A Preliminary Study on A New Crop-Soil Model Using Data Analysis

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Abstract

Today, with the rapid development of the computer industry, big data systems can provide more accurate predictions for a variety of industries, including agriculture. At home and abroad, the simulation of carbon and nitrogen cycles in crop-soil circulation, nitrogen, phosphorus and potassium fertilizers have been simulated. There has been a great deal of research and application, and the combination of a large number of elemental crop-soil models with medium- and micro-element crop-soil models is unprecedented. This paper is based on the development of a crop growth model based on a large number of soil background data, planting data and crop nutrition related data, a crop-soil cycle model that can simulate crop yields for different fertilization plans for different texture soils. The crop quality corresponds to the range; on the contrary, under the expected yield and crop quality conditions, a scientific and rational application of a large amount of element fertilization scheme and a medium and trace element fertilization scheme is simulated.

Keywords

Macronutrients fertilizer, micronutrients fertilizer, simulate, crop production, quality, economic effectiveness.

1. Introduction

China has a long history of farming and a large area of cultivated land. Since ancient times, it has been named as a big agricultural country. From 1950 to 2010, China has experienced traditional agriculture and green agriculture. Since 2010, it has been transforming into functional agriculture. Its mission is to eliminate "invisible hunger" [1]. Satisfaction is no longer the focus of national pursuit. People have further requirements for the quality of agricultural products. Fruit size, color, aroma, freshness, sweetness, and taste are more likely to enter the conditions of people's choice of agricultural products. The content of nutrients such as vitamin C, vitamin A and calcium, iron, zinc and selenium has become the direction that people pursue and yearn for. Farmers supplement soil nutrients by adding fertilizer to the soil to improve crop yield and quality to meet market demand.

Since the development of China's fertilizer industry, nitrogen, phosphorus and potassium have been widely used as agricultural fertilizers in agricultural production. Their functions and application have been widely studied. In recent years, the excessive use of nitrogen, phosphorus and potassium has led to the continuous improvement of soil quality. Declining, the serious imbalance of nutrient elements and microbial population structure seriously hinders the sustainable development of agriculture. The lack of trace elements in soil has surpassed a large number of elements such as nitrogen, phosphorus and potassium, and has become a major factor restricting the yield and quality of crops.

The reduction of trace elements in the soil leads to the shortage of trace elements in the growth and development of crops, which leads to the decrease of photosynthesis in crops, the decrease of protein and fat content in fruits, the small fruit, the decrease of vitamin C and vitamin A content, and the titratable sugar. A series of problems such as reduction, aroma, taste, and immigration are adversely affected, resulting in adverse effects on fruit yield and quality, resulting in lower economic benefits. Appropriately supplemented with medium and trace element fertilizers can not only repair the soil, but also increase crop yield and quality and increase economic benefits. However, excessive application of medium and trace element fertilizers results in waste and reduces economic benefits;

the application rate is not enough, and it can not improve the soil, increase crop yield and improve crop quality. Therefore, it is necessary to develop a scientific fertilization program for farmers. However, the area of cultivated land in China can reach 2.024 billion mu [2]. According to the size of soil, it can be divided into loam, sand and clay. According to soil properties, it can be subdivided into brick red soil, red soil, red soil, yellow soil, saline soil and alkaline soil. There are 51 species such as brown coniferous forest soil. The soil nutrient and water holding capacity of each species are different, and the soil properties are changed due to the influence of human factors such as hydroponic, silt, fat and ripening on the soil [3]. Excessive types of soils and climatic characteristics have made it difficult for farmers to scientifically apply medium and trace element fertilizers. Traditional empirical fertilization proposals are not accurate enough, and there are few studies on medium and trace elements, and crop models are used to solve scientific ratios. The key issue of medium and trace element fertilizers has become one of the development trends of functional agriculture in the future. Farmers spend a lot of money on fertilizer , the table 1 shows the use of fertilizers in the last five years, the table 2 shows the use of main crop yield.

Table 1 The use of fertilizers in the last five years

Year / Fertilizer(10000t)	2016	2015	2014	2013	2013
Chemical fertilizer	5984	3022.6	5995.94	5910.86	5838.85
Nitrogen fertilizer	23105	2361.57	2394.24	2394.24	2399.89
Phosphate fertilizer	830	843.06	930.61	830.61	828.57

(From:data.stats.gov.cn/)

Table 2 The crop yield in last seven years

Year	2016	2015	2014	2013	2013
Crop yield	61625.05	362143.92	60702.92	60193.84	58957.97

(From: data.stats.gov.cn/)

2. Research background and research status of crop models

Prior to the 1960s, agricultural research relied almost entirely on laboratory and field trials. With the development of agricultural science, traditional experimental research is no longer in line with the status quo of agricultural economic development, which leads to the difficulty of popularization and application of experimental research results under the changing climate conditions and soil environment changes [4, 5]. In this case, we need to use advanced science and technology and information technology to integrate the conditions needed for crop cultivation and make predictions about crop growth.

The crop growth model is referred to as the crop model, which is a new research field that has been introduced since the introduction of system analysis methods and application of computers in crop science [6, 7]. The basic principle of crop model is the application of computer technology and mathematical methods to quantitatively express the changes of various mechanisms in various periods of crop growth and development. It is necessary to assume the ideal state of stable growth of crops and to be able to grow various crops. The physical and chemical parameters are predicted, and the budget time can be detailed to the daily unit. Through various regular analysis of crop growth, the model of the whole plant growth and development process is obtained, and finally the theoretical yield of the crop can be calculated by calculation evaluation [8]. People can use the crop model to make more accurate analysis and prediction of the relationship between the natural environment and crop growth and development, so as to better control the crop growth process and maximize the utilization of natural resources without damaging the environment. Thereby achieving the dual importance of increasing production and enhancing ecological balance.

2.1 Foreign research progress

Crop models were the fastest growing in the Netherlands and the United States. The Netherlands began researching crop models in the 1970s and developed the earliest crop models. ELCROS, the annual crop growth simulation model MACROS, the PHOTON model, and the ORYZA rice series model were introduced. These models can not only be used for crop growth. Forecasting, and integrating a large number of growth factors, such as natural environment, resources, climate change, genetic factors, etc. into the model, can more systematically and accurately evaluate the soil structure and predict the crop yield in the use area. The crop model is more adaptable and operability, allowing the crop model to truly serve agricultural production [9-11]. LINTUL is the global scale model that the Netherlands is researching and promoting. It is the first crop growth model that is not based on photosynthesis.

The crop model study in the United States was later than the Dutch study, which began in the late 1970s, but the US crop model will affect the factors of crop growth and development into more models, making the model more practical and practical. The process is more reliable [10]. The earliest US crop model crop-environment resource integrated system CERES is a decision support system. The growth environment produces a series of models that can simulate the relationship between crops and natural resource environment. The birth of CROPGRO universal model simulates the relationship between crops and crops. To make the cultivation method more diverse [11-13]. The DSSAT model is a combination of the CERES model and the GROPGRO model. It analyzes and evaluates the various conditions required for crop growth and development, thereby increasing crop yield, reducing production risks, planning planting methods and planting areas, and making full use of resources. Make new agricultural technologies better serve production and reduce crop damage while increasing crop yields [14, 15].

2.2 Domestic development

China's research on crop growth model began in the 1980s. It began to learn from foreign models. After improvement, it developed a crop growth model suitable for China's native species. Since then, research on the optimization and decision-making of crop model fertility and utilization models has become a researcher. The object of concern. The earliest model study was the rice model developed by Gao Liang and others, and then the crop computer simulation optimization decision system CCSODS was developed. On this basis, Chinese scientists have successfully developed the SMPSM corn crop model with independent intellectual property rights [16]. The model can simultaneously investigate the whole corn growth process after the integration of multiple influencing factors, and integrate various environmental factors. Greatly improved the credibility of the forecast.

With the development and advancement of information technology and systems science, we can predict the relationship between crops and the environment from theoretical analysis and rationally arrange production plans. After the 1990s, crop growth simulation models have been widely used in agricultural production, mainly in crop water balance, nutrient balance, growth period prediction, regional yield prediction, soil carbon and nitrogen cycle, agro-ecological zonal research, etc. [17, 18]. The current representative soil and crop growth simulation models include APSIM (Agricultural Production System Simulator), STICS, DSSAT (Agricultural Technology Transformation Decision Support System), CENTURY; EPIC (Soil Erosion Model), DNDC (Denitrification and Decomposition Process Model).) and so on [19]. These models can be used to simulate different agricultural management practices, crop daily growth under different climatic conditions, soil organic carbon and nitrogen, soil moisture and nitrate nitrogen dynamics, but the performance between models is different because they set crop growth. The way the process is very different, the model structure, the type of input data and the model parameters are also different [20]. More and more researchers are engaged in the development and application of models. The scope of application of the models is wider and wider, and the precision is also increasing.

3. Technical route and significance of a large number of element crop-soil growth models

Among the essential nutrients in plants, nitrogen, phosphorus and potassium are the most important elements required by plants, and they are all essential elements of plants, which are the basis of plant survival.

Nitrogen is extremely important for plant growth and development, and it plays a decisive role in plant life activities. Many experiments have shown that reasonable application of nitrogen fertilizer can significantly increase vegetable yield, but too high application rate reduces yield and reduces economic benefits [21]. Nitrogen has a great influence on the quality of crop nitrate, VC, protein and starch. Studies have shown that an appropriate amount of nitrogen fertilizer can increase the VC content in vegetables. If the dosage is too high, the VC content will drop sharply, and the effect on sugar content also shows this trend.

Phosphorus is a major component of nucleic acids, phospholipids, ATP, and nuclear proteins, and participates in the metabolism of plants in a variety of situations. Phosphorus is involved in cell formation, promotes crop respiration and promotes protein formation [22]. Phosphorus participates in the structural composition of macromolecular substances, contributes to the development and growth of crop roots, and improves the water use efficiency of the crops, thereby contributing to crop growth, increasing yield, and improving quality [23, 24]. and other experiments explained that the relationship between phosphorus and yield is parabolic, and the yield is no longer increased when the phosphate fertilizer is applied to a certain extent [25]. Wen Yang and other experiments have shown that increasing the application of phosphate fertilizer can not only significantly increase the absorption of calcium and potassium by strontium [26].

Potassium, one of the three major elements necessary for planting, is known as the "quality element". It is the activator of more than 60 enzymes in plants, and it also accounts for the first metal element in the body [27]. The ATP and NATPH contents in plants are more abundant when the potassium supply is sufficient, which contributes to the call of CO_2 and the synthesis of protein and starch. Zeng's potash helps crops to absorb nitrogen and increase nitrogen utilization.

There are many studies on the growth of crops by the combination of NPK, and there are relatively few studies on the characteristics of the action. How to accurately and scientifically apply NPK fertilizer to accurately explore the crop-soil demand. Accurate fertilization is of great significance for improving fertilizer efficiency, increasing yield, economic benefit, environmental protection, sustainable development and national economy.

4. Technical route and significance of medium and trace element crop-soil growth model

So far, there is no crop model that can simulate the effects of trace elements on crop yield and quality, and it is gradually accepted and applied with medium and trace elements, such as a large number of elements - crop growth models and medium trace elements - crop growth Combining the models to create a model that can be used for a large number of element-crop growth models and medium-micro-element-crop growth models, and predicting crop yield and crop quality through application rates is an issue that is now eager to solve.

5. Work content and implementation method

A good model is inseparable from a large number of scientific data and accurate calculation methods. The medium and trace element crop-soil model combines soil properties, crop varieties, field management, crop yield, and crop quality performance in different regions. Soil properties include soil texture, pH value, nutrient content, organic matter content of 17 plants, field management including film mulching, fertilizer application, organic fertilizer, microbial fertilizer dosage, etc. Crop yield includes yield per plant and yield per mu, crop quality Contains the unique qualities of each crop as well as sweetness, vitamin C, vitamin A, mouthfeel, aroma, and single fruit weight. Through the large collection and collation of the above factors, we will create a large database of medium and micro-element fertilizers, and at the same time accumulate the nutrients needed for crop growth through scientific experiments and related data, and combine the macro-data and fertilizer macro-data with the nutrients needed for crop growth. The training of medium and trace element-crop growth model is carried out in large quantities, scientifically and effectively, and finally the scientific, effective and application-oriented medium and trace element-crop growth model is established. The establishment process is divided into the following three stages:

The first stage: collecting data, according to crop types, extracting crop varieties, growing age, soil texture, soil pH, soil nutrient content, fertilization program, other field management, yield, single fruit weight, vitamin C content, sweetness Effective information such as acidity, hardness, and crop-specific quality characteristics, and preliminary establishment of a big data sample set;

The second stage: processing the existing data by computer scientific calculation, using multiple computer software, analyzing and processing, and obtaining a linear function;

The third stage: collecting relevant information on crop diseases, pests, phytotoxicity, grass damage, meteorological disasters, etc., and adding them to the database to enrich the crop yield and quality factors, and obtain the medium and trace elements with more scientific and applicable scope-crop growth model.

The expected effect of the medium-trace element-crop growth model is that the system can accurately output crop yield and crop quality factors by inputting crop type, variety, soil properties, field management, etc., and conversely, input crop type, variety, soil properties. After partial field management data, expected yield and quality of the filming situation, the system can show the scientific fertilization formula of a large number of elements and medium and trace elements.

The medium and trace element-crop growth model is of great significance in scientific research and agricultural development. In scientific research, the medium and trace element-crop growth model fills the blank of the crop growth model in the field of medium and trace elements, and has strategic significance for the development of crop models. At the same time, it also adds an enhanced model for climate factors, diseases and pests. Based on the foundation, there is a qualitative leap in the study of trace elements in plants; in terms of application, according to different regions and soil types, the qualitative application of medium and trace element fertilizers in planting is transformed into more scientific and rational quantitative application, reducing unnecessary production. Investing to reduce production risks caused by excessive fertilization,

Reduce production costs, correct too low fertilization plans, and then increase crop yields, improve crop quality, improve economic efficiency, and further free Chinese agriculture from the status quo of "depending on the weather, relying on experience." Scientific fertilization can also prevent soil deterioration progress, improve soil remediation, maintain soil fertility, improve soil quality, increase the number of beneficial microbial populations, enhance the friendly relationship between planting and the environment, and contribute to the sustainable development of agriculture.

6. Prospects and outlook

The research and development of the fertilization model is aimed at rational fertilization, giving full play to the soil potential and improving the fertilizer utilization rate. The application and research of medium and trace elements in agricultural production is relatively weak at present, especially the trace element fertilizer in soil application has just developed in the past two years. Up, there is no complete standard system and technical concept. The establishment of the model can greatly promote the application of medium and trace element fertilizer. Rational fertilization is an extremely complicated problem. There are many factors to be considered, especially the research on medium and trace elements. It is not very extensive. The data in all aspects is not very sufficient. It is even more demanding that the data in the database must have good realism. In the future production practice, the relevant data will be accumulated continuously, and the database will be improved and updated. On the one hand, according to the requirements of the model and the natural conditions of each place, the standardized parameter database required by the model is gradually established. On the other hand, the existing models can be optimized and combined, and the data of the medium and trace elements are added to improve the applicability and comprehensiveness of the model. Sexuality, develop crop expert systems on the basis of models, and form multi-disciplinary and multi-organizational synergies. As a large agricultural country, China's agricultural modernization with modern science and technology industrialization will have broad prospects for development.

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