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Changes in Anti-deflation Resistance of Chernozem Typical under Different Tillage and Fertilizers

Abstract. The scale wind erosion is increasing in Ukraine in connection with the arid climate and intensive agricultural land use. Deflation causes significant damage not only to the soil cover, but also to the environment. Research showed that the resistance of soils to deflation depended on their structural state. The aim of the present study was to establish the influence of different tillage systems and fertilizers on agrophysical parameters of the soil. According to the method of dry sieving according to Savvinov, the content of particles larger than 1 mm and the number of agronomically valuable particles per 1% of humus according by V.V. Medvedev were determined in the soil. The research was conducted on a stationary experiment of the M.K. Shikula Department of Soil Science and Soil Conservation in Separated subdivision of NULeS of Ukraine "Oleksandr Muzychenko Velykosnytsinske Educational and Research Farm" of Fastiv district of Kyiv region. The soil of the experimental site is chernozem typical. It was found that in the variant with the application of straw, green manure and mineral fertilizers for reduced tillage, the content of particles larger than 1 mm was the highest and amounted to 75.1-77.5%. Conservation tillage systems provided a deflation-resistant soil surface, as the content of particles over 1 mm was greater than 60%. Reduced tillage together with the fertilizer variant "Straw 1.2 t/ha + N₁₂ + N₇₈P₆₈K₆₈" creates the best conditions for aggregation in a layer of 0-30 cm of chernozem typical. On non-plowing tillage, more favorable aggregation conditions were on the variant "Straw 1.2 t/ha + green manure N₁₂ + N₇₈P₆₈K₆₈". On variant with plowing, the indicators of the structural state of chernozem typical deteriorated

Keywords: wind erosion, lumpiness, soil structure, reduced tillage, aggregation standards, typical chernozem

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INTRODUCTION

Wind erosion is second among all soil degradation processes and causes substantial damage to agriculture (Yang, Geng, Fu, Coulter, Chai, 2020).

In the spring of 2020, an extraordinary meteorological phenomenon occurred – a powerful dust storm that covered the territory of Kyiv, Zhytomyr, Chernihiv and other regions of Ukraine. The main reason for this phenomenon was the abnormal weather conditions of 2019 and the first half of 2020: insufficient rainfall in autumn and spring in combination with a snowless winter, as well as high wind speeds. is not only due to climate change. An essential factor in the occurrence of dust storms is the irrational use of soil resources. After all, the main factor in wind erosion or deflation is excessive plowing of agricultural and (Fig. 1).



Figure 1. Dust storm in Kyiv, April 18, 2020

According to the the State Service of Ukraine for Geodesy, Cartography and Cadastre, as of 01.01.2016, the total area of agricultural land in Ukraine was 41.5 million hectares, including arable land – 32.5 million hectares. Plowing of soils

on average in Ukraine is 78.4%. This is one of the highest rates in the world, which has continued to grow in recent years. At the same time, the area of forest, protective forest belts, hayfields and pastures is declining. This causes a violation of the ecological balance in agricultural landscapes, which leads to a decrease in their resistance to degradation processes, including water and wind erosion. The cause of wind erosion is the destruction of the soil structure. That is why scientific studies of soil deflation stability are important.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Intensity of the effects of deflation processes depends on the physical and geographical conditions of the distribution of agricultural land, systematic soil protection activities and the availability of vegetation. It was established that the acceleration of the deflation processes occurred in the territories with increased anthropogenic pressure. An understanding of soil resistance to wind erosion as affected by the integration of cropping system intensification and tillage method is imperative for reducing wind erosion, thereby improving global food security and reducing environmental degradation (Dudiak, Pichura, Potravka, Stroganov, 2020).

The intensity of deflation directly depends on the degree of wind resistance of the soil surface and wind speed. The degree of anti-deflation resistance of the upper layer is determined both directly by the stability of the soil and plant debris on its surface. (Voloshenyuk, A.V., 2015).

Significant changes in soil aggregate size distribution associated with wind erosion processes may occur in short periods of time. Thus, temporal variability of soil surface properties, including crust and clods stability, needs to be considered in wind erosion research in agricultural soils (López, Gracia, Arrúe, 2000).

Conservation tillage is commonly used in regions affected by water and wind erosion. Research scientists found the positive impact of reducing the intensity of tillage on fertility rates (Tan, Cao, Yuan *et al.*, 2015; Berezniak, M., & Berezniak, E., 2019; Pikovska, 2011; Tykhenko O.V., 2016). Soil erosion estimates in the study area under conservation tillage with stubble retention was significantly lower than that under conventional tillage during the monitoring period. (Gao, Dang, Yu, Li, Liu, and Wang, 2016).

The size distribution and stability of soil aggregates have a major influence on the wind erodibility of soils (Tatarko, 2001). Geometric mean diameter, erodible fraction, and dry aggregate stability are soil parameters deduced by dry sieving that are used to identify soil susceptibility to wind erosion (Graciela Hevia, Mariano Mendez, Daniel Buschiazzi, 2007).

MATERIALS AND METHODS

The research was conducted on a stationary experiment of the M.K. Shikula Department of Soil Science and Soil Conservation in Separated subdivision of NULS of Ukraine "Oleksandr Muzychenko Velykosnytsinske Educational and Research Farm" of Fastiv district of Kyiv region. The soil of the experimental site is chernozem typical. The soil of the experimental site was characterized by the following indicators. The content of physical clay in the upper horizon was 34.5%, in the middle 22% of silt and 28% of sand, the content of coarse dust – 46.3, middle – 6.8, fine – 3.4%. The humus content in the subsoil is 3.6%, in the subsoil – 3.5%. The reaction of the soil medium is neutral, the number of absorbed cations is 35.4 mg-eq / 100 g of soil, and the degree of saturation of the bases is 93.4%.

The experiment includes three variants of tillage:

- a) plowing at 25-27 cm;
- b) deep plowless cultivation;
- c) reduced tillage on deep 10-12 sm.

3 fertilization systems with the introduction of 1 ha of crop rotation area were researched:

1. Control (without fertilizers)
2. Straw 1.2 t/ha + $N_{12} + N_{78}P_{68}K_{68}$
3. Straw 1.2 t/ha + N_{12} + sideats + $N_{78}P_{68}K_{68}$.

Indicators of the structural state were determined by N. I. Savvinov, the humus content – by the method of I.V. Tyurin in the modification of V.N. Simakov. The norm of soil structure formation (aggregation) was the number of structural units (agronomically valuable structure ranging in size from 10 to 0.25 mm), which accounts for 1% of the total humus (Medvedev, V. V., 2010).

Indicators of soil macrostructure, in particular the content of aggregates more than 1 mm in dry sieving by the method of Savvinov, are used as an indirect but universal indicator of anti-deflation resistance of soil (Chornyy, S.H., Vydyniv'ska, O.V., Voloshenyuk, A.V., 2012; Chornyy, S.G, Pysmennyj, O.V., 2011).

The aim of the research was to establish the impact of various farming practices on structural indicators aggregate composition.

RESULTS

Tillage systems significantly affected the structural and aggregate composition of chernozem typical of Right-Bank Forest-Steppe of Ukraine. The highest content of dust particles in all variants was observed in the upper layer of 0-10 cm, while cloddy – in the layer of 20-30 cm for plowing 28.20-32.4%. The content of units with a size of 0.25-0.5 mm is higher under plowing on all fertilizer variants.

To assess the resistance of soils to blowing on the content of particles larger than 1 mm, the most informative is their number in the upper 0-10 cm layer. In the present studies, their content varied significantly according to the options in the above layer and was 52-77.5%. The lowest values were found in the control of plowing, while on deep non-plowing tillage – 56.8%. Minimization of tillage of chernozem typical helped

to create conditions for the formation of a deflation-resistant soil surface even without fertiliz-

er, where the percentage of particles over 1 mm was 67.7 (Fig. 2).

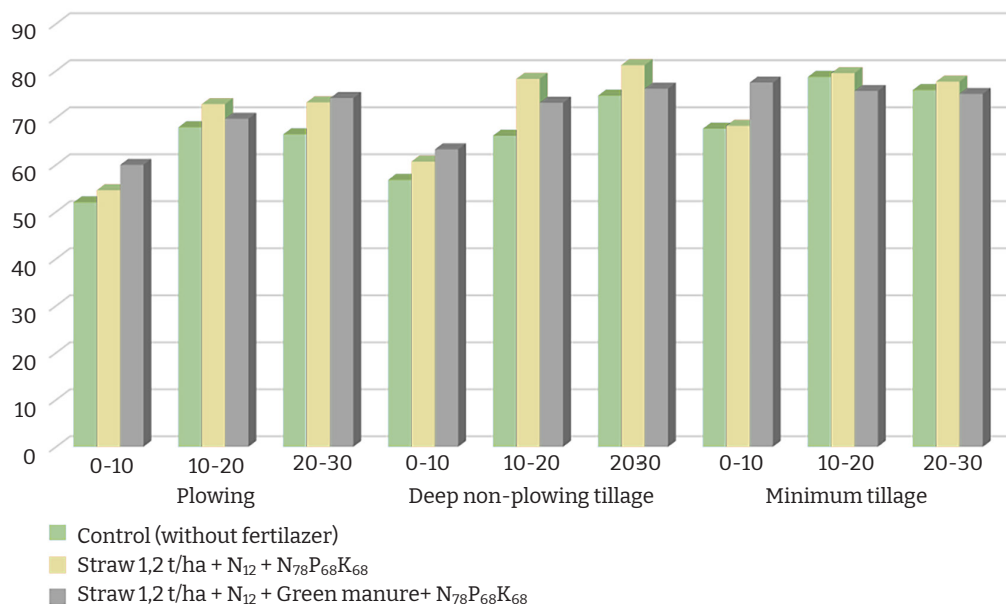


Figure 2. The content of aggregates sizes larger 1 mm in chernozem typical

In the layer of 10-20 cm, similarly to the upper 0-10 cm layer, higher values of particles larger than 1 mm were observed: for deep non-plowing tillage 66.2-78.3 and for the reduced tillage – 75.7-79.5%. However, in the deepest researched layer of 20-30 cm, the advantages were for deep non-plowing tillage (74.7-81.2%) against 75.1-77.7% for the reduced tillage and 66.5-74.2 on plowing.

The use of organo-mineral fertilizers increased the deflation stability of the surface of chernozem typical. In the variant with the combined use of straw and mineral fertilizers, the particle content of more than 1 mm was higher compared to the control without fertilizer for plowing by 2.6-6.8%, for deep non-plowing tillage – by 3.9-12.1%, while under the reduced tillage increase in the percentage of particles was only 0.6-1.8. Reduced tillage provided the best conditions for soil structuring under the

influence of green manure. In the variant with the application of straw, green manure and mineral fertilizer, the content of particles larger than 1 mm was 75.1-77.5%.

Studies on chernozem ordinary Northern Steppe of Ukraine established that the use of reduced and zero tillage ensured the preservation of their fertility. The content of aggregates larger than 1 mm in the 0-10 cm layer of ordinary chernozem at reduced tillage was 60%, at No-till – 62%, while during plowing the particle content was only 49%. (Pikovska, 2020)

Medvedev V.V. (2010) on the basis of research established a relationship between the content of agronomically valuable structural aggregates (10-0.25 mm) and the content of humus in the soil. He recommends the use of aggregation standards for soils of Ukraine: the content of macroaggregates of 10-0.25 mm, which is 1% of humus, in the

Forest-Steppe for medium loamy soils should be 20%. This level of structuring of arable soils, which is provided by the relevant aggregation factors, should be maintained and their deterioration should not be allowed. The consequence will be the reduction of aggregation agrophysical degradation, leading to deterioration of soil resistance to the action of water and wind erosion.

These V.V. Medvedev's (2010) standards were used to identify potential realization of aggregation, comparing the ratio of the actual value of the index options aggregation experiment. If the actual value is less than the standards, then there are conditions in the soil that inhibit the process of aggregation. The results of calculations of indicators for different options are shown in Figure 3.

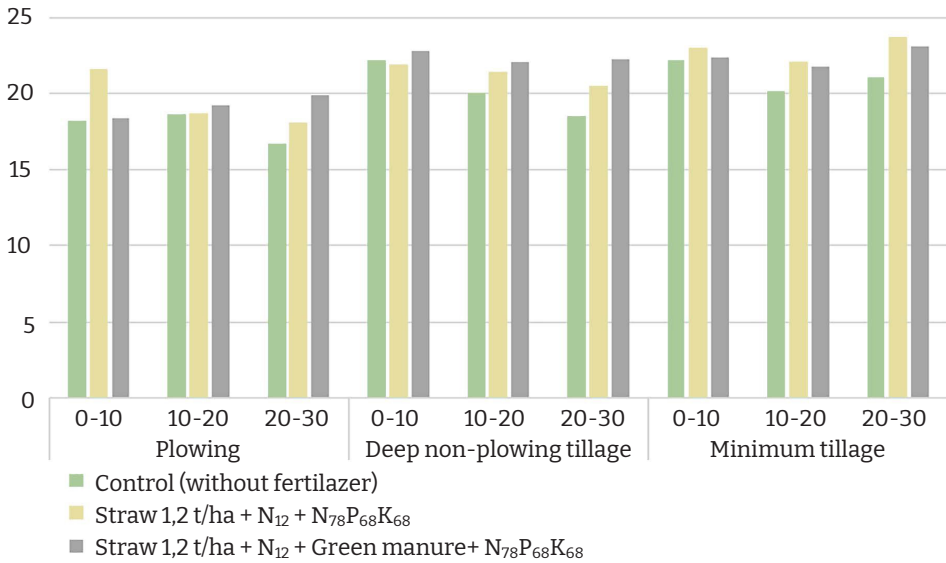


Figure 3. Content of agronomically valuable aggregates 10-0.25 mm per 1% of humus in chernozem typical

It was found that the aggregation rate for the content of agronomically valuable aggregates for all fertilizer variants compared to plowing increased. In the case of reduced tillage, this content was the highest – 20.1-23.7, while in deep non-plowing tillage it was in the range of 18.5-22.8; for plowing the values were the lowest – 16.7-21.6%.

The lowest values of indicators for different tillage systems were found in the layer of 0-10 sm. During plowing in almost all layers and variants of fertilizers the values were lower than

the normative 20%, which indicates the presence of factors that slow down the process of aggregation in the arable layer.

Deep non-plowing tillage increased the aggregation capacity of the soil on all variants of fertilizer in a layer of 0-30 cm compared to plowing. It should be noted that fertilizer options helped to improve soil aggregation conditions. The best conditions for aggregation in all layers of the studied soil (22.1-22.8%) were created on the variant "Straw fertilizer 1.2 t/ha + N₁₂ + green manure + N₇₈P₆₈K₆₈". And for this

variant of cultivation there was the smallest differentiation of soil layer 0-30 cm. In the variant of minimal tillage, some changes were noted in the variants of fertilizer compared to deep non-plowing tillage.

The highest content of aggregates with a size of 10-0.25 mm, per 1% of humus, was observed in the variant of joint application of straw and mineral fertilizers (22.1-23.7%). Slightly lower values of this indicator were in the case of straw, green manure and mineral fertilizers (21.8-23.1%). We explain this phenomenon by the fact that with shallow cultivation there is a worse earning of green mass of green manure in the soil.

Thus, the application of reduced tillage in conjunction with the fertilizer option «Straw 1.2 t/ha + N₁₂ + N₇₈P₆₈K₆₈» creates the best conditions for aggregation in 0-30 cm layer of typical chernozem. However, with deep tillage to create favorable conditions for aggregation, we can recommend the option «Straw 1.2 t/ha + green manure N₁₂ + N₇₈P₆₈K₆₈». Systematic application of plowing will worsen the structural

condition of soils, especially without the use of fertilizers, which can reduce the resistance of soils to deflation.

CONCLUSIONS

Irrational agricultural use of soils leads to the development of degradation processes, including wind erosion. Based on the research, it is established that tillage systems have a significant impact on the development of deflationary processes. To assess the anti-deflation stability of chernozem typical use parameters of the structural and aggregate composition of the soil. It was found that the reducing of tillage together with the organo-mineral fertilizer system provides the formation of deflation-resistant surface of chernozem typical in the conditions of the Right Bank Forest-Steppe of Ukraine compared to plowing, where the content of particles larger than 1 mm was less than 60%. Further researches on establishment of moisture-preserving effect of various systems of tillage in the conditions of aridization of climate are perspective.

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Зміни антидефляційної стійкості чорнозему типового за різного обробітку ґрунту та удобрення

Анотація. Масштаби вітрової ерозії в Україні зростають у зв'язку з посушливим кліматом та інтенсивним сільськогосподарським використанням земель. Дефляція завдає значної шкоди не тільки ґрунтовому покриву, а й навколишньому середовищу. Дослідження показали, що стійкість ґрунтів до дефляції залежить від їхнього структурного стану. Метою даного дослідження було встановити вплив різних систем обробітку ґрунту та добрив на агрофізичні показники ґрунту. Методом сухого розсіву за Саввіновим у ґрунті визначали вміст часток розміром більше 1 мм та кількість агрономічно цінних часток на 1 % гумусу за В. В. Медведєвим. Дослідження проводили на стаціонарному досліді кафедри ґрунтознавства та охорони ґрунтів ім. М. К. Шикуні у Відокремленому підрозділі НУБіП України "Великоснітинське навчально-дослідне господарство ім. О. В. Музиченка" Фастівського району Київської області. Ґрунт дослідної ділянки - чорнозем типовий. Встановлено, що у варіанті з внесенням соломи, сидератів та мінеральних добрив за мінімального обробітку ґрунту вміст часток розміром більше 1 мм був найвищим і становив 75,1-77,5 %. Ґрунтозахисні системи обробітку забезпечували дефляційно стійку поверхню ґрунту, оскільки вміст часток розміром понад 1 мм перевищував 60%. Поглиблений обробіток ґрунту разом з варіантом удобрення "Солома 1,2 т/га + $N_{12} + N_{78}P_{68}K_{68}$ " створює найкращі умови для агрегації в шарі 0-30 см чорнозему типового. За безполіцевого обробітку ґрунту більш сприятливі умови агрегації були на варіанті "Солома 1,2 т/га + сидерат $N_{12} + N_{78}P_{68}K_{68}$ ". На варіанті з оранкою показники структурного стану чорнозему типового погіршилися

Ключові слова: вітрова ерозія, грудкуватість, структура ґрунту, мінімальний обробіток, показники агрегатного стану, чорнозем типовий