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INFORMATION TECHNOLOGIES IN PRECISION AGRICULTURE

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Abstract

Information support of technology of variable rate application of fertilizers is one of the most important and difficult blocks of technology components. Methods and technical means for obtaining information about spatially distributed data and their assessment are analyzed in the article. Efficiency of the variable rate application of fertilizers in many respects depends on the volume of the received information and its quality. For the purpose of decrease in costs of obtaining information development of methods of a choice of ways of obtaining information and justification of that minimum quantity of information at which the maximum payback of fertilizers can be provided is necessary.

Keywords: precision agriculture, information support, model, algorithm, variable rate application of fertilizers.

Introduction

Use in agricultural production of precision agriculture and, in particular, technologies of the site-specific application of fertilizers demands large volume of information on a condition of a field and plants. For its receiving it is necessary to use the special technological equipment and services, such, for example, as systems of monitoring of productivity, positioning (GPS), software (GIS) for collecting information on parameters of fertility of a field, a condition of crops, adoptions of optimum administrative decisions [1].

For adoption of administrative decisions on doses and terms of the variable rate application of means of fertilizers it is necessary to know nature of distribution of the main agrochemical indicators of fertility of a field. In the first turn it is necessary to refer acidity, the content of phosphorus, potassium, nitrate nitrogen, organic substance and microcells to such indicators. The number of parameters which need to be measured depends on models or algorithms of the differentiated introduction doses used for definition.

Materials and methods

When carrying out the analysis of information support of technologies of precision agriculture survey materials FGNU "Rosinformagrotekh", agricultural Russian Academy of Agrarian Sciences and KATU libraries of S. Seyfullin, information received as a result of oral and written

communication with the experts who are engaged in distribution of the equipment, software for exact agriculture were used.

When carrying out the analysis of world experience of practical application of technologies of precision agriculture results of researches of foreign scientists according to the use of elements of precision agriculture by farmers, dealer services, and the opinion of consultants from the USA, England, Denmark, Germany, Australia, China and Japan were used. These data are from the Internet, the Russian Academy of Agrarian Sciences agricultural library, libraries of universities of the USA.

Results and discussion

The analysis and modeling of spatial data on diversity of parameters of fertility of a field demands application of an integrated approach and various methods characterizing this or that feature of the phenomenon. Complexity of such analysis is caused by several factors: existence of large volume of quantitative and qualitative information on parameters of fertility of a field, multiscale and multivariability, existence of various factors of influence [3].

The existing approaches to the analysis and processing spatially of the distributed data can be relatively subdivided into 4 groups.

1. Deterministic models (interpolators): triangulation, a method of the return distances in degrees, the multisquare equations, etc.

2. The models which are based on interpretation of data with the use of geostatistics.

3. Algorithms of artificial intelligence (artificial neural network of various architecture, genetic algorithm).

4. The models which are based on the statistical theory of training (Vapnik's theory - Chervonenkis): cars of vectors of support (Support Vector Machines).

Of course, such division is conditional. So, geostatistical models can be stated in the deterministic formulation and vice versa, a number of deterministic models have close statistical analogs. In turn, statistical approach on which the geostatistics is based includes regression models of spatial interpolation (prediction) and methods of stochastic modeling which purpose and tasks are various.

The most complex problem during the work with spatially distributed data is to receive spatial assessment. The solution of this problem is possible on the basis of application of methods of geostatistics [3]. Within this problem it is possible to set a number of specific objectives:

- to obtain data on the level of fertility of a field using this or that technique;
- to estimate values in points where measurements weren't taken;
- to make a chart, to build isolines (to define values on a dense grid);
- to estimate an interpolation error;
- to consider an error of measurements when interpolating;
- to define probability of excess of the set level;
- to carry out the joint spatial analysis of the correlated variables;
- to receive a set of equiprobable spatial realization of distribution;

- to describe spatial variability and uncertainty.

The traditional deterministic methods which are widely used in problems of spatial interpolation allow answering practically only the first two of above questions posed. Data of measurements are, as a rule, discrete and non-homogeneous spatially distributed. The analysis of data and its results considerably depend on quality and quantity of basic data and on methods and models of data processing. Frequency of sampling and the sizes of a field influence on statistical and geostatistic indicators. Even in the case when spatial properties of sites are identical, distinction in the technique of sampling and the way of data processing gives various values of estimated statistical characteristics.

Techniques of selection of soil tests significantly differ from each other. Some indicators are measured directly, others indirectly, due to measurement of the accompanying indicators, for example conductivity. Often mediated way of measurement of soil indicators allows selecting tests with a bigger density though in some cases the accuracy decreases. The interpolation process used for data presentation, received at various sizes of a grid according to one size, leads to big errors.

A number of scientists [4] conducted researches on justification of necessary number of tests depending on a land relief. Researches on justification of number of tests and distance between cells with attraction of methods of geostatistics and the regression analysis are actively conducted. In result of researches it is established that for receiving an adequate picture of distribution of such elements as P, K, Zn it is necessary to divide a field into bigger number of sites, than for N, C and pH. The researches made by us showed that results of the statistical analysis of data considerably depend on the size of registered sites from which the soil tests were taken.

Essential distinction of statistical characteristics is explained by the fact that in a statistical row there can be values of indicators much exceeding average values. Such phenomena are caused by anomalies of the content of the nutritious elements in the field caused, for example, by existence of spots with the high content of the nutritious elements formed on places of long storage of organic fertilizers, in haystacks or straw. With the decrease in quantity of registered sites the probability of an exception of anomalies increases. It gives essential decrease in variability of data and change of min and max values. Such statistical characteristics as a mean square deviation, and respectively variation coefficient are most sensitive to anomalies. Therefore at the first stage of justification of the minimum quantity of registered sites for sampling and an assessment of a possible error it is necessary to consider existence of anomalies and their features.

The quantity of registered sites also influences the accuracy of the received cartograms. Irrespective of the chosen way of interpolation of experimental data, the number of contours is reduced, their form changes. Therefore, in each case according to the solved task and initial diversity of fertility of a field it is necessary to choose the quantity of registered sites on the basis of the analysis of the

available information on a field and the selective analysis [5,6].

Joint influence of the numerous factors predetermining condition of a field and crops causes errors of various levels and they can not be estimated quantitatively. Moreover, the number of factors on which productivity and its importance depend can change. At each stage of data processing and usage of information received on their basis there are various levels of uncertainty. Therefore when receiving and using information for decision-making it is necessary to know:

- probable sources of uncertainty and its level;
- methods to avoid this uncertainty.

In process of accumulation of experimental data, researchers will be able to test and create more perfect methods of receiving and statistical processing of experimental data (for more reliable assessment of the studied objects).

Discussion of the obtained data and the conclusion

For successful control of technological process of the differentiated application of fertilizers it is necessary to know relation between change of controlled factors and values of output function (productivity). If this relation is weak, for example, at the expense of the high level of "noise", strict control is impossible. It is the main complexity to find functional relation between the entering and leaving parameters at their spatial and temporary variability.

Costs of sampling from registered sites in system of positioning directly depend on quantity of sites into which the field is divided. Choosing the strategy of data acquisition on diversity of parameters of fertility it is necessary to decide how many soil tests to select and by what technique. The structure of making decisions on strategy of sampling depends on the following factors:

1. The expected coefficient of a variation of the studied indicator;
2. Needs for additional information on a field;
3. The expected quantity of zones of management;
4. Sampling costs by the chosen technique;
5. Restrictions on duration of sampling, expenses of work and finance.

The number of the selected tests is the result of the solution of a compromise task on costs of sampling and the accuracy of the received information. It is necessary to take into account that reduction of number of tests for the purpose of decrease in expenses leads to loss of important information on a condition of a field. Therefore it is expedient to increase quantity of places for tests when sampling and reduce the quantity of samples. Such approach will allow considering bigger influence type of soil, a field relief, etc.

When determining doses of application of fertilizers one mainly uses information received as a result of agrochemical inspection of a field, by means of selection of soil tests and their analysis. This procedure is also quite expensive and requires much work. In order to increase efficiency of the differentiated use of fertilizers, the costs of obtaining information on a condition of a field are necessary to reduce by

means of search or development of new less expensive ways of obtaining information. The way based on divisions of a field on sections (zones) which are uniform in agrochemical indicators can be alternative to a grid method of sampling. For realization of this method it is necessary to have basic information on soil characteristics of a field and its relief, the chart of productivity, history of a field and materials of aerial photography.

We made researches on influence of a land relief on distribution of radiation temperature of a landscape. Thermal radiation of the soil and vegetation was registered by remote sensing in the thermal infrared range with use of the Thermovision - 880 scanner forming the image in real time scale. Significant linear correlation of radiation temperature with the local height, the steepness, orientation of slopes of a relief is determined.

Using effect of heterogeneity of the floristic structure of grassy vegetation (for example, a condition of grain crops) caused, mainly, by various level of availability of nitric fertilizers of plants it is obviously possible to develop operating plans of the fractional differentiated introduction of nitric fertilizers on organogenesis stages.

Results of researches testify that remote sensing in the thermal infrared range of the spectrum obviously defines the content of phosphorus, potassium and other elements in the soil.

Conductivity of the soil is the integrated indicator which is closely connected with other indicators influencing productivity of crops: moisture content in the soil, structure of the soil, the content of organic substance, thickness of a soil layer, acidity, exchange calcium (Ca) and magnesium (Mg). Now most often use two ways of measurement of conductivity of the soil in the field - by means of electromagnetic induction and by means of contact electrodes.

The sensors allowing receiving information at the movement of the unit across the field are necessary for broader application of contact and contactless methods of diagnostics of the soil and plants. Especially such sensors are necessary for measurement of parameters which quickly change in time: the content of nitrogen in the soil, humidity of the soil. Are currently being developed and partially used sensors for:

- estimations of properties of the soil (structure of the soil and its physical properties, maintenance of elements of nutrition);
- estimations of condition of crops (density of crops; susceptibility of plants to stresses; availability of plant nutrients);
- productivity monitoring (weight and humidity of grain, actual width of capture of the harvest unit);
- control of the differentiated introduction of fertilizers and means of protection of plants (a consumption of fertilizers).

Researches on development of new ways of obtaining information on a condition of the soil and crops are conducted. The devices based on use of electromagnetic induction, conductivity of the soil, system of recognition of images are developed (weeds, wreckers and diseases).

Information on parameters of a field and condition of the plants

influencing productivity of crops, received by means of various methods (selection of soil tests for an assessment of the maintenance of nutriments, remote sensing of the soil and crops, drawing up digital cards of a relief of a field), is in most cases interdependent and interchangeable. Therefore for the purpose of decrease in costs of obtaining information is necessary to develop methods of a choice of ways of obtaining information and justification of minimum amount of information at which the maximum payback of fertilizers can be provided.

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Резюме

Информационное обеспечение технологии дифференцированного применения удобрений, является одним из самых важных и сложных блоков составляющих технологию. В статье проанализированы методы и технические средства для получения информации о пространственно распределенных данных и их оценки. Эффективность дифференцированного внесения удобрений во многом зависит от объема получаемой информации и ее качества. С целью снижения затрат на получение информации необходима разработка методов выбора способов получения информации и обоснования того минимального количества информации, при котором может быть обеспечена максимальная окупаемость удобрений.

Түйін

Ақпараттық қамтамасыз ету тыңайтқыштарды саралап енгізу

технологиясының ең басты және аса қиын құраушы бөлігі болып табылады. Мақалада кеңістікте таралған мәліметтер туралы ақпараттарды алу және оларды бағалауға қажетті әдістер мен техникалық құралдар талданды. Тыңайтқыштарды саралап енгізудің тиімділігі негізінен алынатын ақпараттың көлеміне және олардың сапасына байланысты. Ақпараттарды алуға қажетті шығындарды азайту үшін ақпараттарды алу әдістерін таңдау әдістемесін жасау және олардың минималды санын тыңайтқыштардың максималды тиімділігін қамтамасыз ететіндей қылып негіздеу қажет.