., 1992).

Displaying crop growth process makes user observe the crop growth and development intuitionisticly. To make the crop growth and development process visualized, many scientists have made great efforts. With respect to crop virtual technology, L system put forward by theoretical biologist Lindenmayer in 1968 became one of the main method for plant modeling (Hu Baogang et al., 2001). In order to effectively deploy short-rotation woody crop plantations for energy and fiber production at regional scales, Host et al (1996) described an object-oriented strategy for scaling ECOPHYS, an individual tree growth process model for hybrid poplar, to a plantation, which overcame the shortage of traditional individual tree growth process models, which were too complex to use at the plantation scale (G. Host et al., 1996). Deng et al (2005) developed a mathematic model for changes on morphology in corn leaf, aimed at visualizing the information for simulation model (Deng Xuyang et al., 2005). Chen et al (2005) discussed the modeling of leaf growth dynamics in winter wheat, and simulated the leaf growth dynamic using Logistic equation (Chen Guoqing et al., 2005). China Agricultural University and Beijing Academy of Agriculture and Forestry Sciences developed virtual model for maize growth (Ma Yuntao et al., 2006; Guo Xinyu et al., 2007).

Wheat is the dominating food crop in China, which possesses planting area and yield just less than rice. Wheat diseases restrict the grain quality and quantity, and imperil the food safety. From the ninety's of twenty-first century, more and more expert system for wheat diseases and insect pests prediction had been developed (Rossing WAH et al., 1994). In 1993 Denmark researched probabilistic model to predict and cure wheat mycosis, and the simulation system EPIDEMIC simulating the popular wheat diseases by analyzing the information concerning disease occurrence incidence, local climate, production and management etc. Winter wheat bactericide model WDM belongs to Decision Support System for Arable Crops (DESSAC) took weather, crop varieties, diseases occurrence incidence into account, can provide decision support for making use of wheat bactericide (D. Brooks, 1998). Gonzalez-Andujar et al developed aphid recognition expert system (J. L. Gonzalez-Andujar et al., 1993). Guo et al analysed field prevalence trend and factors of main diseases in Wheat in Luohe (Guo Chunqiang, 2007), predicted the prevalence of diseases based on systematic analysis of the impact elements of main diseases using weighted crosstabs, Fisher's two group discriminant analysis and stepwise regression analysis and built up the models for forecast. The forecast and management system for main wheat disease, wheat eyespot, wheat head scab, etc., was set up by means of Visual Basic 6.0 sharp and mufti-media technology. The system was made up of diagnosing module, forecast and control decision module, system explanation module.

From these existing studies, we can see that some only analyzed the topology structure; some model systems made plant growth visualized, but couldn’t couple with the growth simulation model data effectively. Displaying growth dynamics of leaf, stem and stamen as well as the occurrence rule and symptom for primary wheat diseases is important for teaching, research and management, especially for these users such as decision-maker and generic agronomic technician. It is necessary for them to develop a visualization system to enhance enthusiasm. This study developed 3D visualization model for wheat growth and disease, and integrated it with wheat simulation model.

2. WHEAT SIMULATION MODEL

Based on the past studies (Li Shijuan et al., 2007), we collected related literatures and agronomic expert information in a large scale, then designed wheat cooperative models in accordance with wheat growth and development discipline, and combined the models with corresponding database and repository, and constitute wheat simulation model system using technologies of system engineering theory, software engineering theory, computer and animation and image processing. The system consists of cooperative models, database and interface etc.

Wheat model system evolved from CERES-Wheat, which is a crop specific model aimed at dynamic simulation of wheat growth as affected by climatic, plant and soil properties along with certain farm management practices (J.T. Ritchie and S. Otter), computes LAI, light Interception, photosynthesis, and dry matter production and distribution in wheat, and calculates N uptake and distribution. Wheat development is divided into 8 stages in wheat development model: from sowing to germination, from germination to seeding emergence, from seeding emergence to juvenile stage, from juvenile stage to jointing stage, from jointing stage to silking stage, from silking stage to beginning of grain filling, from beginning of grain filling to physiological maturity. Temperature, water, photoperiod and genetic parameter restrict the replacement of development stages. Genetic parameter can be input by user or decided automatically by parameter determination program in system. Water balance model is built to simulate water leakage, runoff, soil evaporation, plant transpiration and root water absorption in each soil layer according to water movement rules, soil water status and wheat absorption characteristic adopting Priestly-Taylor equation and SCS Curve Number Method. N balance model mainly simulates N mineralization and fixation of organic matter in soil, N losses and uptake by crop. N deficit index calculated by the model affects directly daily accumulated value of wheat dry matter and LAI. This model considers the amount of nitrate leached out of wheat root zone (here define it as 2 meters) with water movement, and evaluated possible effects of the leached nitrate on groundwater. The effects on main wheat quality (protein, starch and fat) of variety trait, weather, cultivation management and nutrition are analyzed by grain quality model which deducted the algorithm with Logistic equation by drawing up the relation between quality and impact factors such as density, days after grain-filling, water and nutrition.

3. 3D VISUALIZATION MODEL SYSTEM FOR WHEAT GROWTH

3D visualization model mainly simulates the wheat growth based on agronomic shape knowledge, image and 3D animation technology, and the simulation data in results database from above simulation model. After getting the wheat growth dynamic data from growth simulation model, 3D Studio MAX was used to develop basic crop model files such as seed, root, stem, leaf, leafstalk, corncob and stamen, which were in the format of MAX. Then these model files formatted as MAX were transferred to format as 3DS, and then these 3DS files were transferred to data files formatted as filename.h and filename.gl. In the program compilation, files formatted as .h were used, and files formatted as .gl were used in the program execution. With wheat growth data and files formatted as .h and .gl, the 3D visualization function would be implemented by analyzing wheat growth principle in a computer, with the operational platform Windows 2000 in

Chinese version, and Microsoft® Visual C++ 6.0 was used as programming language.

3D visualization output of wheat growth includes 7 stages, i. e. seed, germination, leaf development, root growth, tiller dynamic, heading, grain-filling process. Fig.1 shows the 3D visualization results. The system supports many kinds of databases such as Access, Excel, SQLSERVER, Oracle, MySql, SqlServer etc. and shows the 3D wheat plant and population according to the setting of plant density. When simulating single plant, the effect of rain, water and nitrogen on wheat grown should be expressed. When simulating wheat population, system can show the effect of plant density. It creates animation file named as wheat.avi which supports network as display material. It makes it easy to observe and predict wheat growth, development and yield formation directly. The methods such as rigid body kinematics and flexible system were applied to model construction in order to realize the functions such as zoom, growing longer, growth, horizontal movement, rotation, color change and total shape change. User can observe whole wheat growth from different angle by means of horizontal moving, zoom in, zoom out, and so on. Horizontal axis and vertical axis are the circumgyration center.

4. VISUALIZATION DESIGN FOR PRIMARY DISEASES

Consulting a great deal of research material and literature to in-depth understand and grasp the occurrence condition, popularity season, key impact factors for main wheat diseases such as stripe rust，leaf rust，stem rust，head blight, powdery mildew, we designed the flow chart for wheat diseases visualization model (Figure 1). Each disease has its key impact factor, among which air temperature is the most important one, and is related to each disease we study. In addition, the rainfall in April affects the occurrence rule of leaf rust, and the occurrence degree of head blight depends on the days of more than 0.1mm rainfall after tasseling.

The final occurrence degree lies on the key impact factors for each disease. For leaf rust, stem rust and powdery mildew varietal resistance determine their degree. The occurrence degree of stripe rust is influenced by varietal resistance and the rainfall in april. Varietal resistance and the days of more than 0.1mm rainfall after tasseling decide the final occurrence degree of head blight. As illustrated by the case of stripe rust, according to the disease-resistant ability we classify the wheat varieties to following 4 types: high-resistance, middle-resistance, middle-susceptivity and high-susceptivity. For certain kind of variety, the more rainy days or rainfall April has, the more serious the final occurrence degree is. Here the rainy days or rainfall in April is divided into 3 groups shown in table 1. Figures in table 1 express the final occurence degree: 1 indicates there's no further development and plant retains the earlier symptom; 2 means the ratio of the leaves catching the disease to the normal leaves reaches 20%; 3 shows above ratio reaches 40%; 4 expresses more than 60% leaves catch the stripe rust, and stem catches the disease too.

By means of 3D animation technology too and analysing the occurrence rule and fractal feature, We'll develop 3D visualization model for primary wheat diseases on the basis of 3D visualization model for wheat growth and phase development, and express the occurrence and development process of main diseases realistically. Our main works consist of three steps listed below. First, the basic concept models for corresponding fractal of main

Tab.1 Influence of rainfall in April on different kinds of resistant varieties

Varietal resistance	Rainfall in April		
	Rain days >15 or Rainfall>50mm	Rain days: 10-15 or Rainfall 15-40mm	Rain days<5 or Rainfall<15mm
High-resistance	2	1	1
Midding-resistance	3	2	1
Midding-susceptivity	3	3	2

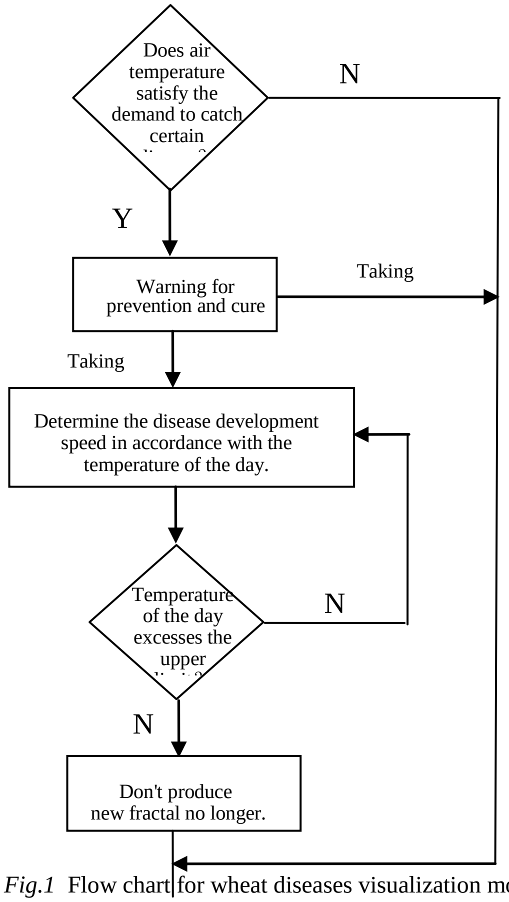

Fig.1 Flow chart for wheat diseases visualization model

wheat diseases are built with 3DMAX, and the data in models can be read in computer program. Secondly, combining with database (mainly weather data) and above basic models, 3D visualization model for wheat growth expresses the disease occurrence process in leaf, stem or ear. Finally the control over image display and 3D animation will be realized. Model development would adopt programming language Microsoft Visual C++ 6.0 and Open GL.

5. CONCLUSION

We described the implementation of 3D visualization system for wheat growth, development, yield formation, and occurrence rule and symptom for primary diseases, and the system could help the user understand the principle of wheat growth and diseases better. By the system, we can observe the process of growth, development and yield formation obviously and conveniently, at the same time, it will be a good tool to help farmer and technician to use crop growth simulation model better and provide decision-making support.

Due to the complexity of wheat growth process principle, this system might also has some shortages such as the morphology of root, leaf, stem, corncob weren't very realistic; the system couldn't simulate the population shade effect on the growth and so on. Additionally, disease occurrence rule depends on meteorological data which often are difficult to get and can't suits to the simulation location thoroughly. In the future, we will improve the function of the system by 3D digitalization of the plant and population, and more field experiment, which maybe solve above problems and make the system serve for the crop production better.

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