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# SEASONAL VARIATION OF SOME SOIL STRUCTURE INDICATORS

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A b s t r a c t. Seasonal changes of soil carbohydrate and root weight were studied for the grey forest soil at different phases of the growth of barley. The soil structure was characterized simultaneously by soil aggregate composition, bulk density and water retention capacity. Concurrent changes of the characteristics measured were observed. Water retention capacity was inversely related to macroporosity. The role of hydrocarbons in less than 2 mm soil aggregate formation was analysed by the method of cluster processing. Surface areas of less than 3 mm aggregate fractions increased with the increase of carbohydrate content and decreased after oxidation of carbohydrates.

K e y w o r d s: polysaccharides, aggregation, soil structure

## INTRODUCTION

Natural cycles of drying and wetting cause changes of aggregate composition and pore space structure [13,17]. Plant roots and soil microorganisms, producing organic substances, contribute to soil aggregate formation [4,14]. The dependence between the extent of hydrocarbon oxidation and stability of soil aggregates [3] and soil surface area [11] is well established. There are, however, only a few data on the conjugate changes of hydrocarbon content and soil structure. These studies are the objective of our paper.

## METHODS AND OBJECTS

The experiment was carried out on the grey forest soil with barley at the field experimental station of the Puschino Institute. Soil cores were sampled from two plots: control (C1) and fertilized (C2: N-120, P-80, K-90 kg $ha^{-1}$) and two depths: 10-15 and 25-30 cm. These samples were taken before and at four phases of barley growth: stem elongation, inflorescence emergence, milk beginning and wax stage.

The soil water retention capacity was estimated for a soil water potential range from -1 to -50 kPa according to Várallyay and Mironenko [19]. The aggregate composition was determined by wet sieving [18]. The root weight was measured after washing out the soil material from undisturbed cores on 2.5x2.5 mm sieve. Carbohydrate content was determined according to Dubois *et al.* [7]. The porosity was determined by the mercury intrusion in the pressure range from 0.1 to 190 MPa. Macroporosity was calculated by the Hall technique [2]. The seasonal changes of the carbohydrate content were analysed by the cluster processing method. The soil surface area was estimated by the Brunauer, Emmet and Teller (BET) method as described by Vadiunina and Korchagina [18]. To estimate statistically reliable discrepancies from a small data choice the Dmitriev [6] approach was applied. Soil carbohydrates were oxidized with 0.02 M $NaJO_4$ by the Cheshire *et al.* [3] method.

## RESULTS AND DISCUSSION

The root weight increased by the mid vegetation period and decreased by the harvest time. The carbohydrate content increased at mid vegetation followed by a slight decrease (Fig. 1a). The obtained relations are similar to those observed for chernozem under barley [1].

A concurrent seasonal changes of root weight and the content of 2.5-100 mm aggregates were observed (see Fig. 1b and c). Plant roots and soil microorganisms spread within the large pores and produce organic substances which form and enlarge soil aggregates [11,16]. When the root weight and macroporosity increased, the bulk density decreased (Fig. 1b, d and e). Macropores (>0.06 mm) are responsible for soil water retention at the soil suction >0.005 MPa [2,10] and the main part of plant roots occur in these pores [2]. The decrease of water retention and bulk density at harvest was consistent with the changes of the root weight and macroporosity. A small decrease of the macroporosity at the seasonal minimal soil moisture content occurred probably because of pores deformation as a result of the drought (Fig. 1d and f). Seasonal changes of macroporosity and bulk density seem to be influenced mainly by plant roots.

The data of the seasonal changes of the carbohydrate content for aggregate fractions: >10, 10-7, 7-5, 5-3, 3-2, 2-1, 1-0.5, and 0.5-0.25 mm were analysed by the cluster processing method. The seasonal changes in hydrocarbon content were initially analysed separately for different depths and fertilizer levels and subsequently the same was done for all the experimental data. All the curves illustrating data changes were divided into two clusters. The first one consisted of the curves for aggregate fractions >2-3 mm, and the second one - for the aggregates <7 mm. The curves for the aggregate fractions 3-7 mm were found either in the first or in the second cluster for the different experimental sets. The content of aggregate fractions less then 2-3 mm correlates with the carbohydrate content what is in agreement with the literature [11,14]. Cheshire *et al.* [3,5] observed a correlation between the extent of soil carbohydrate oxidation with sodium periodate and the stability of < 2 mm soil aggregates.

The occurrence of two clusters may be a result of different mechanisms of carbohydrate interaction with soil particles having different sizes. Depending on aggregate sizes carbohydrates may either be sorbed on the surface of small particles or penetrate into the inner space of swollen soil minerals [9,20]. Carbohydrate-metal complexes are sorbed on aggregate surfaces and the sorbed segments form hydrophylic coatings on the soil particles [8,12,15]. This mechanism may be confirmed by the surface area values. For the mixed samples and aggregate fractions 3-2, 2-1, 1-0.5, 0.5-0.25 mm of the soils studied, the surface areas decreased after the oxidation of carbohydrates by the Cheshire method (see Table 1). Statistically reliable differences of the surface area values for oxidized and non-oxidized samples were noted for all aggregate fractions less than 3 mm. The lack of the above dependence

**Table 1.** Soil surface values of the grey forest soil samples before (I) and after (II) sodium periodate treatment for two sampling times

| Samples | 13 May | | 18 June | |
|---|---|---|---|---|
| | I | II | I | II |
| Mixed samples | 49.26 | 44.45 | 50.54 | 48.30 |
| Aggregate samples: | | | | |
| 3-2 mm | 49.96 | 45.30 | 50.65 | 43.30 |
| 2-1 mm | 50.53 | 46.20 | 50.88 | 47.20 |
| 1-0.5 mm | 51.10 | 47.60 | 50.80 | 45.06 |
| 05-0.25 mm | 49.72 | 46.20 | 49.10 | 46.40 |

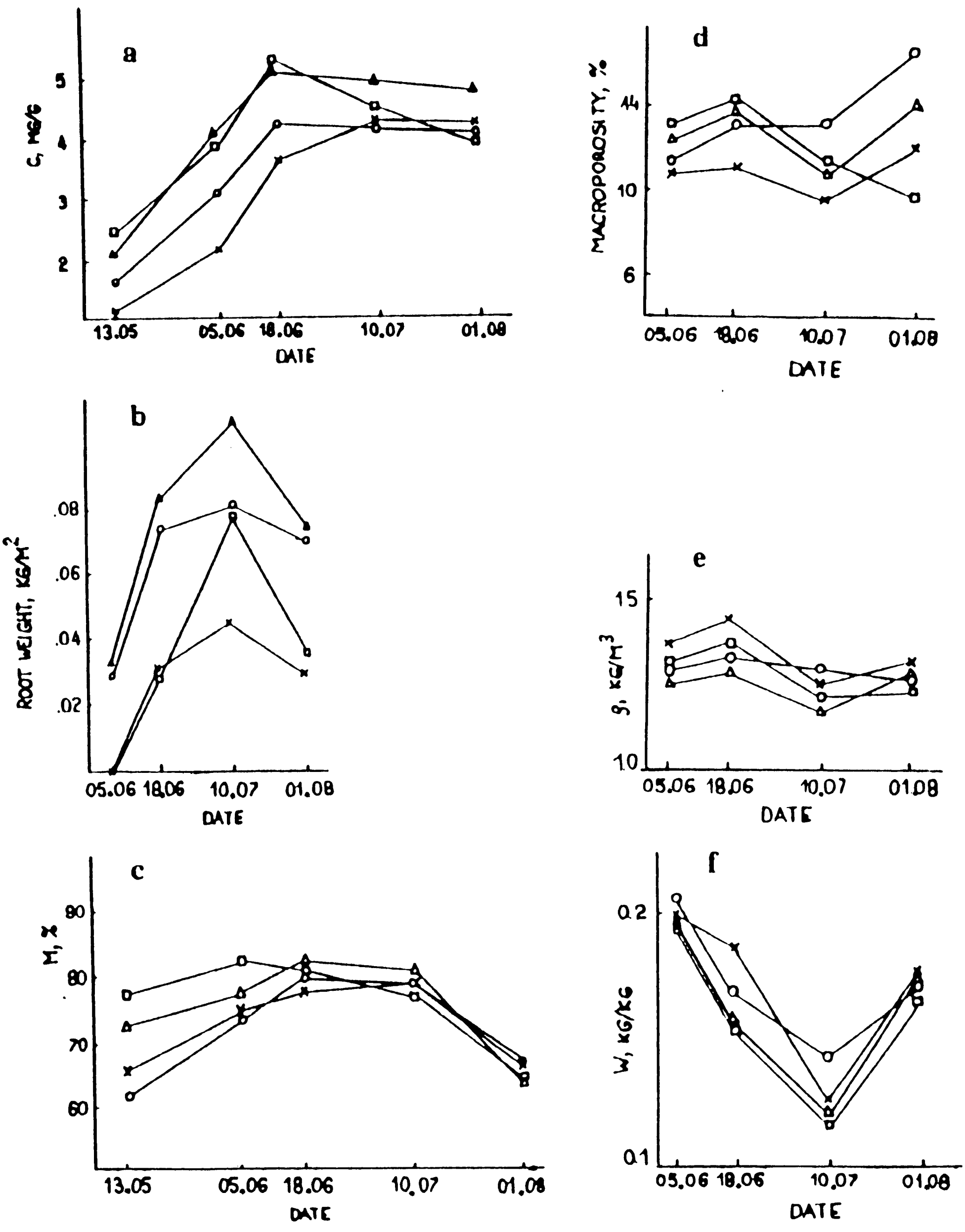


**Fig. 1.** Changes of: carbohydrate content (a), root weigths (b), 0.2-100 mm aggregate content (c), macroporosity (percentage of pore space) (d), bulk density (e), field moisture (f) (C, mg/g) for two different treatments C1 (control) and C2; (fertilized) and two depths h1 (10-15 cm) and h2 (25-30 cm).
Circles: C1h1; x-es: C1h2; triangles: C2h1; squares: C2h2.

for mixed samples can support the hypothesis on different mechanisms of the carbohydrates binding to small and large particles.

## CONCLUSION

Plant roots appear to play an important role in seasonal changes of aggregate composition, bulk density and macroporosity. Soil carbohydrates influence particles binding into small aggregates.

## REFERENCES


1. **Bezuglova O.S., Erizhevskaya V.P., Morozov I.V., Yanova E.V.**: Content and distribution of carbohydrate in the soils of the Rostov region (in Russian). Biologicheskie Nauki, 12, 134-142, 1990.
2. **Bullock P., Thomasson A.J.**: Rothamsted studies of soil structures. II. Measurement and characterization of macroporosity by image analysis and comparison with data from water retention measurements. J. Soil. Sci., 30, 391-414, 1979.
3. **Cheshire M.W., Sparling J.P., Mundle C.M.**: Effect of periodate treatment of soil on carbohydrate constituents and soil aggregation. J. Soil Sci., 34, 105-112, 1983.
4. **Cheshire M.W., Sparling J.P., Mundle C.M.**: Influence of soil type, crop and air drying on residual carbohydrate content and aggregate stability after treatment with periodate and tetraborate. Plant Soil, 76, 339-347, 1984.
5. **Cheshire M.W., Lowax J.A., Mundle C.M.**: Structure of soil carbohydrates resistant to periodate oxidation. J. Soil Sci., 40, 865-872, 1989.
6. **Dmitriev E.A.**: Mathematical Statistics in Soil Science. Moscow University Publ. 291, 1972.
7. **Dubois M., Jilles K.A., Hamilton J.K., Rebers P.A., Smith F.**: Colorimetric method for determination of sugars and related substances. Analitical Chem., 28, 350-356, 1956.
8. **Flir G., Liklema Y.**: Sorption on the solid surface from solutions. Nauka, Moskwa, 226, 1986.
9. **Greenland D.J.**: Interaction between clays and organic in soils. Part 1. Mechanisms of interaction between clays and defined organic compounds. Soil Fert., 28, 415-425, 1965.
10. **Luxmore R.J.**: Micro-, meso-, and macroporosity of soil. Soil Sci. Soc. Am. J., 45, 671-672, 1981.
11. **Oades J.M.**: Soil organic matter and structural stability: mechanisms and implication for management. Plant Soil, 76, 319-337, 1984.
12. **Painter T., Lassen B.**: A further illustration of nearest-neighbour auto-inhibitory effects in the oxidation of alginate by periodate ion. Acta Chem. Scand., 27, 1957-1962, 1973.
13. **Reid J.B., Goss M.J.**: Effect of living roots of different plant species on the aggregate stability of two arable soils. J. Soil. Sci., 32, 521-547, 1981.
14. **Rennie D.A., Trop E., Allen O.N.**: Soil aggregation as influenced by microbial gum, level of fertility and kind of crop. Soil Sci. Soc. Am. Proc., 18, 399-403, 1954.
15. **Theng B.K.G.**: Clay - polymer interaction summery and perspectives. Clay Clay Minerals, 30, 1-10, 1982.
16. **Tisdall J.M., Oades J.M.**: The measurement of rye grass to stabilize aggregates of a red-brown earth. Austr. J. Soil Res., 18, 415-422, 1980.
17. **Tisdall J.M., Oades J.M.**: Organic matter and water-stable aggregates in soils. J. Soil Sci., 33, 141-163, 1982.
18. **Vadiunina A.F., Korchagina Z.A.**: Methods of studying of physical properties of soils and subsoils. Moscow, Vishaya Schkola Publ., 399-415, 1973.
19. **Várallyay G., Mironenko E.V.**: Soil water relationship in saline and alkali condition. Agrokemia es Talajtan, 28, 33-68, 1979.
20. **Williams B.G., Greenland D.J., Quirk J.P.**: The effect of polyvinyl alcohol on the nitrogen surface area and pore structure of soils. Austr. J. Soil Res. 5, 77-92, 1967.