Multi-objective Optimization Analysis Model for County Range Soil Nutrients Sampling Point Layout Based on Improved Genetic Algorithm

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Abstract: The layout of soil nutrients sampling points directly influence on the representative of soil samples and the precision of fertilization, also on sampling efficiency and sampling costs. By analyzing the various factors of county range farmland soil nutrients sampling, and setting the boundary conditions and objective function, the paper established multi-objective optimization model for distribution of soil sampling points in large number of small farmlands of county range, the solution of the model based on improved genetic algorithm was also discussed in the paper. Agriculture and soil nutrients data of Baoyin County in Jiangsu province was used to verify the model and the solution process; the result shows that the model is suitable for soil sampling points layout optimization analysis for county range which including a large number of scattered farming farmland.

Keywords: Soil Sampling, Multi-objective Optimization Model, Genetic Algorithm, Geo-statistics

INTRODUCTION

1. Study site descriptions

Baoyin County (Fig.1) is located in middle area of Jiangsu Province, China (33°02′46″- 33°24′55″ N, 119°07′43″-119°42′51″ E) and covers a total terrestrial area of 1087 km^2 with arable land area of 654 km^2. Baoyin County has a humid monsoon climate in the north subtropical zone, with four distinct seasons, plentiful precipitation, abundant sunlight, and a long frost-free period. The average annual temperature and precipitation is 14.2 °C and 973 mm.

$$\begin{cases} Minimize(W) \\ W = \sum_{i=0}^{n} X_i \times \Delta_i \\ X_i = |f_i - p_i| \end{cases}$$

Fig1: Layout of farmland parcels in research area

Multi-objective Optimization Model for Soil Sampling Point Layout

The objective of the optimization model is to correctly distribute the limited soil sampling points into county range which covers a large number of scattered farming farmland parcels, the model below to describe the solution using multi-objective optimization model.

Where W is comprehensive measurement index of soil sampling point layout representativeness which considering characteristic value of specified farmland parcel attribution. X is the different between ratio of the points located in the certain farmland parcel and the ratio of the farmland parcel which own characteristic value of specified attribution. i is the number of the farmland parcel attributions which be considered. Δ is the weight of specified attribution. f is the ratio of the farmland parcel which own characteristic value of specified attribution. p is the ratio of the sampling points located in the certain farmland parcel.

Result & Discussion

Base on agriculture area data of Baoyin County and GIS software, the paper developed the Java program to implement the multi-objective optimization model for soil sampling point layout. the ratio difference were shown in Table.2，the output soil sampling points coordinates and points layout map were shown as Fig.2.

Table.2：occupy ratio compare of sampling points & farmland parcels in certain attribution

FieldsoilType	**Sand**	**Sandsoil**	**Loam**	**Claysoil**	**Clay**	**TOTAL**
Ratio of farmland parcels	*12%*	*8%*	*19%*	*61%*	*0%*	*100%*
Ratio of points	*10%*	*12%*	*19%*	*59%*	*0%*	*100%*
FieldType	**Fields**	**Greenhouse**	**Orchards**	**/**	**/**	**/**
Ratio of farmland parcels	*82%*	*6%*	*13%*	*/*	*/*	*100%*
Ratio of points	*82%*	*6%*	*13%*	*/*	*/*	*100%*
FieldQuality	**Low**	**Middle**	**High**	**/**	**/**	**/**
Ratio of farmland parcels	*18%*	*66%*	*16%*	*/*	*/*	*100%*
Ratio of points	*16%*	*67%*	*17%*	*/*	*/*	*100%*
Altitude	**Low**	**Middle**	**High**	**Very high**	**Peak**	**/**

Ratio of farmland parcels	*14%*	*28%*	*45%*	*14%*	*0%*	*100%*
Ratio of points	*17%*	*31%*	*40%*	*12%*	*0%*	*100%*

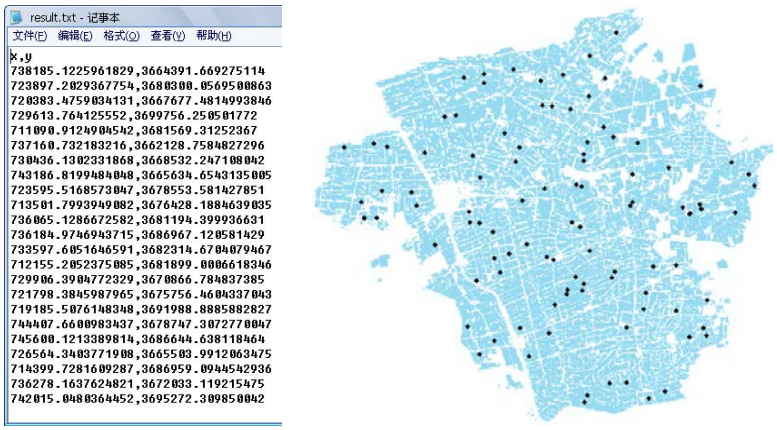

Fig2: optimization result of farm soil sampling point's layout

Conclusion

Soil sampling point layout optimization is supposed to explore the solution for reducing sampling points on the premise of keeping the sampling accuracy, or find out the sampling point layout methods to ensure the best representative under the restriction of points quantity. this paper comprehensively considered a variety of farmland environmental factors affected soil sampling points layout to put forward a kind of multi-objective optimization decision-making model of farmland soil nutrient sampling point layout, which is suitable for county range which including a large number of scattered farming farmland parcel, and solve the model by using the improved genetic algorithm to provide the method and basis for carrying out regional farmland soil sampling more scientifically and rationally.