A granulometric composition of the Zauralye black soils

A Plotnikov¹ and A Sozinov¹*

¹Kurgan State Agricultural Academy named after T. S. Maltsev, Lesnikovo 641300 Russia

E-mail: savrey@ya.ru

Abstract. The article presents results of the study devoted to the granulometric composition of Zauralye black soils. The main patterns of the profile differentiation of soils in connection with the genesis and anthropogenic load on agricultural land are considered. There are signs of elution in the upper part of the soil profile when analyzing the nature of the distribution of fractions of granulometric composition. In general, a black soil profile on the granulometric composition is poorly differentiated.

1. Introduction

Currently, the rational use, protection, and improvement of soil fertility have become one of the most important problems of mankind. Especially acute, it is placed in areas of intensive agricultural development. Numerous studies have found that morphological features, water-physical, and agrochemical properties change significantly in black soils due to prolonged agricultural use. The loss of turf and the homogenization of horizon A to the depth of the main treatment are the most significant changes in the morphology of virgin black soils after plowing. A number of scientists believe that the profile of arable Eastern European black soils varies slightly [1, 2]. However, the West Siberian black soils change when plowing to a much greater extent due to their provincial features [3-7].

The granulometric composition of contemporary soils reflects the genesis of soil-forming rocks and indicates the direction of their transformation under different conditions of agricultural use. It largely determines its structural and functional properties, being one of the main structural levels of the organization of the soil solid phase and directly participating in the formation of micro and macrostructures. The quantitative ratio in the distribution of elementary soil particles and their properties by fractions significantly affect both the aggregate level and the nature of the dynamics of the pore space [8, 9].

An optimal granulometric composition varies for different crops. The soils are light in granulometric composition, they are well aerated, but they have low water holding capacity, they are less resistant to drought, water erosion, and deflation. Medium and heavy soils have a higher coherence and moisture capacity. By comparison to light sandy soils, they are well supplied with nutrients and humus. Reserves of moisture and nutrients in these soils are able to provide good yields of agricultural crops, they have a pronounced structure and contain a sufficient number of water-resistant aggregates [1, 2, 9].

In the territory of the Kurgan region, the type of black soil is represented by the following two subtypes: leached black soils (ΨŁ); ordinary black soils (ΨO) (they occupy 2,149.7 thousand hectares, or 30.3% of the total area). In the subtype of ordinary black soils in the region, the following genus are distinguished: ordinary, alkaline, alkaline carbonate, carbonate, solodized, deep stripping.
The share of these soil subtypes in the structure of arable land is different in zones. In the black soils northwestern zone, a share for leached soils is 44%, and it is 35.7% for ordinary alkaline soils; in the central zone, it is 33 and 45.7%, respectively. In the eastern zone, there shares are 48.3 and 68.0%, and 48.3 and 25.4% in the southern zone [3].

Ordinary and leached black soils have a loamy and clayey granulometric composition in most parts of the Zauralye forest-steppe [3, 5]. Leached black soils, light in granulometric composition, are less common.

2. Materials and Methods
The purpose of the study is to measure the granulometric composition of black soils in the process of soil formation at different levels of anthropogenic load.

The research objects include two subtypes of black soils: leached and ordinary. Research was conducted on the following experimental fields of the Kurgan Research Institute of Agriculture:

- Central and Kurgan State Agricultural Academy (Ketovsky district, central zone);
- Makushinsk (Makushinsky district, eastern zone);
- Yuzhnoye (Tselinny district, southern zone).

Related studies of soils with different agricultural loads were carried out to determine the influence of anthropogenic factors on soil formation processes. Sampling was carried out at the closest possible distance from each other so that, unlike the anthropogenic factor, the natural factors of soil formation were as close as possible.

Two cuts to the horizon of parent rock C are laid on each experimental field. Sampling was conducted on two agricultural backgrounds: virgin and arable. Samples for laboratory analysis were taken from each genetic horizon. We determined the soil granulometric composition by the pipette method (according to N. A. Kachinsky) in the laboratory.

Wild vegetation on virgin areas is mainly represented by Aster and Bean families. Agrocenoses on arable land are represented by field crop rotation (crops of continuous sowing - wheat, annual grasses).

3. Results
The results of analyzes of the granulometric composition showed that in leached black soils an increase in clay fraction occurred as a result of agricultural use. So, on the Experimental Field of the Kurgan State Agricultural Academy in the upper humus horizon on virgin soil, the content of physical clay was 29.5%; on arable land, its content increased to 33.0%; and, according to Kachinsky’s classification, the soil already goes into the category of medium loamy. Fine sand and sludge fraction predominate in the composition of granulometric fractions. In this regard, the medium loamy variety has received an additional name – silty sand (Table 1).

In the Central Experimental Field, a significant weighting of the granulometric composition occurred due to an increase in the fraction of fine dust. In horizons A and AB in virgin soil, the content of physical clay was 19.4-22.6%, while its content was 32.7-33.5% in arable and subsurface horizons.

On the Yuzhnoye Experimental Field, in the upper humus horizon on virgin soil, the content of physical clay was 19.4-22.6%, while its content was 32.7-33.5% in arable and subsurface horizons.

Thus, the content of the sludge fraction within the humus-accumulative soil horizons tends to increase regardless of the type of use. In leached black soils, it increases by 0.2%.

The granulometric composition of the ordinary saline black soils on the Makushinsky Experimental Field is represented by a heavy variety. The coarse silt (Krupnopylevataya) and sludge fraction predominate in the composition of the granulometric fractions. A heavy variety on virgin soil is silty-large-silty (ilovato-krupnopylevataya). An increase in the fine sand fraction was observed on arable land. A similar pattern is observed in the treated area in the horizon, as well as in leached black soils: an increase in the fraction of sludge and physical clay in horizon A (from 41.7 to 48.3%).
Table 1. A granulometric composition of the leached and ordinary Zauralye black soils.

| Cut location | Genetic horizon | Large and medium sand, 1-0.25 mm | Fine sand, 0.25-0.05 mm | Coarse dust, 0.05-0.01 mm | Medium dust, 0.01-0.005 mm | Fine dust, 0.005-0.001 mm | Sludge, less than 0.001 mm | Physical clay, less than 0.01 mm |
|--------------|-----------------|---------------------------------|------------------------|--------------------------|----------------------------|---------------------------|---------------------------|-----------------------------|
| Virgin lands | A (4-27)        | 7.0                             | 49.9                   | 13.6                     | 6.9                        | 10.3                      | 12.3                      | 29.5                        |
|              | AB (27-40)      | 8.2                             | 49.5                   | 12.1                     | 7.0                        | 7.1                       | 16.1                      | 30.2                        |
|              | B (40-62)       | 6.3                             | 45.7                   | 10.6                     | 9.2                        | 7.5                       | 20.7                      | 37.4                        |
|              | BC (62-89)      | 10.0                            | 49.3                   | 11.4                     | 4.7                        | 7.3                       | 17.3                      | 29.3                        |
|              | C (> 89)        | 11.4                            | 56.4                   | 8.9                      | 2.3                        | 7.8                       | 13.2                      | 23.3                        |
| Arable lands | A (0-24)        | 5.2                             | 57.2                   | 4.6                      | 2.9                        | 10.5                      | 19.6                      | 33.0                        |
|              | AB (24-37)      | 4.6                             | 54.5                   | 5.6                      | 1.7                        | 9.6                       | 24.0                      | 35.3                        |
|              | B (37-60)       | 5.3                             | 55.0                   | 5.5                      | 1.6                        | 8.7                       | 23.9                      | 34.2                        |
|              | BC (60-85)      | 5.5                             | 64.7                   | 3.7                      | 1.3                        | 6.0                       | 18.8                      | 26.1                        |
|              | C (> 85)        | 12.0                            | 48.5                   | 19.1                     | 1.8                        | 5.9                       | 12.7                      | 20.4                        |

Leached, light loamy black soil (Experimental field of KSAA)

| Virgin lands | A (3-26)        | 6.4                             | 43.3                   | 27.7                     | 2.4                        | 8.7                       | 11.5                      | 22.6                        |
|              | AB (26-43)      | 5.5                             | 37.6                   | 37.5                     | 1.5                        | 7.5                       | 10.4                      | 19.4                        |
|              | B (43-68)       | 8.9                             | 24.8                   | 41.8                     | 1.0                        | 7.5                       | 16.0                      | 24.5                        |
|              | BC (68-102)     | 8.4                             | 20.0                   | 33.8                     | 3.5                        | 14.5                      | 19.8                      | 37.8                        |
|              | C (102-120)     | 8.3                             | 20.5                   | 43.6                     | 1.4                        | 13.5                      | 12.7                      | 27.6                        |
| Arable lands | A (0-24)        | 7.5                             | 39.9                   | 19.9                     | 4.2                        | 15.9                      | 12.6                      | 32.7                        |
|              | AB (24-40)      | 6.6                             | 36.5                   | 23.4                     | 6.6                        | 13.5                      | 13.4                      | 33.5                        |
|              | B (46-68)       | 8.0                             | 21.9                   | 24.6                     | 3.6                        | 15.6                      | 26.3                      | 45.5                        |
|              | BC (66-100)     | 6.2                             | 22.8                   | 33.8                     | 1.1                        | 12.7                      | 23.4                      | 37.2                        |
|              | C (> 100)       | 7.9                             | 21.2                   | 38.3                     | 1.6                        | 16.3                      | 14.7                      | 32.6                        |

Leached, light loamy black soil (Central Experimental Field)

| Virgin lands | A (5-28)        | 5.1                             | 19.4                   | 33.8                     | 8.1                        | 11.7                      | 21.9                      | 41.7                        |
|              | AB (28-46)      | 6.2                             | 24.1                   | 28.0                     | 6.6                        | 11.7                      | 23.4                      | 41.7                        |
|              | B (46-68)       | 2.7                             | 22.3                   | 23.6                     | 8.1                        | 12.1                      | 31.2                      | 51.4                        |
|              | BC (68-80)      | 4.3                             | 16.4                   | 16.3                     | 8.4                        | 16.1                      | 38.5                      | 63.0                        |
|              | C (> 80)        | 7.7                             | 28.6                   | 11.8                     | 2.2                        | 10.9                      | 38.8                      | 51.9                        |
| Arable lands | A (0-22)        | 3.5                             | 26.1                   | 22.1                     | 9.8                        | 11.9                      | 26.6                      | 48.3                        |
|              | AB (22-38)      | 5.3                             | 28.6                   | 21.7                     | 6.9                        | 13.0                      | 24.5                      | 42.4                        |
|              | B (38-62)       | 5.4                             | 20.5                   | 22.2                     | 6.1                        | 11.9                      | 33.9                      | 51.9                        |
|              | BC (62-78)      | 6.1                             | 21.6                   | 10.1                     | 8.4                        | 14.3                      | 39.5                      | 62.2                        |
|              | C (> 78)        | 4.0                             | 28.3                   | 5.6                      | 6.0                        | 14.9                      | 41.2                      | 62.1                        |

Ordinary alkaline heavy loamy black soil (Makushinskoe Experimental Field)

| Virgin lands | A (4-26)        | 6.3                             | 47.6                   | 15.1                     | 5.8                        | 10.4                      | 14.8                      | 31.0                        |
|              | AB (26-41)      | 6.7                             | 41.6                   | 15.7                     | 3.5                        | 7.8                       | 24.7                      | 36.0                        |
|              | B (41-72)       | 7.6                             | 47.9                   | 13.2                     | 0.8                        | 6.3                       | 24.2                      | 31.3                        |
|              | BC (72-93)      | 5.6                             | 46.8                   | 14.6                     | 4.6                        | 7.5                       | 20.9                      | 33.0                        |
|              | C (>93)         | 6.7                             | 42.0                   | 12.3                     | 3.9                        | 18.1                      | 17.0                      | 39.0                        |
| Arable lands | A (0-24)        | 6.3                             | 47.1                   | 15.4                     | 5.1                        | 10.9                      | 15.2                      | 31.2                        |
|              | AB (24-40)      | 4.8                             | 45.8                   | 13.3                     | 6.5                        | 4.7                       | 24.9                      | 36.1                        |
|              | B (40-68)       | 5.7                             | 49.4                   | 11.0                     | 7.9                        | 4.2                       | 21.8                      | 33.9                        |
|              | Bx (68-78)      | 4.5                             | 39.1                   | 15.4                     | 5.7                        | 9.5                       | 25.8                      | 41.0                        |
|              | BC (78-90)      | 7.5                             | 46.3                   | 16.5                     | 0.1                        | 13.6                      | 16.0                      | 29.7                        |
|              | C (>90)         | 4.5                             | 50.4                   | 10.9                     | 3.2                        | 18.6                      | 12.4                      | 34.2                        |

Source: Compiled by the authors.

4. Discussion
Zonal features of soil formation are revealed in a comparative study of the distribution over the soil profile of the most dispersed and active fraction, which is the sludge fraction (particles <0.001 mm).
This study gives an idea of the most important manifestation of the soil-forming process: the nature of transformations and movements of the soil solid phase, the degree of its fixation, mobility, migration in the soil profile. That is, such a study gives an idea of the processes of elution, eluviation, and argillization of the soil mass, etc.

Signs of elution in the upper part of the soil profile are detected when analyzing the nature of the distribution of fractions of granulometric composition. In general, the black soils profile is poorly differentiated by the granulometric composition. There is a slight silt depletion in the upper part and some compaction in the middle part with a weakly pronounced maximum in the illuvial horizons. This is a physical characteristic of the soil studied.

5. Conclusion
The content of the sludge fraction within the humus-accumulative soil horizons tends to increase regardless of the type of use. In leached black soils, it increases by 0.8-4.8% and by 1.5-4.9% in ordinary alkaline.

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