

Research on the model of variable-rate fertilization in Maize Based on Geographic Information System

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Abstract: Agriculture is a giant and complex system, and agricultural problems are closely related to the time and space information. Information agriculture is based on the soil characteristics of crop growth, adjust the input of crops. The promotion of precision agriculture can improve the productivity of the soil, with the least or the most savings to achieve the same income or higher income, and improve the environment. This paper mainly introduces the establishment of the model of variable rate fertilization of maize and the process of field operation in Changchun City, Jilin Province Nong'an County and combination of Geographic Information System and precision agriculture, save the input of chemical fertilizer, improve maize yield and efficiency.

Introduction

Precision agriculture is developed from the field of agricultural production and an interdisciplinary field of study at home and abroad has been widely recognized. Precision fertilization is one of the core precision agriculture. Precision agriculture is based on soil properties for crop growth, adjusted for crop inputs, namely on the one hand to grasp farmland soil properties spatial variability and productivity, on the other hand to determine the production target crops, locate the "System diagnostics, optimization formulation, technical assembly, scientific management" to improve the productivity of the soil, improving the environment, soil nutrients balanced, efficient use of all types of agricultural resources, to achieve economic and environmental benefits^[1-5].

GIS is from the 1960s, developed a new IT tools^[6]. GIS application in agriculture is very broad, such as agricultural production forecasting, crop suitability analysis, Soil erosion, land production potential, agricultural research system modeling and simulation, and the GIS and RS, GPS technology for integration. Combined with GIS and precision agriculture is today more important issue of agriculture, adding GIS, GPS and RS, and other related computer technology in agricultural production, improve efficiency, output, it enables better integration of the two fields^[7]. In this paper, based on GIS technology and maize variable rate fertilization in precision agriculture operations combined to complete land acquisition by GIS and mapping, and then complete the process variable fertilization by large fertilizer operations. Thus greatly improving the tedious manual analysis of previous fertilization, and saves time and effort, and improve efficiency.

Materials and Methods

Source material

The data comes from Changchun City, Jilin Province Nong'an County Helong Town Chenjiadian Village three experimental plots, named for JiaQian JiaXi and WenShi, including sampling point selection, land surveying, spatial data and model data. Soil sampling point by determining the content of effective elements (nitrogen, phosphorus, potassium, organic matter, PH value, as well as nitrogen, phosphorus and potassium utilization, etc.), determine the amount of fertilizer through the soil. Lot data including soil texture, land area, soil production capacity. Spatial data includes original plot, the sampling points GPS, variable fertilizer prescription diagrams. Model data including fertilization model, fertilization data, variable fertilizer. Soil monitoring point data using the sampling results of tests in 2015, the use of handheld GPS positioning using handheld mapping predetermined plots, to get latitude and longitude edge, thus rendering the original plot, presented on a computer. Positions of the three experimental plots of JiaXi sampling point distribution shown in Figures 1 and 2 below.

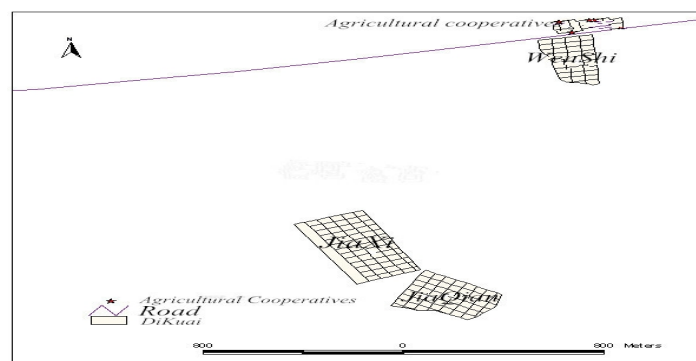


Fig 1. Precision fertilization core block

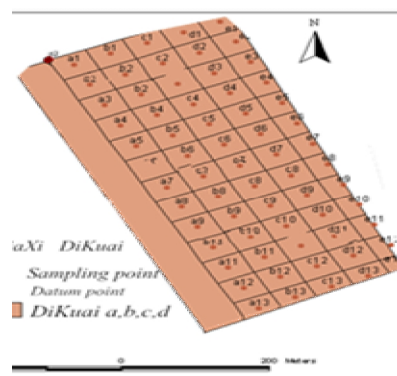


Fig 2. Sampling point distribution map of JiaXi

Research methods

Establish maize variable fertilization model

Establish maize variable fertilization model is the theoretical basis of the implementation of variable rate fertilization. The maize variable fertilization model is the establishment according to a predetermined sampling point plot of nitrogen, phosphorus, potassium (in this case only to these three elements, for example) and other elements. Here is an example of sampling points a1 ~ a5 in JiaXi, the nitrogen, phosphorus and potassium content distribution as shown in Fig 3.

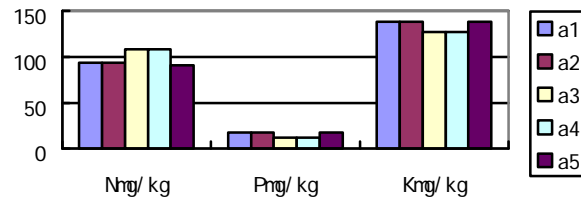


Fig 3. Content distribution of N, P and K in sampling points a1~a5

In calculating the nutrient content of the soil arable farmers, we used the weighted average method. The formula is:

$$Y = \sum_{i=1}^n \frac{A_i}{A} \times B_i \quad \text{Eq.1}$$

A represents the total cultivated area for the user, A_i represents the i -th grid within the user's area of arable land, B_i represents the nutrient content of the soil within the i -th grid. Through the above-mentioned formula, we measured the content of N, P, K elements and analysis.

If the information and nutrient value of the soil was determined by GPS positioning database already contains the farmers, then the system will automatically display the content of soil nutrient value of the farmer's land. In available phosphorus, for example, the program code is as follows:

(1) Display nutrient content of the soil

```
m_CSP.ResetContent( );// Empty the contents of the list box
```

```
m_CSP.AddString("<10");
```

```
m_CSP.AddString("10 -15");
```

```
m_CSP.AddString("15 -25");
```

```
m_CSP.AddString("content >25");
```

```
// Interval values of available phosphorus added to the list box
```

```
if(m_pZhuce.m_P2O5 == "")
```

```
m_CSP.SetCurSel(2);
```

// If the database is not the farmer's land available phosphorus nutrient amount, "15-25" entries are displayed for the user to select the reference.

```
else
```

```
m_CSP.SetWindowText (m_pZhuce.m_P2O5);
```

```
// Otherwise, it displays the amount of nutrients that farmers' plots available phosphorus.
```

```
UpdateData(FALSE);
```

(2) Content value extraction of soil nutrients

```
CString temp_Ph1;
```

// Temporarily save available phosphorus, may be interval values, it may be content value determined by user input or GPS positioning of soil nutrients.

```
m_CSP.GetWindowText(temp_Ph1);
```

```
//Extraction of input data
```

```
if (temp_Ph1=="<10")
```

```
P_hl=10;
```

```
else if(temp_Ph1=="10 -15")
```

```
P_hl=12.5;
```

```
else if(temp_Ph1=="15 -25")
```

```
P_hl=20;
```

```

else if(temp_Ph1=="content>25")
P_hl=25;
// If the extracted data interval value, the available phosphorus content is a boundary value or
intermediate value range.
else P_hl=atof(temp_Ph1);
// Otherwise, the database export character data is converted to floating-point data, used to
calculate the amount of fertilizer. Code calculates the amount of phosphorus fertilizer is as follows
CString temp;
CEdit * pEdit
=(CEdit *)GetDlgItem(IDC_EDIT_mbcl);
pEdit->GetWindowText(temp);
// Maize yield value extraction target of
double mbcl=atof(temp);
return
(mbcl* 0.0115/2-2.25 * tryfh1* trgyxs)/(0.46*0.25);
// "tryfh1" is soil nutrient content, "trgyxs" is soil effective nutrient conversion factor,
diammonium phosphate containing P2O546% [8].

```

If each sample point are subjected to the same amount of fertilizer, so some will be excessive, while others lack, so the variable rate fertilization model is necessary, and is extremely effective. Soil sampling point corresponding to an amount corresponding to impose fertilizer will increase yield and efficiency ^[9,10]. Therefore, using the formula to determine the final amount of fertilizer, combined with the actual operation of variable rate fertilization diagram, we came to the conclusion, comparative analysis, can greatly improve production efficiency, reduce costs and achieve a greater degree of green fertilization, precise fertilization.

Process Research

Process variable based GIS maize fertilization research is not complicated, Applied to the software include ARCVIEW, SMS Basic, EXCEL and so on. Specific process of variable-rate fertilization shown in Fig 4.

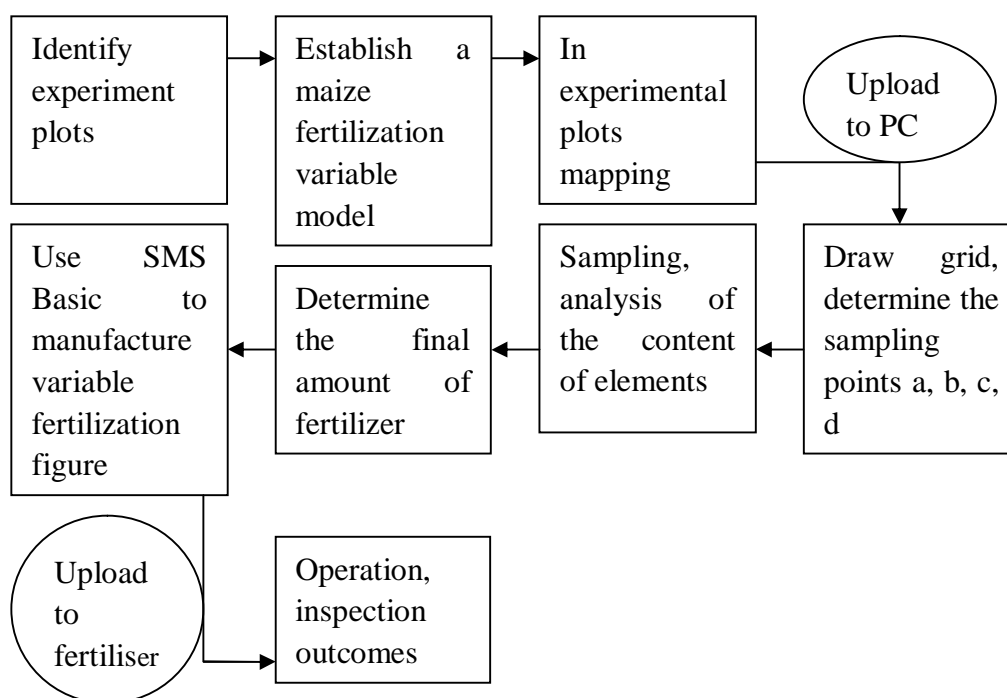


Fig 4.Variable rate fertilization flow chart

Soil nutrient analysis

For from the sampling point samples were taken back to the soil nutrient analysis, soil major elements, such as nitrogen, phosphorus, potassium, organic matter, P utilization, N utilization content distribution, determine the value of the final amount of fertilizer. According to the literature, the utilization of nitrogen season in developed countries up to 50% to 60% , the utilization of phosphorus season is generally 10% to 30%, potash quarter utilization rate of 20% to 60%. In China, nitrogen, phosphorus, potassium average utilization rate was , respectively, 35.0, 19.5% and 47.5% percent, showing that our nitrogen use efficiency below the world average ^[11]. Therefore, scientific fertilization is necessary. Part of the sampling points and elements in a soil fertilizer in JiaXi in Table 1 below.

Table 1.Sampling point “a” element content and final fertilizer application in JiaXi

D kuai	Sampl ing poi nt	Longi tude	Lat i tude	N ng/kg]	P ng/kg]	K ng/kg]	P ut il i z a t i o n	N ut il i z a t i o n	The final amount of fertilizer
Ji aXi	a1	125. 139558088680	44. 0779319630533	94	17. 55	138	0. 85614538	0. 262480629	1270. 981
Ji aXi	a2	125. 139738705585	44. 0775981212080	94	17. 55	138	0. 85614538	0. 262480629	1270. 981
Ji aXi	a3	125. 139919322490	44. 0772642793627	108	11. 85	127	1. 148936527	0. 232519262	1355. 136
Ji aXi	a4	125. 140099939394	44. 0769304375175	108	11. 85	127	1. 148936527	0. 232519262	1355. 136
Ji aXi	a5	125. 140280556299	44. 0765965956722	91	17. 55	138	0. 85614538	0. 270019258	1270. 981
Ji aXi	a6	125. 140461173203	44. 0762627538269	91	17. 55	138	0. 85614538	0. 270019258	1270. 981
Ji aXi	a7	125. 140641790108	44. 0759289119816	91	11. 4	138	1. 182740171	0. 270019258	1362. 822
Ji aXi	a8	125. 140822407013	44. 0755950701364	91	11. 4	138	1. 182740171	0. 270019258	1362. 822
Ji aXi	a9	125. 141003023917	44. 0752612282911	98	17. 55	127	0. 85614538	0. 253103127	1270. 981
Ji aXi	a10	125. 141183640822	44. 0749273864458	98	17. 55	127	0. 85614538	0. 253103127	1270. 981
Ji aXi	a11	125. 141364257726	44. 0745935446006	108	30. 85	138	0. 561124149	0. 232519262	1127. 189
Ji aXi	a12	125. 141544874631	44. 0742597027553	108	30. 85	138	0. 561124149	0. 232519262	1127. 189
Ji aXi	a13	125. 141725491535	44. 0739258609100	115	17. 55	138	0. 85614538	0. 220114504	1270. 981

Variable fertilizer prescription map

Variable fertilization technology is becoming the key elements of modern farm machinery and equipment research field worldwide ^[12]. With the help of ARCVIEW complete mesh partition manually, choose the sampling point. SMS Basic is a software, it is completely directed to agriculture and the production of fertilizer prescription map, you can use it to create convenient and efficient variable fertilizer prescription map. Fig 5 is a variable fertilizer prescription map of JiaXi.

Shades of color in the figure represents the number of changes of fertilizer, so as to achieve the purpose of variable rate fertilization.

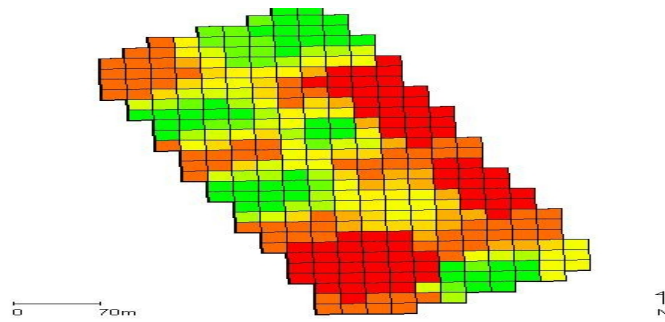


Fig 5. Variable-rate fertilization prescription map of JiaXi

Variable fertilization machine

Because of the variable rate fertilization in precision agriculture applications has just started, most of the need to introduce foreign machinery and technology, and foreign machinery to sell all of the overall package, and mostly large machinery is very expensive and difficult to maintain. Therefore, we developed for our country and variable fertilization system with independent property rights, not only to reduce costs, for the sustained and stable development of China's agriculture can also play a role. Our efforts in this regard have been doing^[13,14]. In this experiment we use a John Deere 7200 tillage planter. As shown in Fig 6. There are three boxes with fertilizer and six boxes containing seeds during the operation in the field, seeding, fertilization is carried out with smart decisions and implement variable by tractor internal GPS and field computer control. Variable fertilization diagram in the field of computer displays, GPS location by latitude and longitude on the diagram corresponds to to implement variable rate fertilization.



Fig 6. Variable-rate fertilizing machine

Implementation and Application

Maize variable rate fertilization in establishing a model while after the completion of the final amount of fertilizer is known, will make the completion of variable fertilization diagram into field computer, the field computer connector with GPS and variable fertilization machine You can follow the latitude, longitude and fertilizer on the field computer displayed during the experiment, comparative analysis, production efficiency is greatly improved, and saving a lot of cost.,

Conclusion and discussion

In three experimental plots variable fertilization test of Changchun City, Jilin Province Nong'an County Helong Town Chenjiadian Village results show that the model through the establishment of variable rate fertilization and the use of procedures meshing and GPS positioning technology, can better get variable fertilizer and can accurately be variable fertilization; according to soil element content and the amount of fertilizer determined, According to the soil element contents and final determination of the amount of fertilizer, the maize variable fertilizer prescription map drawn to achieve precise fertilization; Based on the model of the establishment of variable rate fertilization on the actual conduct field experiments and achieved good results, effectively increase maize yield, cost savings, improving the environment and efficient economic and environmental benefits achieved.

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