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ASSESSMENT OF CROP YIELDS IN MODERN AGRICULTURE ON THE BASIS OF GIS-TECHNOLOGIES

Rukhovich O. V. [1,5], Belichenko M. V. [1,5], Sychev V. G. [1,5], Romanenkov V.A. [1,5], Lukin S. [2,5], Sheudzhen A. K. [3,5], Schindler U.[4,5], Müller L.[4,5], Eulenstein F.[4,5]

ZUSAMMENFASSUNG/SUMMARY

The uneven distribution of natural properties- for example, soil quality, topography, microclimate - on the territory of any size determined a different degree of their suitability for growing different groups of crops.
Information-analytical system of ensuring agricultural technologies was developed on the base of several GIS and models of crop yield. The system included creation of maps of potential yield (function of the natural factors) and possible (function of the real level of the field fertility) yield of various crops. These dates were received in the field experiments with fertilizers and in available modern bases of agro-chemical, landscape, climatic parameters.

SCHLÜSSELWORTE/ Keywords: winter wheat, potential yield, landscape conditional and climate provided yield, really possible productivity, forecast

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[1]Pryanishnikov All-Russian Institute of Agrochemistry (VNIIA) of the Federal Agency of Scientific Organizations (FANO) Pryanishnikova Str. 31a, 127550 Moscow, Russian Federation

[2]Russian Institute for Organic Fertilization and Peat (VNIIOU) 601390, Vladimir Oblast, Sudogodskiy Rayon, Vyatkino 492.2 Russian Federation

[3]All-Russian Institute of Rice, Belozerny Str. 3, 350921, Krasnodar; Kuban State University, Krasnodar, Russian Federation

[4]Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) Müncheberg, Eberswalder Straße 84, D-15374 Müncheberg, Email: feulenstein@zalf.de

[5]Mitscherlich Academy for Soil Fertility, Prof.-Mitscherlich-Allee 1, 14641 Paulinenaue, Germany

EINLEITUNG/ INTRODUCTION

In each even a relatively small area; there are areas most and least favorable for the cultivation of a particular group of crops, for example, by soil, location or microclimate.
Based on several GIS and profitability models, an information and analytical system for the provision of agricultural technologies has been developed, including the creation of capacity maps (depending on natural factors) and possible (depending on the real level of fertility of each region) crop yields of different crops in accordance with mass field experiments with fertilizers and agrochemicals have modern, landscape, climatic indicators.
The methodology for calculating the yields of different crops is not based on subjective experience, but on the author's preferences and independent objective evaluation of various factors affecting the methods of linear and nonlinear multiple regression, and on the basis of several GIS results are presented on yield maps. Factors affecting the productivity of labor are divided into two large groups - natural (climate, relief, soils, etc.) and agrochemical (application of fertilizers, plant protection products, intensity of cultivation technology, etc.). Modern systems of agriculture are aimed at rational land use and optimization of agricultural technologies in relation to the current and expected soil-climatic and agro ecological conditions in order to obtain high and sustainable yields of ecologically clean crop production. The cycle of substances and energy in these systems occurs with the indispensable participation of man, but natural and climatic factors determine the fate of agroecosystems no less than technological impacts.
The Institute of Agricultural Chemistry has developed a methodology for calculating crop yield models for selected regions of Russia, which is based not on subjective experience and authorial preferences, but

on an independent objective assessment of various factors affecting yields by linear and nonlinear multiple regression methods.

MATERIALS AND METHODS

Sources of data for the calculation of yield characteristics models:

- On the cultures - electronic databases of field experiments with fertilizers of the Geonetwork and Agrochemical Service "Agrogeos" on different crops and the quality of the harvest of the Prianishnikov Institute of agrochemistry. Their distinctive feature was that they were conducted in the territory of the former USSR from the 1960s to the mid-1990s on a single method, which allows them to be averaged over the years and cultures.
- On the relief - the altitude matrix SRTM30 with a resolution of 30". It also calculated the matrices of 18 other characteristics of the relief - the morphometric values that determine the processes occurring in the agrolandscape - the illumination, the slope heat regime, the intensity and direction of the flows of substances, the microclimatic features of the territory, etc.
- On the climate - matrices of average long-term precipitation and temperatures for each month. They also calculated the matrices of seasons and annual average.

EREBNISSE/RESULTS

Factors affecting yields are divided into two large groups - natural (climate, relief, soils, etc.) and agrochemical -

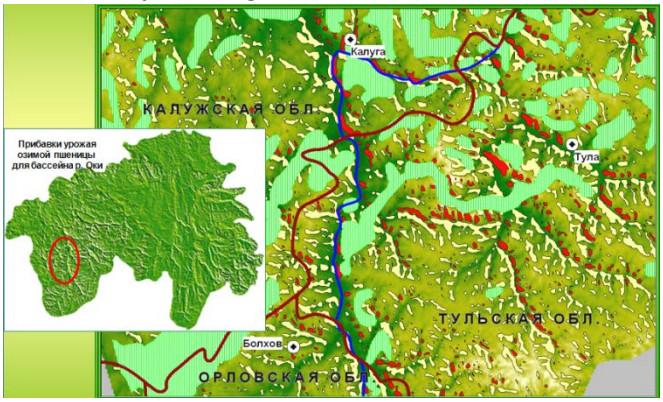

Fig.1 Areas of winter wheat yield increment, projected for the south-western part of the Oka basin.

(application of fertilizers, plant protection products, intensity of cultivation technologies, etc.). First, consider natural factors that are independent of man and determine the potential yield.

As an example of the modeling result, one of their maps is presented - a map of the effectiveness of fertilizer application for winter wheat for the Oka river basin (Fig.1) -relatively closed natural system, for its components are inherent interdependence and interaction. On the map presented, red areas - areas with an expected yield increase of more than 10h / ha, yellow - less than 5h / ha.

Between selected areas most likely gain 5 - 10 kg / ha. This is exclusively due to the natural features of the territory.

Such maps may be of interest for calculating the projected return on fertilizer costs.

Also piques interest the assessment of yields for the levels of the district, farm, field. In this paper we analyze the yield of winter wheat calculated on the basis of the obtained matrix for the levels of districts, farms, and fields in the Moscow region located in the Oka basin. Figure 3 shows the forecast map of the Stupino District of the Moscow Region, implemented in GIS ArcView. There is a large enough scatter in the data, it is possible to estimate the effectiveness of the application of fertilizers in general for the Stupino district.

Figure 3 shows the yield map for a single farm. On average, half of the fields have a high potential for winter wheat yield. It should be noted again that this potential for yield is due only to the natural features of the territory. What place in the productivity categories of agricultural lands occupy the characteristics of the harvest calculated by the models?

The presented modeling results are based on an assessment of the influence of relief, climate and soils on obtaining close to the maximum crop yield under production conditions of crop cultivation, as the basis for calculations is the results of field experiments with fertilizers obtained under conditions that are optimal for culture.

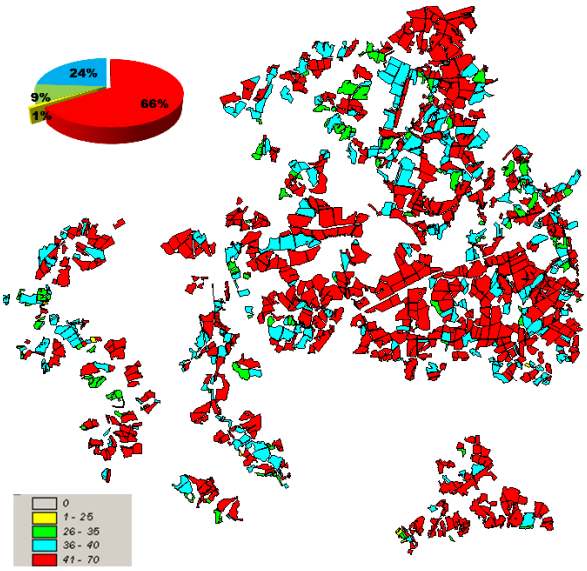

Fig. 2 Landscape conditioned and climatically guaranteed productivity of winter wheat, h / ha in the farms of Stupino district, Moscow region

Thus, the crop characteristics calculated from the models are landscape-conditioned and climatically secured. Landscaped and climatically ensured yields are comparable to potential yields (Tooming, 1967, 1978), which is calculated on the basis of the values of phased arrays (dependent on the intensity of light radiation). This fact makes it possible to use landscape-conditioned and climatically-provided yields for calculating the really possible yields in forecasting crops.

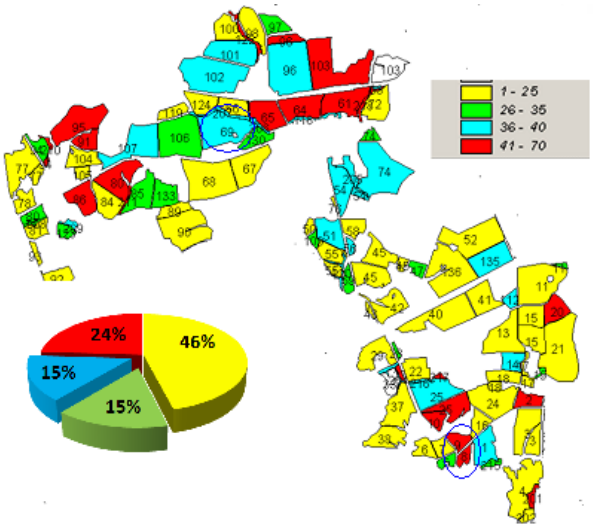

Fig. 3 Map of landscape-conditioned and climate-assured yields of winter wheat, h / ha, farm "Lenin's Covenants", Stupino district, Moscow region.

But the fertility is affected by the fertility of the soils of each individual field. It can significantly differ from each other due to different field history, different intensity of growing technologies and predecessors. To be able to use this system, it is necessary to have information for each field on the particle size distribution, as well as humus, pH and mobile phosphorus.

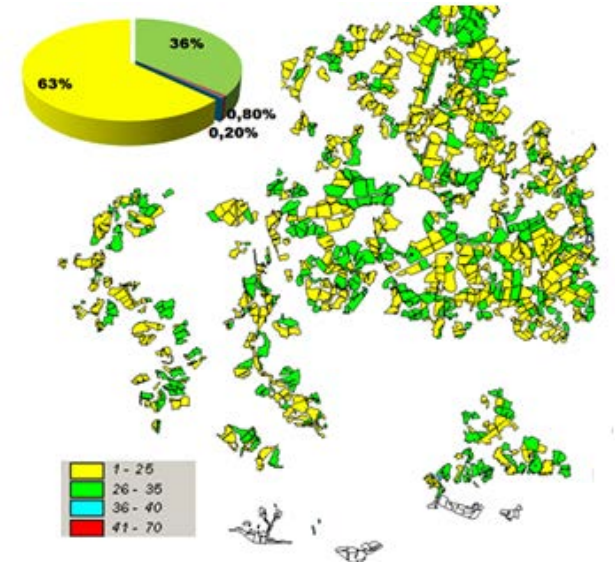

Fig. 4 Really possible yield of winter wheat, h / ha in the farms of Stupino district of the Moscow region with a humus content of 2.0-3.0%; pH = 4.5-5.0; P2O5 = 100-200 mg / kg

For example, Figures 4 and 5 show the productivity of winter wheat for the Stupino district as a result of modeling a hypothetical situation that the parameters of fertility in all fields of the economy are the same. Then it is very clearly visible which fields and how they will respond with yield

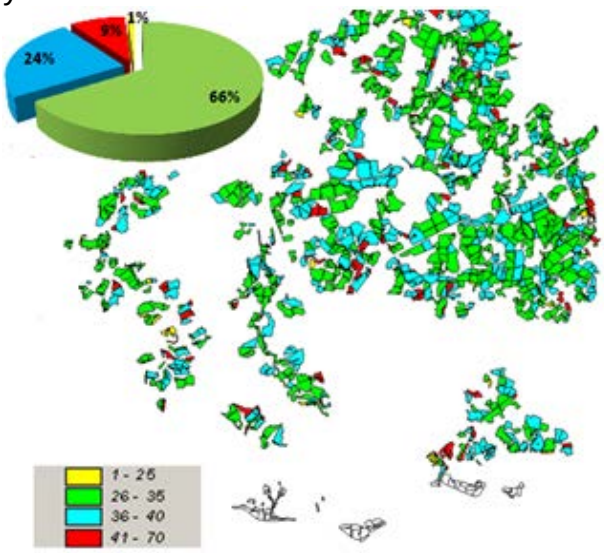

Fig. 5 Really possible winter wheat yield, C/ha in the farms of the Stupino district of the Moscow region in the humus content = 2.0 to 3.0%; pH = 5,0 - 6,5; P2O5 >200 mg/kg

on this situation. The diagram shows the share of fields with different yield levels.
The possibility of applying technology of this or that intensity to individual fields and cultures can also be estimated from maps of possible yields. If there is a sufficiently low possible harvest on the field, then there is no point in applying intensive technology in this field, which involves serious investments in fertilizers, protective equipment and requiring high soil fertility. But, on the other hand, if the potential yield is high enough on the field, then the agricultural producer can decide which technology to apply to him in this field, and, thus, to more consciously assess his investments.

SCHLUSSFOLGERUNGEN/ CONCLUSION

The proposed calculation system allows taking into account soil fertility and highly variable in space and time indicators, with the possibility of maximum practical use of existing and modern materials of soil and agrochemical surveys and on-farm land valuation.

LITERATURE

Sychev V.G., Rukhovich O.V., Romanenkov V.A., Belichenko M.V., Listova M.P. Experience of creating unified systematized database of field experiments of Agrohimsluzhba and Geonet "Agrogeos" // Problems of agrochemistry and ecology, 2008. - N.3. - P.35-38.

Hijmans R.J., Cameron S.E., Parra J.L., Jones P.J., Jarvis A., 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978.

Rukhovich O.V., Sharaya L.S., Shary P.A., Romanenkov V.A. Experience in predicting the characteristics of winter wheat harvest in agro landscapes of the Oka basin using geomorphometry methods // Fertility, 2009. - No. 5 (50). - P.22-24.

Romanenkov V.A., Listova M.P., Belichenko M.V., Rukhovich O.V. The system "Soil-fertilizer-weather-harvest" in the cultivation of winter wheat on sod-podzolic soils ETR // Fertility, 2009.-№15 (46). -P. 14-17.

Rukhovich O.V., Sharaya L.S., Shary P.A. Use of relief characteristics in the analysis of spatial variability of winter wheat yield in the Oka basin // Agrochemistry, 2010. - No. 8. - P.49-57.

Mueller L.M., Smolentseva E.N., Rukhovich O.V., Schindler U., Berendt A., Sychov V.G. Method of assessment the productivity of soils in agrocoenoses on a global scale (Münheberg system of soil quality rating) // Fertility №6 (57) 2010, P. 31-33

Shary P.A., Rukhovich O.V., Sharaya L.S. Methodology of analysis of spatial variability of wheat yield characteristics depending on conditions of agrolandscape // Agrochemistry, 2011. - №2. - P.57-81.

Rukhovich O.V., Shary P.A., Sharaya L.S. Estimation of productivity of agricultural crops depending on conditions of agrolandscape // Fertility, 2013. - №2, P.45-46

Rukhovich O.V., Romanenkov V.A., Ermakov A.A. Yield of agricultural crops depending on conditions of agrolandscape // Fertility, 2014. - №3 (78), P.12-14.

Shary P.A., Rukhovich O.V., Sharaya L.S. Predictive modeling characteristics of harvest of winter wheat // Digital Soil Cartography: theoretical and experimental research. - M.: Soil Institute named after V.V. Dokuchaev, 2012. - P.310-326.

Shary P.A., Sharaya L.S., Mitusov A.V., 2002. Fundamental quantitative methods of land surface analysis. Geoderma 107: 1-32.

Shary P.A., Rukhovich O.V., Sharaya L.S., 2016. Analytical and cartographic predictive modeling of arable land productivity. In: Mueller L., Sheudshen A.K., Eulenstein F. (Eds.). Novel Methods for Monitoring and Management Land and Water Resources in Siberia. Heidelberg: Springer, 2016. Chapter 21, pp. 489-502.