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Study on agrochemical information and analytical systems in irrigated agriculture

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Abstract. This paper presents findings on the creation of digital agrochemical maps for irrigated meadow-alluvial soils in Uzbekistan through the application of contemporary GIS technologies. Additionally, it explores the utilization of these maps to establish optimal fertilizer application rates and timings for various agricultural crops. The research aims to leverage Geographic Information System (GIS) technologies to develop digital agrochemical cartograms specifically for irrigated meadow-alluvial soils in Uzbekistan. These cartograms serve as digital representations of the agrochemical characteristics of the soils in the region. The adoption of GIS facilitates a comprehensive and spatially explicit understanding of soil attributes, enabling a more precise and informed approach to agricultural management. The primary objective is to determine optimal rates and timings for fertilizer application tailored to the distinct characteristics of irrigated meadow-alluvial soils. By integrating soil information into the GIS framework, the study seeks to establish a connection between spatial variability in soil properties and the corresponding agricultural practices. This approach allows for the development of targeted fertilization strategies based on the unique attributes of each soil type.

1 Introduction

Currently, the International Fertilizer Association (IFA) forecasts a gradual annual increase in global mineral fertilizer consumption, projecting a total of 203.5 million tons by 2023-2024. Notably, around 80 percent of this consumption is attributed to Latin America, South Asia, Africa, and Eastern Europe. Given this scenario, achieving high-quality agricultural yields through scientifically determined norms and timing for mineral fertilizer application, aided by digital agrochemical maps, stands as a pressing imperative [1,2].

Globally, agrochemical information and analytical systems are evolving to maintain regularly updated records of agricultural land, assess the agrochemical status of soils, enhance fertility, and build agrochemical databases specific to each field contour using modern geoinformation technologies. Emphasis is placed on scientific research aimed at optimizing fertilizer application based on soil nutrient levels and the nutritional requirements of crops, ultimately enhancing soil fertility and maximizing crop yields [3–6].

In response to challenges posed by adverse natural conditions in the Aral Sea region, substantial scientific research is underway in Uzbekistan. This includes the implementation of new technologies to improve the agrochemical condition of irrigated soils, preserve soil fertility, and cultivate crops [7,8]. The Development Action Strategy of the Republic of Uzbekistan for 2017-2021 outlines crucial objectives, emphasizing the optimization of agricultural land use, integration of intensive methods, adoption of modern water and resource-efficient agricultural technologies, and the establishment of advanced systems for mineral and organic fertilizer application [9–12].

The creation of digital agrochemical cartograms for the republic's irrigated soils using contemporary GIS technologies is a pivotal step. These cartograms, monitoring periodic changes in soil nutrient levels, crop nutrient uptake, and differentiated mineral fertilizer application based on soil agrochemical conditions and crop types, holds significant importance. The introduction of digital agrochemical services in agriculture becomes paramount in this context [13–14].

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The works of various researchers, including R. Afanasyev, E. Meshchaninova, I. Kostin, V. Zheleznyakov, V. Yakushev, L. Gafurova, G. Jalilova, Sh. Bobomuradov, D. Kadyrova, Z. Bahodirov, and M. Dauletmuradov, feature studies on monitoring changes in agrochemical soil properties using geographic information technologies. These studies aim to discern the impact of these changes on both the quantity and quality of crops [7,10,11].

2 Material and Methods

Agrochemical soil analyses were conducted following the protocols outlined in the widely recognized soil science manual "Manual on Chemical Analysis of Soils" by E.V. Arinushkina. Geoinformation analysis of the collected data utilized the Geostatistical Analyst and Empirical Bayesian kriging methods within the ArcGIS 10.6.1 program. In the development of an information and analytical system for agrochemical soil research, ArcGIS 10.6.1 software played a central role. Additionally, guidance from the manual issued by the State Committee for Land Geodesy Cadastre and the Ministry of Agriculture of the Republic of Uzbekistan, titled "Guidelines for Conducting Agrochemical Research and Compiling Agrochemical Cartograms of Soils on Irrigated Lands, as well as the Development of Scientific Requirements for Mineral Fertilizers," was followed [1–13]. The determination of norms and agrotechnical timing for the application of mineral fertilizers was executed with reference to the manual provided by the Agro-Industrial Committee of Uzbekistan, titled "Recommendations for the Differentiated Use of Mineral and Organic Fertilizers for Agricultural Crops on Irrigated Lands of Uzbekistan [4–6].

3 Results

The research focuses on irrigated meadow-alluvial soils in the northwestern regions of Uzbekistan. Morphological characteristics of the soil cover are intricately influenced by topography, soil-forming rock, vegetation, climate, groundwater levels, and salinization processes. The predominant mechanical composition of the soils in the area is typically medium loamy, occasionally featuring interlayers and sandy loams. These soils exhibit significant variability in physical clay content (<0.01 mm), ranging between 15.3% and 47.1%, with a prevailing presence of coarse dust and fine sand particles.

Distinctive salt distribution profiles, in terms of content and salinity, characterize the soils in the area, mainly classified as chloride-sulfate and sulfate salinization types. Across soil profiles, humus content ranges from 0.12% to 1.19%, total nitrogen content is between 0.016% and 0.097%, gross phosphorus content varies from 0.033% to 0.199%, and total potassium content ranges from 0.70% to 2.10%. In mixed soil samples from the arable horizon of elementary plots, humus content was found to be between 0.383% and 1.302%, mobile phosphorus ranged from 9.7 to 40.1 mg/kg, and exchangeable potassium was recorded at 87–291 mg/kg.

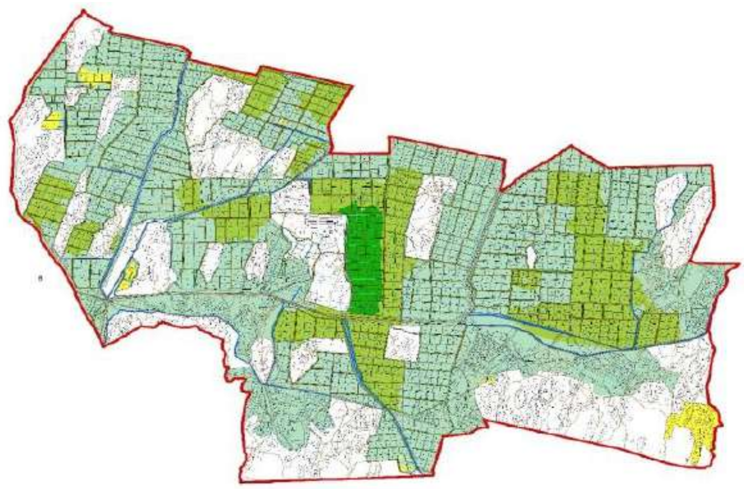

Fig.1. Digital agrochemical cartogram reflecting the degree of soil supply with humus

As part of the research, an agrochemical cartogram at a scale of 1:5000 was developed using ArcGIS 10.6.1 software, showcasing the quantitative distribution of humus and nutrients in irrigated soils. Considering the adherence to current guidelines, the substantial area covered, the inaugural agrochemical research on the territory, and the intricacy of the scientific undertaking, the cartogram was practically implemented on a 1:25000 scale. According to the agrochemical cartograms, out of the total massif area of 6261.5 hectares, 167 hectares (2.7%) exhibit very poor humus content, 3474.1 hectares (59.8%) are classified as low, 2121.8 hectares (33.8%) as average, and 231.6 hectares (3.7%) as above average (see Figure 1).

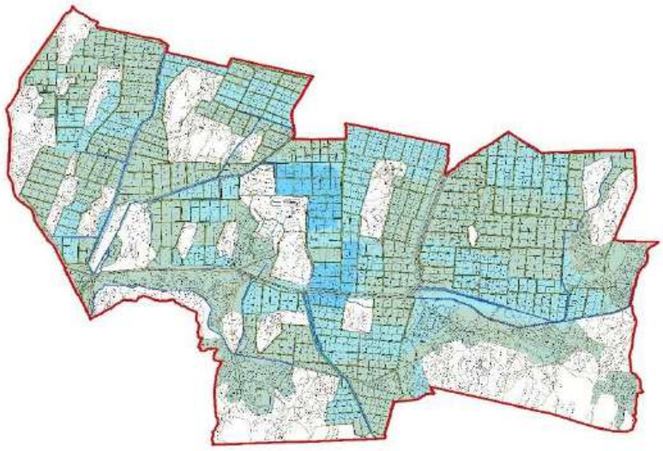

Fig. 2. Digital agrochemical cartogram reflecting the degree of soil supply with mobile phosphorus

3305.8 hectares or 52.8 percent of the total area of the massif are very poorly provided with mobile phosphorus, 2571.8 hectares (41.1%) are low, and 383.9 hectares (6.1%) belong to the moderately provided group (Figure 2). 1921.0 (30.7%) are very poorly provided with exchangeable potassium, 3423.3 hectares (54.7%) are low, 917.2 hectares (14.6%) are moderately provided (Figure 3).

Fig. 3. Digital agrochemical cartogram reflecting the degree of soil supply with exchangeable potassium

Using the created computerized agrochemical cartograms, scientifically sound norms and schedules for optimal fertilizer application for the most common crop kinds grown on farms were developed. To establish the fertilizer application rates for the entire massif, an improved approach was used. To determine the rates and timing of mineral fertilizer application, this method used correction factors for mobile phosphorus (Kf = 1.1088) and exchangeable potassium (Kk = 1.0383). When determining the nitrogen fertilizer rate, the nitrogen coefficient Ka = 1.5817 was used.

These coefficients contributed to the differentiation of scientifically based mineral fertilizer requirements for major agricultural crops. For instance, 761 hectares of cotton fields necessitate the application of 133.6 tons of nitrogen, 66.1 tons of phosphorus, and 43.9 tons of potassium mineral fertilizers. Similarly, 1055 hectares of grain areas require 148.4 tons of nitrogen, 73.0 tons of phosphorus, and 29.2 tons of potassium mineral fertilizers. Fertilizer standards were accordingly established for other key crop types.

In addition to coefficient-based calculations, scientifically grounded standards and schedules for mineral fertilizer application were determined directly from the indicators of digital agrochemical cartograms, reflecting nutrient content in the soil composition. For cotton, an annual nitrogen fertilizer norm of 94.9 kg/ha was suggested, with specific amounts allocated for sowing and multiple feedings. Phosphorus and potassium fertilizers were also recommended. Grain crops were prescribed an annual nitrogen fertilizer norm of 52.6 kg/ha, with specified amounts for each feeding. Phosphorus and potassium fertilizers were similarly advised for application during the autumn fall. Vegetable crops were allocated annual nitrogen, phosphorus, and potassium fertilizer norms, each with designated

amounts for various stages. A comparative analysis between the developed norms and the actual fertilizer usage in the reference massif revealed an excess of nitrogen fertilizers in the latter, surpassing the needs of soils and crops. Insufficient application of phosphorus fertilizers, particularly in cotton, grain, rice, and melon fields, was identified.
Additionally, deficiencies in potash fertilizers were observed in melon and potato fields, while orchards and vineyards received no phosphorus and potassium mineral fertilizers in recent years.

4 Conclusion

As per agrochemical cartograms generated through GIS technologies, the land area exhibiting a very low level of exchangeable potassium covers 34 hectares, low-supply land encompasses 36 hectares, and medium-supply land spans 3.3 hectares. The research also conducted a variogram analysis of agrochemical properties distribution in soils using the Empirical Bayesian kriging method in the ArcGIS software.
According to the agrochemical cartograms, the land area with a very low provision of exchangeable potassium constitutes 1921.0 hectares or 30.7%, low provision covers 3423.3 hectares or 54.7%, and land with an average provision amounts to 917.2 hectares or 14.6%.
Drawing upon the compiled digital agrochemical cartograms, coefficients for phosphorus (P1.1088) and potassium (K1.0383) were devised for the cultivated agricultural crops in the massif, facilitating the determination of annual norms for mineral fertilizers. Specifically, it was calculated that for 761 hectares of cotton fields in the massif, there is a requirement for the application of 133.6 tons of nitrogen, 66.1 tons of phosphorus, and 43.9 tons of potassium mineral fertilizers. Similarly, for 1055.2 hectares of grain areas, the recommended application rates include 148.4 tons of nitrogen, 73.0 tons of phosphorus, and 29.2 tons of potassium mineral fertilizers. Consequently, fertilizer standards were formulated for other primary crop types.

References

1. Gafurova LA, Saidova ME, Ergasheva OX, Kadirova DA, Dauletmuratov MM, Modern ecological - biological condition of salt-affected soils in the Aral sea area, *Int J Advanced Science and Technology* **28**, 533-540 (2019)
2. Djalilova GT, Gafurova LA, Ergasheva OX, Kadirova DA, Measures on erosion-preventive forest melioration in mountain areas of Uzbekistan, *Journal of Critical Reviews* **7**, 283-287 (2020)
3. Gafurova LA, Ergasheva OX, Djalilova GT, Kadirova DA, Degraded soils of Surkhan-Sherabad valley and their biological activity, *Journal of Critical Reviews* **7**, 292-295 (2020)
4. Gafurova LA, Ergasheva OX, Bioindication in ecological assessment of eroded soils in mountain areas, *Journal of Critical Reviews* **7**, 288-291 (2020)
5. Juliev M, Matyakubov B, Khakberdiev O, Abdurasulov X, Gafurova L, Ergasheva O, Panjiev U, Influence of erosion on the mechanical composition and physical properties of serozems on rainfed soils, Tashkent province, Uzbekistan, *IOP Conference Series: Earth and Environmental Science* **1068**, 012005 (2022)
6. Rakhimov D et al., Application of hyperspectral and multispectral datasets for mineral mapping, *E3S Web of Conferences* **386**, 04007 (2023)
7. Musirmonov J, Gafurova L, Ergasheva O, Saidova M, Wastewater treatment in Central Asia: a review of papers from the Scopus database published in English of 2000–2020, *E3S Web of Conferences* **386**, 02005 (2023)
8. Juliev M, Ng W, Mondal I, Begimkulov D, Gafurova L, Hakimova M, Ergasheva O, Saidova M, Surface displacement detection using objectbasedimage analysis, Tashkent region, Uzbekistan, *E3S Web of Conferences* **386**, 04010 (2023)
9. Sidikov S, Ergasheva O, Ermatova M, Valieva A, Innovative technologies to increase the fertility of irrigated soils and crop yield, *E3S Web of Conferences* **386**, 01012 (2023)
10. Saidova M, Gafurova L, Kodirova D, Shadiyeva N, Ergasheva O, Biodiagnostic survey of salt soils of the desert zone of Uzbekistan, *IOP Conf. Series: Earth and Environmental Science* **1142**, 012073 (2023)
11. Juliev M, Gafurova L, Ergasheva O, Ashirov M, Khoshjanova K, Mirusmanov M, Land Degradation Issues in Uzbekistan. In: Al-Quraishi AMF, Mustafa YT, Negm AM (eds) Environmental Degradation in Asia, Earth and Environmental Sciences Library, Springer, Berlin (2022)
12. Ergasheva O, Qarshiboyev Sh, Husanova S, Atashev E, Toshpulatov N, Yuldosheva Ch, Mustofoyev G, Study on the influence of fertilizers on the yield and quality of barley and potatoes, *E3S Web of Conferences* **497**, 03013 (2024)
13. Kuchkarov A, Boltaboev A, Ibragimov Q, Ergasheva O, Makhmudov M, Frequency of occurrence of field bugs-mirids on the cotton–alfalfa agrocenosis in the Tashkent oasis, *E3S Web of Conferences* **497**, 03007 (2024)
14. Turatbekova A, Kuramboev T, Ergasheva O, Kayumova N, Babayev A, Jumanazarov Sh, Tasheva U, Study on physiobiological features of grain and contemporary storage methods, *E3S Web of Conferences* **497**, 03022 (2024)