UDC 631.4:551.3

Magnetic receptivity of chernozem soils of Kharkiv area and its diagnostic significance

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The purpose. To characterize magnetic receptivity (MR) of chernozem soils as the major ones in agrarian ratio for Kharkov region and to show perspectives of its application at adoption of administrative solutions in farm-production. **Methods.** Agro-physical, agro-chemical, statistical, geoinformational analysis. **Results.** Allocation of values of MR of chernozem soils to terrain of Kharkov area is studied. Their statistical characteristics and link with the basic agrochemical indexes of soil are probed. Features of correlation between indexes at different territorial levels are shown. Large-scale of correlation of values of MR with the content of organic carbon and capacity of exchange cations is registered. **Conclusions.** Chernozem soils of Kharkov area are characterized by the heightened and tall values of specific MR of the upper layer of soil. A range of values of MR is 40 – 120 · 10 – 8kg/m3, that is in 3,5 – 4,5 times higher, than in parent rocks. Having analyzed link between soil's MR of the area and some its agro-chemical characteristics, they state low extent at the regional territorial level. At the same time at local level (one field with equal agro-industrial conditions) they determined high dependence between MR and contained humus, MR and sum of the absorbed bases. High dependence between the content of humus and MR allows using the last in events where detailed determination of humus (erosive researches and large-scale mapping of soil covering) is necessary.

Key words: *water erosion, humus, correlation, magnetic properties, chernozem.*

DOI: https://doi.org/20.31073/agrovisnyk201910-02

Introduction. Operational methods of soil cover study are the basis for managerial decision-making in modern agriculture. The transition to the concept of "precision farming", modern methods of protecting land from erosion and other innovations require more accurate definitions of soil properties [1]. Traditional laboratory methods of their definition, as laborious and costly, are gradually superseded by remote and contactless ones [2]. Geophysics - electrometric and magnetometric [3] occupy a prominent position among them. The most common geophysical characteristic - magnetic susceptibility (MS) of soils, has long been used as an additional indicator of the ecological status of the soil cover [4,5].

The purpose of the work is to characterize the MS of the black earth soils as the most important in agrarian relation for the Kharkiv region and to show the prospects of its application in making management decisions in agricultural production.

Objects and research methods. The data collection for the study included sampling of soils from the upper horizon of the chernozem soils distribution area in the Kharkiv region: podzolic chernozem, typical chernozem and ordinary. Considering the tasks of the study, mainly intensive agricultural land was studied. In some cases, soil samples were taken. The sampling scheme is shown in Fig. 1. The map "Soils of Kharkiv region, ecological resources and normative productivity of crops" was adopted as a cartographic basis (by M.I. Polupan, V.B. Solovey).

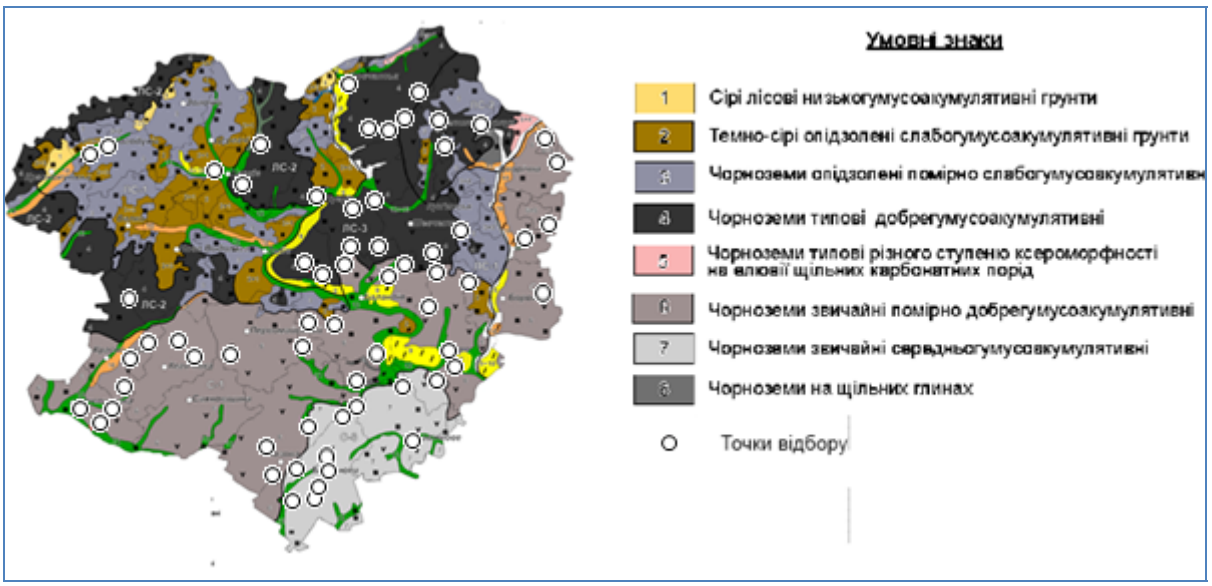

Fig. 1. Soil sampling scheme

Research methods include the determination of specific MS of air-dry soil using the KLY-2 capacitor (Czech Republic) according to the Evans method [6]. A similar technique was used to modify the calculation of the result. Vadunina [7]. The sample weight was determined using Ohaus 402 electronic scales. The determination of organic carbon content (followed by humus conversion) was performed according to DSTU ISO 14235: 2005. The results of the study were visualized in QGis. Statistical analysis of the data was performed using a standard software package. The pH of the water was determined according to DSTU ISO 10390: 2007. The determination of phosphorus and potassium content was carried out according to Chirikov or Machigin - DSTU 4114-2002 and DSTU 4115-2002.

Results and Discussion. In all, this study analyzes soil samples taken from 120 sites, including both single and regular or irregular network operations. The total number of samples for which a soil MC was determined was more than 1000. Some agrochemical parameters were determined for single samples from 51 objects. On network sites, the organic matter content was determined to be 300 samples, other indicators (pH, amount of absorbed bases, content of available forms of phosphorus and potassium) from another 110 samples. The main statistics of the data obtained are presented in Table.

Basic statistics of the data obtained

	N	Mean	Mediana	Moda	Min	Max	Variation, %
MS, 10^{-8}kg/m^3	60	82,643	84,465	85,5	43,970	110,440	13,6
C organic content, %	51	2,847	2,845	Multiple	1,520	3,760	17,6
Adsorbed alcalines	51	36,240	36,970	Multiple	21,370	44,220	14,2
pH	51	7,182	7,160	Multiple	5,810	8,25	9,6

The data in table 1 illustrate the studied indicators. MS is characterized by a lower variability than the organic content or amount of absorbed bases. Although the difference is insignificant, it allows to recommend MS for the description of soil properties as a more stable indicator [8]. The fashion was determined only by the MS index, the distribution of others was polymodal (Figure 2). The discrepancy with the normal distribution gives the basis for determining the correlation between the indicators to use nonparametric statistics methods - Spearman correlation.

For single samples, this relationship is poorly expressed. The Spearman correlation is between MS and organic matter content ρ = 0.29, between MS and sum of absorbed alcalines ρ = 0.41. Low values of the degree of communication explain the difference between agrotechnical and agrochemical measures on the studied lands. In this case, the Pearson correlation showed a significantly higher degree of correlation: R = 0.45 and R = 0.55.

A fundamentally different situation is observed when determining the relationship between MS and organic matter content in samples sampled at local sites - separate fields with the same agro-technical conditions. Thus, our studies have shown a high degree of association between MS and humus content in the typical black soil – 0.75 ... 0.89, which is in agreement with a number of European and South American studies [1, 9-11]. The highest effect was thus achieved in solving the problems of erosion.

This correlation is offset by the study of a group of several fields. Thus, the black earth MS of the ordinary field group of the southern part of the Lozovsky district has relatively low humus values (R = 0.45, Fig. 3a), while at the same time the correlation calculated for individual fields has higher rates: 0, 64 and 0.92 (Fig. 3b and 3c).

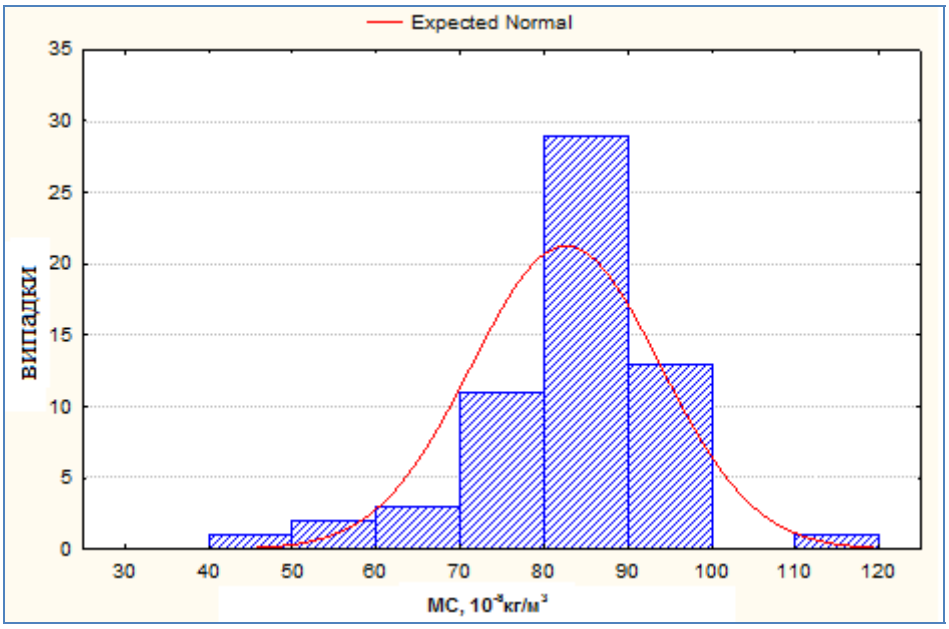

Fig. 2. Histogram of distribution of MS values of chernozem soils of Kharkiv region

The obtained histogram of the distribution of MS soil values has a fashion that is close to the arithmetic mean and has a pronounced peakedness. This form of distribution curve is most likely related to the spatial features of the sampling, more dense in the central part of the region, which is characterized by the MS value of soil 80-90x10^{-8}kg / m^3. In this study, the average values of MS were recorded: for podzolic chernozem 78.5x10^{-8}kg / m^3, typical chernozem of 84x10^{-8}kg / m^3, ordinary chernozem of 88.2 x10^{-8}kg / m^3. There is an increase in values in the north-south direction, which is probably related to the regional trend of Fe_2O_3 content [12].

This study did not establish a relationship between MS and soil pH. At the regional level R = 0.03, in the local areas the correlation coefficient is in the range -0.08 ... 0.12. The degree of association between MS and the potassium phosphorus content determined by Chirikov and Machigin is equally low ρ = 0.11… 0.27 for all studied territorial levels. We explain the presence of weak bonding by the ability of highly crystallized pedogenic iron compounds to attach P_2O_5 ions [10].

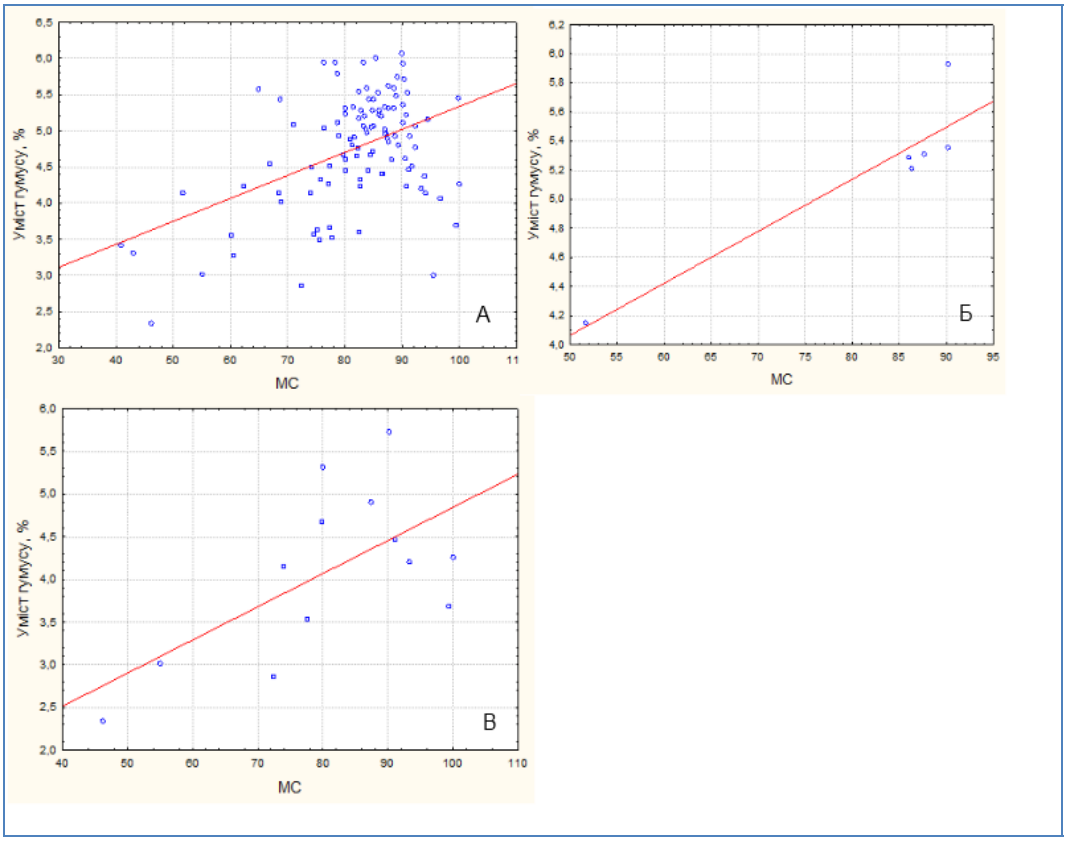

Fig. 3. Relationship between soil MC and humus content at regional (A) and local (B, C) territorial levels (for example, the plot in Lozovsky district)

The sufficiently high value of the MS coupling and the amount of absorbed alcalines ρ = 0.41 is explained primarily by the fact that both indicators are determined by the content of the colloidal fraction. Similar data with higher correlation coefficient were obtained earlier at the local territorial level for typical chernozem in the Kharkiv region [8].

In parallel for a series of single selections samples of soil-forming rock - 11 profiles were collected. Its MC values fluctuate within 19.5… 22.3 10^{-8}kg / m^3. There is no clear spatial differentiation. The lower values are inherent in the lower facies with high groundwater levels. The decrease in MS with depth is monotonous, with a maximum in the upper layer of arable land or 10-20 cm layer for fallow lands - similar to the distribution of humus content in the soil profile. Soil tillage with agitated soil (plowing, deep disking) offsets the layered difference in the values of the MS of the arable horizon. Again, this differentiation is fixed after 3-4 weeks. Changes in the MS of the surface layer after tillage reach -25 ... + 10%, which should be taken into account when conducting magnetometric studies.

Conclusions

Chernozem soils of Kharkiv region are characterized by high values of specific MS of the topsoil. The range of values of MS 40… 120 is 10-8kg / m3, which is 3.5-4.5 times higher than in soil-forming rocks. Analyzing the relationship between MS soil of the region and some of its agrochemical characteristics, we concluded that it is low at the regional territorial level. At the same time, a high degree of MS and humus content (up to R = 0.93), MS and amount of absorbed bases (ρ = 0.41) were found at the local level (one field, with the same agro-production conditions). The high difference between the values of Spearman and Pearson correlations between MS and organic carbon content indicates the significant influence of random "pops" of the studied characteristics.

There was no reliable relationship between MS and phosphorus and potassium content at any of the territorial levels studied.

The high degree of correlation between the content of humus and MS makes it possible to use the latter in cases where mass detailed definitions of humus are required: erosion studies and large-scale mapping of the soil cover.

References

1. Menshov, O., Kruglov, O., Vyzhva, S., Nazarok, P., Pereira, P., & Pastushenko, T. (2018). Magnetic methods in tracing soil erosion, Kharkov Region, Ukraine. *Stud. Geophys. Geod, 62*, 681- 696. https://doi.org/10.1007/s11200-018-0803-1
2. Menshov, A.I., & Kruglov, A.V. (2016). Magnitnye metody pri izuchenii degradatsii agrarnykh zemel Ukrainy [Magnetic methods in the study of degradation of agricultural lands of Ukraine]. *Bulletin of the East Kazakhstan State Technical University*, *3*, 9-14. (In Russian).
3. Nazarok, P.H., Kruhlov, O.V., Kutsenko, M.V., Menshov, O.I., & Sukhorada, A.V. (2015). Do problemy kartohrafuvannia eroziinykh protsesiv [On the problem of mapping of erosion processes]. *Bulletin of Agricultural Science, 9*, 63-68. (In Ukrainian).
4. de Jong, E., Nestor, P.A., & Pennock, D.J. (1998). The use of magnetic susceptibility tomeasure long-term soil redistribution. *Catena, 32* (1), 23–35.
5. Jakšík, O., Kodešová, R., Kapička, A., Klement, A., Fér, M., & Nikodem, A. (2016). Using magnetic susceptibility mapping for assessing soil degradation due to water erosion. *Soil & Water Res*., *11,* 105–113.
6. Evans, M., & Heller, F. (2003). Environmental magnetism: principles and applications of enviromagnetics. Academic press.

Vadyunina, A.F., & Korchagina, Z.A. (1986). Metody issledovaniya fizicheskikh svoystv pochv [Methods of studying the physical properties of soils]. Moscow: Agropromizdat. (In Russian).

7. Kruhlov, O.V. (2012). Osoblyvosti rozpodilu mahnitnoi spryiniatlyvosti chornozemu typovoho na skhylakh [Features of magnetic susceptibility distribution of typical black soil on slopes]. *Bulletin of the Kharkiv National Agrarian University*, *4*, 66-69. (In Ukrainian).
8. Kapicka, A., Dlouha, S., Grison, H., Jaksik, O., Kodesova, R., & Petrovsky, E. (2013). Magnetism of soils applied for estimation of erosion at an agricultural land. *Geophysical Research Abstracts, 15,* EGU2013-4774.
9. Camargo, L. A., Marques Júnior, J., Barrón, V., Reynaldo, L., Alleoni, F., Sobreira Barbosa, R., & Pereira, G. T. (2015). Mapping of clay, iron oxide and adsorbed phosphate in Oxisols using diffuse reflectance spectroscopy. *Geoderma, 251–252,* 124–132.
10. de Souza Bahia, A. S. R., J. Marques, N. La Scala, C. E. Pellegrino Cerri, & L. A. Camargo. (2017). Prediction and Mapping of Soil Attributes using Diffuse Reflectance Spectroscopy and Magnetic Susceptibility. *Soil Sci. Soc. Am.*, *81,* 1450-1462. https://doi.org/10.2136/sssaj2017.06.0206
11. Vodyanitskiy, Yu.N. (1989). Oksidy zheleza i ikh rol v plodorodii pochv [Iron oxides and their role in soil fertility]. Moscow: Nauka. (In Russian).