Soil Suitability Evaluation for Tobacco Based on Grey Cluster Analysis

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TITLE SOIL SUITABILITY EVALUATION FOR TOBACCO BASED ON GREY CLUSTER ANALYSIS

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Abstract: Suitability evaluation of soil for tobacco is the base of spatial analysis and optimization disposition. It provides scientific basis for reasonable development of soil for tobacco. Taking soil in San Menxia city of Henan province as a study of object, five factors which had relation of tobacco growth are adopted, grey cluster method are carried out to appraise suitability evaluation. The result shows that some soil area of Lingbao, Mianchixian and Shanxian are higher suitability areas that contain higher organic matter and K contents ,while the soil area of Lushixian has lower organic matter and N contents are less suitability area. Compared with traditional methods, grey cluster method determined the weight based on factors. The result is objective reasonably.

Key words: soil nutrients; suitability evaluation; grey cluster method

1. INTRODUCTION

Soil planting tobacco suitability evaluation aims to optimally allocate crop planting through measuring the coupling of designating crop to given tobacco land, and considers simultaneously soil physical features and current/future land use patterns (Qiu, *et a*l., 2005) .Soil condition is the base of top quality tobacco engineering and the main environmental factor that affects the quality of tobacco leaves(Zhang, et al.,2003).Soil suitability evaluation for tobacco has important practical significance that not only fully and rationally use natural resource and further develop land potential, but also promote social economic sustainable development. Qiu researched dynamic soil suitability evaluation by using artificial neural network method and discussed how to realize soil suitability evaluation in time and space (Qiu, *et al*., 2002); Liu studied the implementation method of expert system for soil suitability evaluation (Liu, *et al*., 2001); Chen studied the soil fertility suitability evaluation for tobacco in Henan province by using the methods of AHP and fuzzy mathematics (Chen, *et al*.,2007); Wang analyzed spatial variability characteristics of tobacco-planting soils and made suitability evaluation (Wang, *et al*.,2008).Soil suitability evaluation used the methods of parametric, geo-statistics(Chen, *et al*.,2003), fuzzy mathematics(Chen, *et al*.,2007) had been carried out in china. But the evaluation with the method of grey cluster is rarely reported.

The tobacco-growing distribution area is from 300 to 1500m above sea level, topography complex and soil nutrient is of great spatial variability. This study take Sanmenxia soil as study object use grey cluster method to evaluate soil nutrient suitability to detect soil nutrient. The result will provide reference for rational distribution of tobacco, balanced fertilization and tobacco sustainable development.

2. MATERIAL AND METHOD

2.1 Study Area

Sanmenxia is the leading tobacco-producing areas of quality, is located in inland mid-latitude areas, a warm temperate continental monsoon climate. The annual average temperature 13.2 ℃, annual average 2354.3 hours of sunshine, frost-free period of 184 ~ 218 days, with an average annual rainfall 550 ~ 800mm, is suitable for the growth of flue-cured tobacco district.

2.2 Sample Collection

The method in collecting soil samples was used according to the second national soil survey. Sanmenxia in the choice of representative tobacco soil, topsoil from 0 ~ 20cm soil samples, each sampling point of the area on behalf of 20 hm2. In 2007 collecting soil samples 299 were made.

2.3 Study Method

Grey fixed weight cluster method is the method that according to whitenization weight function of index gathering a number of observed objects into several defined types, it empowers the cluster index prior. Grey fixed weight cluster can be carried out based on the following steps (Liu, *et al*., 2004):

Firstly, according to available indicators of observation, we define k subclass whitenization weight function of j index $f_j^k(\bullet)$ (j=1, 2, $\wedge$, m; k=1,2,$\wedge$,s).

Secondly, we determine cluster weight of every index η_j (j=1,2, $\wedge$,m).

Thirdly, according to the whitenization weight function $f_j^k(\bullet)$ (j=1,2, $\wedge$,m; k=1,2,$\wedge$,s), cluster weight η_j (j=1,2, $\wedge$,m)derived from the previous two steps ,as well as observation x_{ij} (i=1,2, $\wedge$,n; j=1,2, $\wedge$,m) of object i on j index, we can calculate the coefficient of grey fixed weight $\sigma_j^k = \sum_{j=1}^{m} f_j^k(x_{ij}) \bullet \eta_j$, i=1,2, $\wedge$,n; k=1,2, $\wedge$,s.

Finally, if $\max_{1 \le k \le s}\{\sigma_i^k\} = \sigma_i^{k^*}$ you can conclude that object i belong to grey category k^*.

3. SOIL SUITABILITY EVALUATION

3.1 Selection of Evaluation Index

According to checking related literature and listening to experience and views of experts , based on the principles of influence that made tobacco quality and growth, variance degree, stability and operability, we finally select 5 indexes: PH, organic, available N, available P and available K.

3.2 Delineation of Suitability standard

According to the evaluation of soil nutrient standards (Ren, *et al*., 2007, Li, *et al*.,2008) and the actual situation of tobacco-growing areas in Sanmenxia, each index will be divided into three levels: most appropriate, suitable and unsuitable corresponding to 1~3(Table 1).

Because soil PH value changes between 6.6~8.8 in tobacco-growing areas of Sanmenxia, the data should be standardized to positively correlate with evaluation standard

Tab.1 soil nutrient suitability evaluation standard

index	unsuitable	suitable	most appropriate
organic(g kg^{-1})	<5	5-10	>10
available N(mg kg^{-1})	<25	25-40	>40
available P(mg kg-1)	<10	10-20	>20
available K(mg kg^{-1})	<80	80-150	>150
PH	<4.5 >8.5	4.5-5.5 8.0-8.5	5.5-8.0

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3.3 Identification of Whitenization Weight Function

We will divide five evaluation index into three gray class: most appropriate, suitable, unsuitable in accordance with their respective evaluation criteria, then j(j=1,2,3,4,5)index k(k=1,2,3)gray class indicate the j index the k gray class. Then, we set whitenization weight function of j index k gray class:

$f_j^k(\bullet)$ (j=1，2，3，4，5； k=1，2，3)

Commonly used whitenization weight functions are typical, upper limit measure, moderate measure, lower limit measure and triangle whitenization weight function in grey system theory. Here, we select upper limit measure whitenization weight function measure the most grey class, moderate measure whitenization weight function measure the suitable grey class, lower limit measure whitenization weight function measure the unsuitable grey class. Based on the soil conditions, we determine the whitenization weight function as follows:

$$f_1^1[0,20,-,-],\ f_1^2[0,13,-,20],\ f_1^3[-,-,11,13]$$
$$f_2^1[0,65,-,-],\ f_2^2[0,50,-,65],\ f_2^3[-,-,45,50]$$
$$f_3^1[0,20,-,-],\ f_3^2[0,14,-,20],\ f_3^3[-,-,10,14]$$
$$f_4^1[0,250,-,-],\ f_4^2[0,180,-,250],\ f_4^3[-,-,120,180]$$
$$f_5^1[0,2.2,-,-],\ f_5^2[0,2.0,-,2.2],\ f_5^3[-,-,1.6,2.0]$$

Based on the above whitenization weight function we can write specific function expression. Here only given whitenization weight function expression of soil organic index three grey classes and other expression can be written similarly.

$$f_1^1(x)=\begin{cases}0, & x<0\\ \dfrac{x}{20}, & x\in[0,20]\\ 1, & x>20\end{cases}$$

$$f_1^2(x)=\begin{cases}0, & x\notin[0,20]\\ \dfrac{x}{13}, & x\in[0,13]\\ \dfrac{20-x}{20-13}, & x\in[13,20]\end{cases}$$

$$f_1^3(x)=\begin{cases}0, & x\notin[0,13]\\ 1, & x\in[0,11]\\ \dfrac{13-x}{2}, & x\in[11,13]\end{cases}$$

3.4 Cluster Results and Soil Suitability Evaluation

Based on the survey data of tobacco fields , combined with observations and recommendations of relevant experts, the weight of organic, available N, available P, available K, PH value are: $\eta_1=0.45,\eta_2=0.15,\eta_3=0.08,\eta_4=0.150,\eta_5=0.17$.

Whitenization weight function $f_j^k(\bullet)$ (j=1,2, $\wedge$,m; k=1,2,$\wedge$,s), cluster weight ηi(j=1,2, $\wedge$,m) and observation x_{ij} (i=1,2, $\wedge$,n; j=1,2, $\wedge$,m) of object i for j index calculate the grey fixed cluster coefficient. $\sigma_i^k=\sum_{j=1}^{m} f_j^k(x_{ij})\bullet\eta_j, i=1,2,\wedge,n; k=1,2,\wedge,s$.

The cluster coefficient of three types can be made according to sample data and the above steps as shown in table 2.As the sample points located in every township, the township as a unit were to be analyzed. From the result, the areas that have the most suitability are: Duguanzhen, Dongmingzhen, Mutongxiang, Xujiawan, Shuanghuaishu, Shizipingxiang, Guanpozhen, Wulichuanzhen, Zhuyangguanzhen of Lushixian; Gongqianxiang of Shanxian; Guoyuanxiang, Hongyangzhen, Rencunxiang of Mianchixian; Wumiaoxiang, Zhuyangzhen of Lingbao. The Soil of these 15 townships organic and soil K content is high, soil pH and N content is medium. The number of sample point account for 29.4%in total.

Tab.2 soil suitability evaluation cluster coefficient in Sanmenxia area

serial number	township	most suitable cluster coefficient	suitable cluster coefficient	unsuitable cluster coefficient
1	guandaokouzhen	0.69	0.91	0.10
2	duguanzhen	0.81	0.58	0.17
3	hengjianxiang	0.69	0.78	0.65
4	fanlizhen	0.69	0.78	0.27
5	wenyuxiang	0.67	0.78	0.70
6	dongmingzhen	0.75	0.72	0.26
7	shahexiang	0.65	0.78	0.32
8	panhexiang	0.69	0.95	0.24
9	mutongxiang	0.87	0.37	0.06
10	mokouxiang	0.72	0.84	0.17
11	xujiawan	0.86	0.54	0.00
12	shuanghuaishu	0.75	0.64	0.15
13	shizipingxiang	0.85	0.24	0.23
14	guanpozhen	0.92	0.29	0.00
15	wayaogouxiang	0.68	0.73	0.23
16	tanghexiang	0.57	0.79	0.87
17	wulichuanzhen	0.83	0.53	0.17
18	zhuyangguanzhen	0.84	0.57	0.07
19	caiyuanxiang	0.72	0.92	0.01
20	dayanwaxiang	0.64	0.87	0.30
21	gongqianxiang	0.70	0.69	0.11
22	xilicun	0.63	0.76	0.62
23	chencunxiang	0.69	0.84	0.35
24	guoyuanxiang	0.77	0.67	0.13
25	hongyangzhen	0.81	0.45	0.14
26	potouxiang	0.68	0.83	0.35
27	rencunxiang	0.81	0.46	0.19
28	tianchizhen	0.61	0.74	0.21
29	xiyangxiang	0.66	0.86	0.42
30	yangshaoxiang	0.76	0.87	0.24
31	yinghaozhen	0.66	0.71	0.31
32	chuankouxiang	0.76	0.69	0.08
33	suncunxiang	0.74	0.79	0.28
34	wumiaoxiang	0.86	0.45	0.00
35	zhuyangzhen	0.87	0.37	0.00

Suitable soil areas are: Guandaokouzhen, Hengjianxiang, Fanlizhen, Wenyuxiang, Shahexiang, Mokouxiang, Wayaogouxiang of Lushixian; Caiyuanxiang, Dayanwaxiang, Xilicunxiang of Shanxian; Chencunxiang, Potouxiang, Tianchizhen, Xiyangxiang, Yangshaoxiang, Yinghaozhen of

Mianchixian; Chuankouxiang, Sucunxiang of Lingbao. Although soil K content is high in these areas, soil organic content is lower in some parts, soil improvement should be pay attention to in the future. The point number is 210(70.4%).

Tanghexiang locate in Lushixian has poor soil suitability. The soil organic content is lower, pH value is higher , N and P content is lower.

Generally, soil planting tobacco suitability is good in Sanmenxia that suitable for the growth of high-quality tobacco leaf. In recent years, soil in this area pH value, N content has an upward trend, pay attention to balanced fertilization to ensure harmonious proportion of N, P, K content.

4. CONCLUSIONS

Gray clustering method for soil suitability evaluation is a new attempt, by choosing its evaluation index, determining whitenization weight function to carry out soil nutrient gray clustering. In this paper, using above method, the study of Sanmenxia tobacco soil suitability assessment carried out. The results show that almost 30% area of this region has better soil suitability. Less than 1% has poor foil suitability, rest area has medium suitability. Taking into account the soil itself is a complex multi-phase organic-inorganic complex, involving the interaction of various factors, the evaluation results must be combining with the actual production, index weight and the determination of whitenization weight function is still value the experience of using the traditional method. The evaluation results basically tallies with actual production. Soil pH value and available N content are higher in Sanmenxia, Attention should be given to improve soil, reduce soil pH value, CL content, control N content, complement P content and stabilize K content.

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