THE USE OF ARCHIVAL MAPS FOR THE MONITORING OF AGRICULTURAL LAND

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Abstract*The results of the regional soil survey conducted in 1983 (scale 1:50000) were compared with the data obtained during the agrochemical survey in 2016. It was found that classification soil map are poorly connected with the modern agrochemical status of cultivated soils. However, archival maps can serve as a valuable source of information about the former state of the territory.*
KEY WORDS: *ARCHIVAL MAPS, AGRICULTURAL LAND, MONITORING, GEOSTATISTICS*

Introduction

There are a large number of soil surveys data that were collected in the Soviet Union in the late 20th-century. They were generalized in the form of large-scale soil maps of farms, districts and a whole region. The accompanying descriptions contain a large amount of information about morphological properties, particle size distribution, soil organic matter content (SOC) and basic agrochemical properties of soil profiles on the basis of which was allocated to the soil contours. The soil profiles locations were pointed on soil maps with the scale 1:10000. But, as a rule, generalized soil-agrochemical maps of regions of scale 1: 50000 are more accessible. These data can serve as a point of reference in assessing changes in land cover that have occurred over the last 25-30 years. However, there are several uncertainties due to both technical and purely subjective reasons. Not always the satisfactory quality of the topographic basis, the inability to verify the geographic location of the soil profiles, the inevitable disruption of paper maps over time due to aging, the various methods of determining soil properties make it difficult to directly compare values at points, but modern geostatistical methods of spatial interpolation can somewhat offset these uncertainties. Another source of uncertainty can be the spatial variability of soil properties. It is known that its numerical measure, namely the variance, depends on the sampling method [1], so the comparison of time-varying data can be difficult due to different methods of sampling at certain points in time. Inaccuracies arising from the attribution of individual sites to a particular soil category make an additional contribution to the overall uncertainty of the results.

Objects and methods

The study was performed on the Bryansk region landscapes, which are the part of the Opolje- Polesye landscape zone of the Russian Plain (Fig.1).

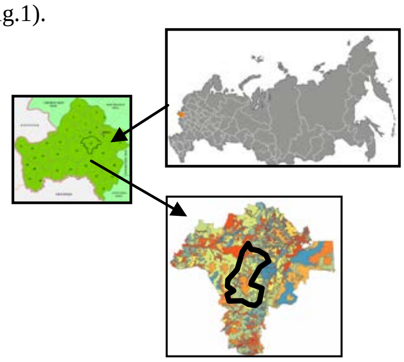

Fig.1. *Soil map 1983 and study area 2016*

The study area was equal about to 10000ha. The basic classification was the classification of soils of USSR, 1977. Within the area studied in 1983, 46 soil classification units were identified.The soil cover is dominated by Albeluvisol Umbric and Phaeozems Albic, which are almost completely under cultivation. Phaeozems Gleyic were associate to depressions. Fluvisols Umbric were marked as part of the territory.

We compare the soil properties (pH, soil organic matter content (SOC), mobile P2O5 and exchangeable K2O) of the top 0-20 cm horizon obtained in 2016 survey on the part of Vygonichsky district of the Bryansk region (Russia) with the data from archive soil map of 1983 (scale 1:50,000). There were 39 individual samples in 1983 and 564 composed samples in 2016 (Fig.2). Modern boundaries of fields are shown in Fig. 2 (a).

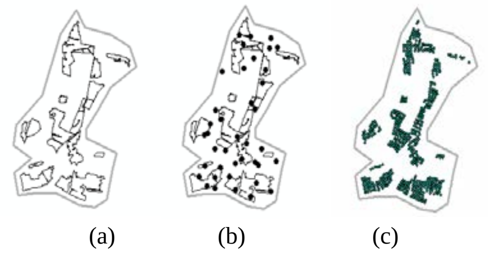

Fig.2.*Soil sampling in 1983 (b, n=39) and 2016 (c, n=564)*

Ordinary kriging technique [2] was used to construct soil property maps for the data collected in 2016. As a model of the structure function (semivariogram), a spherical model was used, with preliminary logarithmisation of the data for the content of phosphorus and potassium.Than values in points of 1983 sampling were interpolated and compared with the initial data.

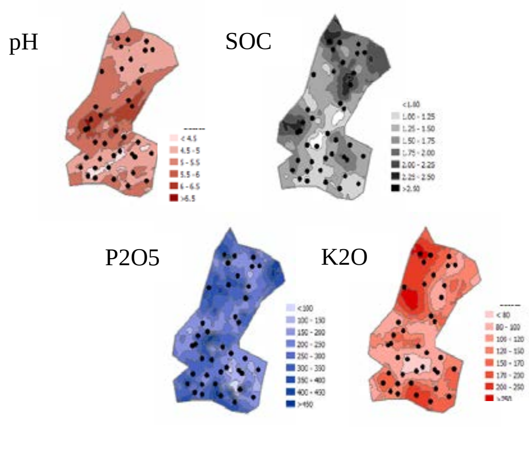

Fig.3. *Maps of soil properties (2016 with points 1983)*

An analysis of the spatial distribution of the values of agrochemical properties was performed using the "hot spots" technique, when the entire available data set is divided into 5 classes corresponding to the selected grades of normalized deviations. [3].

Results and discussion

From soil properties maps one can see that there are high variation inside area under study (Fig.3). Comparison of the statistical characteristics shows that in 33 years the acid-alkaline properties and SOC of the arable horizon within the surveyed territory did not change. However, it can be noted that for pH, both the minimum and maximum values increase, while for SOC the upper bound of the variation range does not change, and the minimum boundary shifts strongly toward higher values (Table 1). The content of mobile phosphorus and potassium increased statistically significantly. In 1983 more than 50% of the surveyed area was in the category of low availability of mobile phosphorus, although in a small number of the surveyed points, the amount of mobile was above average. By 2016, the minimum detectable value is also in the category of low availability, but the maximum value so exceeds the commonly held values that may already indicate excess fertilizer application. The content of exchangeable potassium also increases, but not so much. (Table 1).

Table 1:*Statistics of soil properties*

	pH	SOC, %	P2O5, mg/kg	K2O, mg/kg
1983, n=39				
Mean	5.33	1.56	74	133
St.dev.	0.61	0.5	65	58
Min	4	0.3	12	20
1-quartile	4.9	1.3	27	100
Median	5.2	1.5	50	123
3-quartile	5.7	1.8	94	170
Max	6.7	2.7	250	316
2016, n=564				
Mean	5.59	1.67	239	189
St.dev.	0.57	0.43	101	90
Min	4.43	0.75	49	52
1-quartile	5.15	1.37	166	132
Median	5.51	1.61	231	170
3-quartile	5.99	1.89	293	219
Max	7.26	2.76	1005	813

The proportion of the random component in the spatial variability of the properties was evaluated according to the nugget/sill ratio, where nugget and sill are the parameters of semivariograms. It can be seen that the SOC and P2O5 values have greater spatial ordering, since the random component makes up only about a quarter of the total variability. Random components for other properties were about 60% (Table 2). The ranks of the semivariograms vary considerably, which can also be an indication of different spatial structures of individual properties.

Table 2 :*Parameters of spatial model and correlation between independent (1983)) and predicted (2016) values (marked value is statistically significant at the 0.05 level)*

Propertie	Nugget/sill ratio, %	Rang, м	Correlation coefficient between time points
pH	68	3600	0.014
SOC	25	2867	0.600**
P2O5	26	1200	0.268*
K2O	54	4200	0.007

**Statistically significant at α=0.05 and * - at α=0.10

The structure of the spatial variability of properties varied with time in time. There is no correlation between individual time points for the pH and the content of mobile potassium (the correlation coefficients are close to zero), but for the content of organic matterand mobile phosphorus, the relationship between the values at different instants of time is statistically significant (Table 2). This is a reflection of the different temporal stability of the spatial structures of individual properties. The spatial distribution of SOC is most stable in time. On the one hand, it may be due to the slow variability of this property over time, and on the other hand, to insufficient application of organic matter during the period under review.

The increase in the average content of mobile phosphorus and potassium is due to the massive application of fertilizers in the territories exposed to radioactive contamination as a result of the Chernobyl accident. The different temporal stability of the spatial structures of these indicators correlates well with the different mobility of the elements in the soil. As a rule, phosphorus fertilizers move poorly in the soil profile, and if high doses were once introduced, the spatial structures will be retained for a long time. Potassium can not only move along the profile, but also be fixed by soil minerals, so that the expression of spatial structures in this case will be weaker.

The relationship between the content of organic matter and soil classification units is manifested only at the level of soil types (correlation coefficient 0.65). Other agrochemical properties are practically independent of soil conditions. In this way, classification of soils of the USSR in 1977, which was the basic genetic classification in Russia at the end of the 20th century, almost did not take into account the degree of possible anthropogenic transformation of soils. The visual images of the soil underlying it are loosely related to the substantive characteristics. Some connections are detected only at the level of the subtype of soils.

a) b)

Fig.4. *Hot points (clusters of normal scores) for SOC(a) and P2O5 (b)*

Analysis of the "hot spots" shows that the values of agrochemical properties within individual fields form compact clusters of one (more rarely two) categories (Fig. 4). This confirms that the spatial structure of agrochemical properties in the first is determined by the type of management. Therefore, the digital data of archival soil maps are more informative for monitoring the condition of cultivated soils.

Conclusion

Thus, over the past 33 years the agrochemical status of the surveyed territory has changed significantly. A moderate relationship between the previous state is expressed only for SOC.Spatial structures of agrochemical properties primarily depend on the history of the site and to a small extent on the classification of the soil.

Acknowledgements

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