Design and Implementation of Farmland Prescription Fertilization System Based on WEBGIS and Target Yield Model

Qingfeng Wei, Changshou Luo, Junfeng Zhang

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Qingfeng WEI, Changshou LUO*, Junfeng ZHANG,

Institute of Information on Science and Technology of Agriculture, Beijing Academy of Agriculture and Forestry Sciences, Beijing, 10009, China
weiqf@agri.ac.cn, luochangshou@163. com, zhangjf@agri.ac.cn

Abstract. To meet the need that real-time access to scientific fertilizer suggestions, and make full use of existing digital resources of cultivated land, a solution is proposed based on WebGIS and fertilization model. With Jinshan county of Hubei province as a case, under the support of spatial database of cultivated land resource, the prescription fertilization system is developed based on MapXtreme and target yield model. It provides intuitive and convenient services on scientific fertilization. It is also good to improve the utilization rate of fertilizer and reduce investment to achieve greater economic benefits.

Keywords: Prescription fertilization; WebGIS; Target yield model

1 Introduction

Fertilization is an important measure which is closely related to crop yield， product quality soil fertility and non-point pollution. According to the survey of China Agricultural University, fertilizer used in China is 341 kg per hectare. It is much higher than the EU standard of 170 kg per hectare. The heavy use of fertilizers will lead to nitrate content increase, soil sealing and acidification ， microbial activity decreased， ultimately， make the lower fertility, fertilizer input-output ratio decline, and water contamination[1]. According to the nutritional status of soil, scientific and rational prescription fertilization is the key to solving the problem. In recent years, the Ministry of Agriculture carries out the soil fertility survey and quality assessment throughout the country. After extensive data collection, processing, analysis of the cultivated land during the work, it has accumulated a wealth of basic data resource for the purpose of prescription fertilization. However, farmers who want to obtain fertilizer suggestion, should go to ask the relevant departments. it not only feedback delay, but also miss the farming season.

With the rapid development of WebGIS, it provides strong support for visual fertilization guidance services in the network with the advantages of easy and efficient development, seamless combination with professional application model[2]. In this study, taking MapInfo's MapXtreme as the core components of GIS, based on the target yield model which is mainly used in scientific fertilization, in support of Ajax, taking Jingshan County in Hubei province for example, a farmland prescription fertilization system is developed to provide farmers with more convenient and effective fertilizer consulting services.

2 Materials and methods

2.1 Materials

Study area: Choose the hinterland of Jingshan County in Hubei province for the study. Jingshan County is located in the east longitude 112 ° 43'-113 ° 29 ', latitude 30 ° 42'-31 ° 27'. The total area is 3520 square kilometers. The climate is conducive to the growth of various crops. It is also an major rice areas and high-quality cotton production base of the province.

Soil nutrient data: Sampling the study area, through the laboratory tests, these data were obtained include of the content of organic matter, total nitrogen, available nitrogen, total phosphorus, available phosphorus and potassium were gain, to provide an analytical basis for the amount of fertilizer calculation.

GIS maps: Digitize 1:50,000-scale topographic maps, contour maps, administrative map, present land use maps and soil maps， to provide the necessary maps for the visual fertilization.

2.2 Methods

Target yield model: It determines the amount of fertilizer based on a pre-set target yield. The principle is: Crop nutrient is supplied from the soil and fertilizer. The difference between the nutrient requirement to achieve the target yield and the amount of soil fertilizer supply is the amount of fertilizer required for the production. It fully takes into account of crop demand and soil supply, so widely used in scientific fertilization. The calculation formula, as it is in the literature 3.

MapXtreme：It is one of the most important ways to realize WebGIS. It can fully integrate with the Visual Studio which is a mainstream development platform. With the advantages of cross-linguistic, creating web services, deployment of distributed applications, it can develop the powerful internet geographic information systems quickly and efficiently. It works in thin-client. Client map images are dynamically generated based on user requests. Specific process are：The client submits HTTP requests to the

Web server. Web server receives the request, and then, submits map operation requests to map server. The MapX server was called by map server to response to user operation requests. After spatial analysis and processing, a new map image was generated to return to the web server and was embedded in a HTML page to return to the client's browser. With its support， the developer can create flexible GIS applications.

Ajax: Ajax is composed of multiple technologies including XHTML, CSS, DOM, XSTL and JavaScript etc. It is a development patter which used to create interactive web application [4]. In the WebGIS application system, for the map data is larger than text, longer time required to read and display. Users always need to wait for several seconds to gain the result information after refresh. Ajax can solve the problem. The main feature of it is that the operations on the web don’t need to refresh the page. It can significantly shorten the waiting time.

3、System Design

3.1 System Architecture

It is a three-tier architecture which contains presentation layer, business logic layer and the data layer. The user requests to business logic layer through the MapXtreme control. The request is sent to the ASP.NET engine and MapXtreme components for processing by IIS (Internet Information Server). According to the application model, the data is called from the spatial database by the MapInfo ADO.NET. And eventually, send the result back to the client in a way of Html [5].

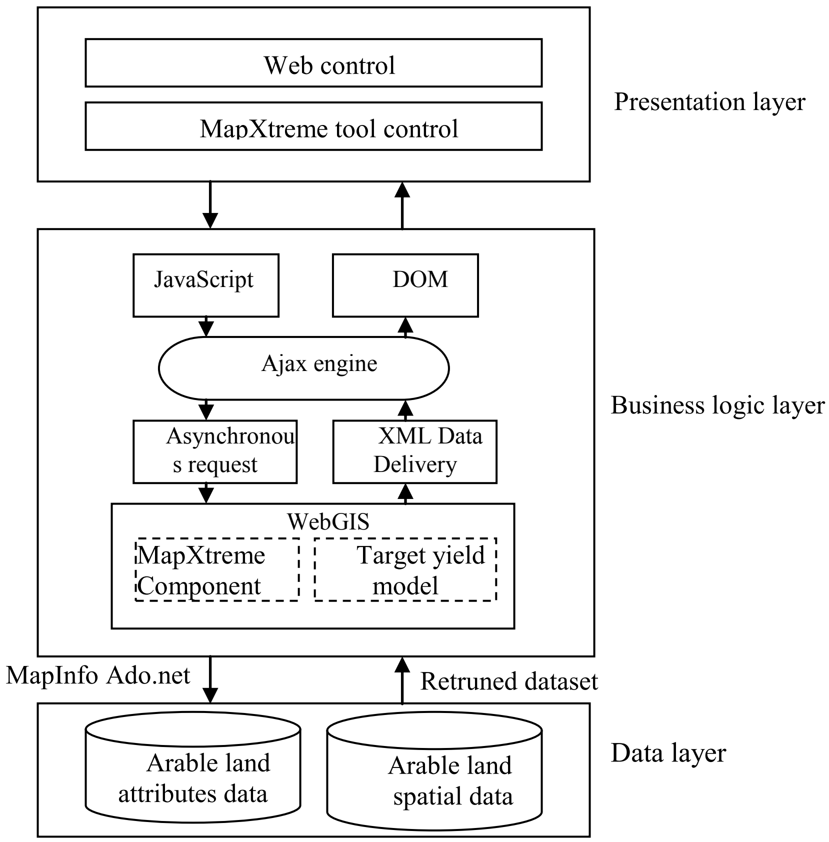

Fig.1 The three-tier architecture of the system

3.2 System Function

The system functions are mainly divided into three parts:1）Farmland information query and operation module, to provide land search, and map operations. 2）prescription generation module, it provides fertilizer calculation, and fertilization prescription printing.3) Spatial database management, including the map data and attribute data management.

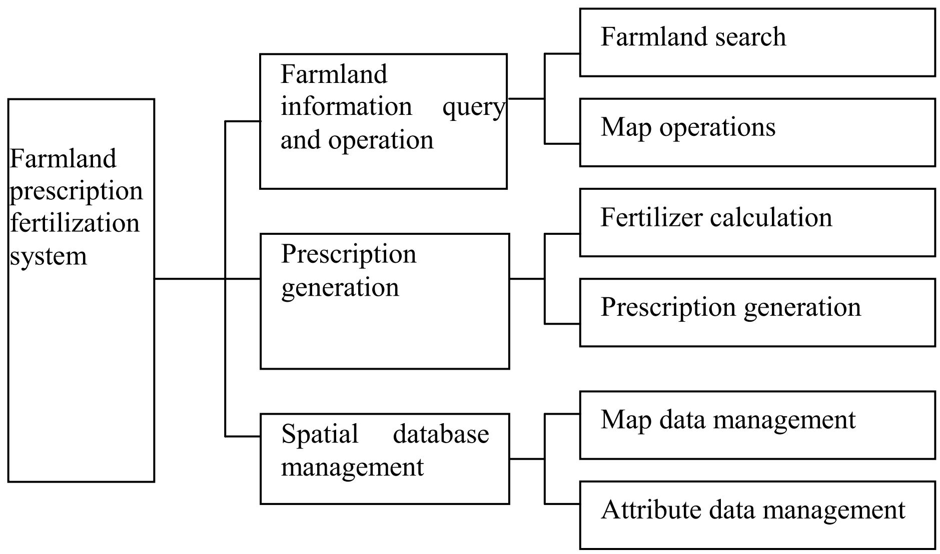

Fig.2 Functional modules of the system

3.3 Spatial Database construction

This study mainly has the following characteristics: Spatial database is composed of spatial data and attribute data. Spatial data is managed by .tab file of MapInfo，it is the data source of visual map in browser. Fertility evaluation unit map was associated with soil nutrient information by ID, so that spatial data and attribute data are connected. The attribute data of soil nutrient, crops type, fertilizer type, fertilizer parameters are managed by the ACCESS.

The system collected the nutrients required per 100kg production of 30 kinds of crops, and nutrient content data of 40 kinds of fertilizer which is commonly used. The nutrient test correction coefficient and utilization rate of fertilizer were calculated by statistical data which is provided by the district.

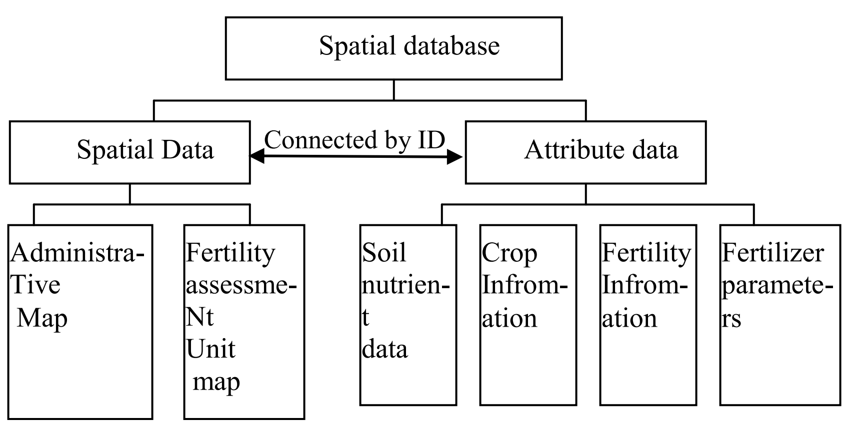

Fig.3 The structure of spatial Database

3.4 Prescription Fertilization Process

The prescription generation process is designed as follows:

Step 1: Prescription fertilization block selection. Based on user selection, corresponding nutrient information of the block is recorded by the system.

Step 2: Crops selection. Based on user selection, fertilizer requirement data of the crop is recorded by the system.

Step 3: Input target yield. The value of target yield is entered by the user or provided by system. The system default value is calculated according to the rule that grain crop increases 13%,vegetable increases 25%,fruit increases 18% base on the last three-year average yield.

Step 4: Fertilizer selection. Based on user selection, corresponding nutrient content in the fertilizer is recorded by the system.

Step 5: Call the target yield model and calculate the amount of fertilizer. Due to legume crops have the capacity of nitrogen fixation，nitrogen absorption from the soil only about one-third，therefore，its nitrogen requirement need multiply the result which the model was calculated by one-third [6].

3.5 Function realization

In the map operation page, select or enter the town and village names where the block is located，then, use the information tool select the target location. The selection result will be marked by the Find Object of MapXtreme. And the block attribute information will be show in the textbox in the bottom of the page，Including fertility level, paddy field or dry land, nutrient status, physical and chemical properties, section properties, site conditions, etc. Click the button of "处方施肥"（Fig 4），the attribute information of the block is passed to the prescription page. According to the tip of the page, select the crop, fertilizer, click the "生成施肥处方"（Fig 5），fertilizer prescription will be generated.

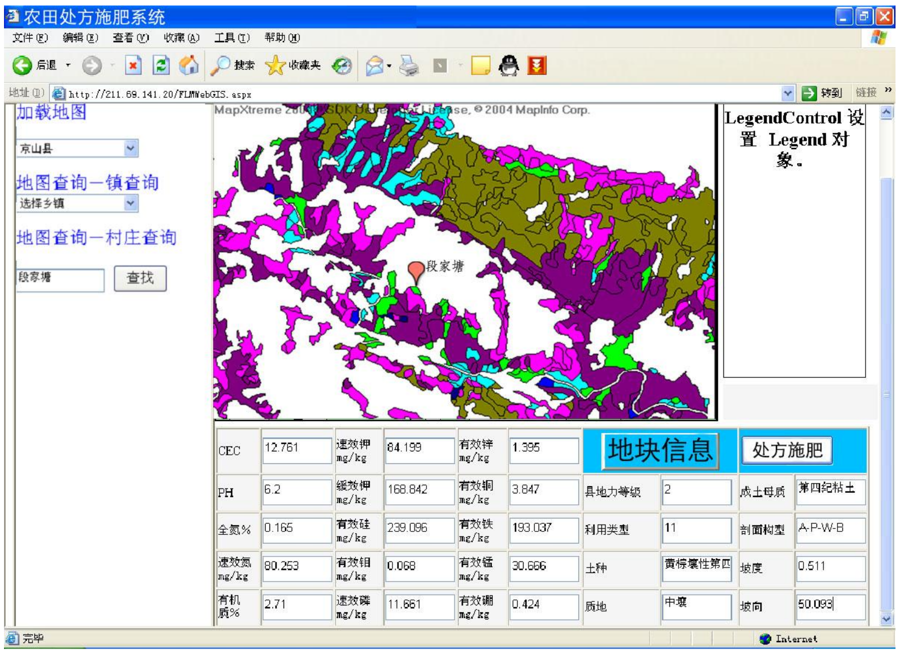

Fig4 The block information interface

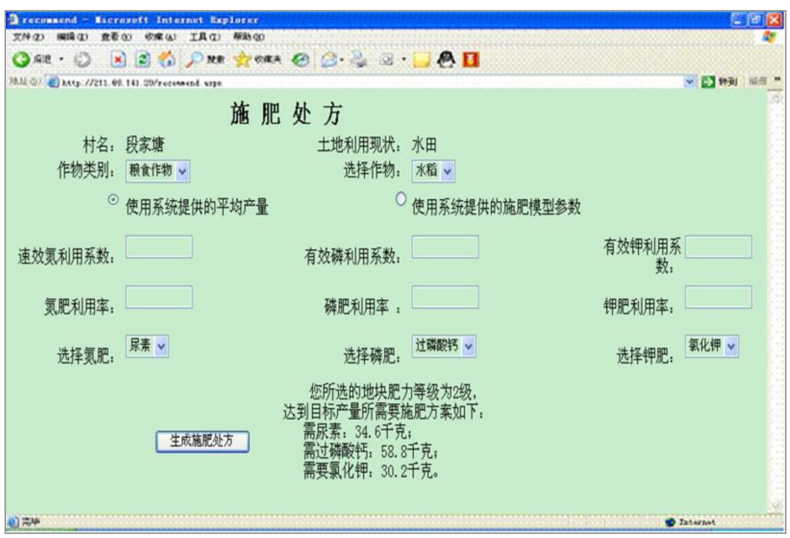

Fig5 The prescription generation interface

4、Discussion and conclusion

In this study, a farmland fertilization prescription system based on WebGIS and target yield model was applied to provide fertilizer guidance. In the support of Ajax, it has the advantages of real time response to the fertilization consulting. It is intuitive and easy to use, and will provide agricultural related user with a new tool to solve the fertilization problems. It is good to less investment to achieve greater economic benefits.

This study conducts a preliminary exploration of farmland prescription fertilization using WebGIS and target yield model. As the system application, the functions are needed to be improved. In research, with the increasingly demand of precision fertilization service, model improvements are needed to further explore.

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