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THE INFLUENCE OF RAINFALLS AND CULTIVATION MEASURES ON THE STRUCTURE AND PHYSICAL PROPERTIES OF TYPICAL LESSIVÉ SOIL (HAPLIC LUVISOL) DERIVED FROM SILT FORMATION

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A b s t r a c t. Research was carried out on changes of the structure and physical condition of arable grey-brown podzolic soil, derived from silt formation, planted with onion. During the analysed period (12.04.-20.07.1990) a crust repeatedly formed on the soil surface. Even though the crust was systematically removed, using hand- and horse-tools, it quickly reappeared because of rainfall. The crust did not have much influence on worsening the soil ability to respirate. Rain also caused the destruction of the aggregate structure and increased the density of the 0-8 cm layer, which was, subsequently, successfully restored by cultivation. The physical state of the soil during the analysed period was considered positive for the growth and development of plants.

K e y w o r d s: soil structure, physical properties, soil crust, rainfall, soil tillage

INTRODUCTION

Rainfall is one of the factors regulating the structure of surface soil. In soils derived from loess and other silt formation, even an intense shower can destroy the aggregate structure formed by cultivation and transform it to a monolythic structure [3,5]. The change of structure leads to a change in the physical status of the soil. This dependence has been indicated by many authors [2,4,8]. Farmers can avoid the physical degradation of soil by adopting measures which not only kill weeds, but also protects both the crumble structure and water retention.

In this paper the author analyses the changes in the surface structure of arable soil, caused by rain and cultivation. The author also attempts to estimate the correlation between the soils structure and some of its physical conditions. In estimating the physical state of the soil, the main stress is put on both morphological and physical analysis. This paper is a continuation of the authors previous paper [6], which considered changes in the structure and physical condition of soil during spring cultivation.

METHODS

The research was carried out on typical lessivé soil (Haplic Luvisol) derived from silt formation, planted with onions (*Allium cepa* L.). The field was in one of Lublin districts - Felin, within the Agricultural Experimental Station of the University of Agriculture.

The arable layer of the investigated soil contained 39 % of particles from 2 mm to 50 μm, 56 % of 50-2 μm particles and 5 % of <2 μm particles. No. 2 mm particles were observed. The content of humus was 1.76 g 100 g^{-1}, density of solid phase was 2.61 Mg m^{-3}, plasticity limit (PL) was 23.8 g 100 g^{-1}. Analysed samples were taken from the surface layer (0-8 cm for the structural investigating and 0-5 cm for physical investigation), after rainfall and cultivation. The research lasted from April 12 to July 20, 1990.

A morphological analysis of the structure

Table 1. Rainfall (mm) in Felin from April to July 1990

Days	April	May	June	July
1	-	-	-	19.3
2	-	-	-	-
3	-	-	-	-
4	1.7	-	-	13.0
5	1.1	-	-	0.2
6	5.4	-	-	6.6
7	13.5	-	3.8	5.4
8	0.5	-	2.2	-
9	-	-	6.1	13.1
10	-	-	3.8	2.8
11	-	-	-	-
12	-	-	-	-
13	-	1.1	-	-
14	-	0.6	0.4	-
15	-	-	-	0.8
16	-	-	0.2	-
17	4.1	2.2	-	1.0
18	0.8	0.1	-	8.0
19	-	-	-	0.3
20	-	-	-	3.7
21	0.2	-	-	2.3
22	1.8	-	7.1	-
23	4.5	-	1.8	1.0
24	-	0.5	-	-
25	3.5	5.3	-	-
26	-	-	-	-
27	3.0	-	-	1.6
28	2.9	-	-	-
29	-	-	-	-
30	0.8	2.6	-	-
31		1.2	24.5	-

was made using opaque soil thin cross-sections (one-side) of 8x9x1 cm. These were made of soil samples hardened by polyester resin Polimal-109, and then cut in slices 1 cm thick and polished. The surfaces of the thin cross-sections were photographed in reflected light. On photograms the solid phase was white, and the pores, filled with resin, were black.

The samples used for investigating the physical property of the soil were collected in metal cylinders of 100 cm^3 volume. They were taken from the same place, and at the same time as were the samples for the morphological investigation.

Soil density measurements, total porosity and air-water property measurements were made. The specific methodology of each investigation is described in the author's earlier paper [6]. In this paper, the soil data for density, total porosity, >50 μm pores contents, actual air volume, and actual air-permeability are discussed. The rainfall data for the research period is shown in Table 1, and the results of the physical analyses are in Table 2.

RESULTS

Onion seed sowing, and subsequent rolling, ended the measures taken for spring cultivation. The purpose of these measures was to prepare the field plants in the first phase of

Table 2. Physical properties of the studied soil layer 0-8 cm

Date	Sampling after	Actual moisture ($g\ 100\ g^{-1}$)	Soil density ($Mg\ m^{-3}$)	Total porosity ($cm^3\ 100\ cm^{-3}$)	Pores >50 μm ($cm^3\ 100\ cm^{-3}$)	Actual air capacity ($cm^3\ 100\ cm^{-3}$)	Actual air-permeability ($m^2Pa^{-1}s^{-1}10^{-8}$)
12.04.	sowing and rolling	19.3	1.24	52.5	18.6	28.2	152
16.05.	one month	13.9	1.36	48.0	10.7	29.1	70
16.05.	harrowing	14.0	1.16	55.7	23.2	39.5	160
4.07.	rain	17.8	1.27	51.3	15.2	28.6	144
4.07.	hoeing	18.4	1.18	54.8	20.1	33.0	275
12.07.	rain	21.2	1.36	47.9	12.1	19.0	181
12.07	hoeing	20.7	1.25	52.0	17.5	26.1	155
20.07.	rain	17.2	1.32	49.5	13.5	26.8	94
20.07.	cultivation with weeder	18.6	1.20	54.0	22.3	31.6	599
Least significant difference (P=0.05)		2.4	0.11	4.4	7.3	6.9	477

vegetation. The physical condition of the soil during this period (April 12) was considered positive. The aggregate structure (Fig. 1a) of the soil caused the optimal total porosity to be a little above 50 $cm^3/100 cm^{-3}$ (Table 2).

Between April 21 and April 30 there was a little rain every day, followed by a dry spell of 12 days. As a result of the rain the density of the soil increased. Soil aggregates were not totally eroded, except for the surface layer (Fig. 1b). In this layer a 12 mm thick crust appeared. A decrease in air-permeability was not statistically significant in relation to the compaction as a result of rolling.

Harrowing with a light harrow removed the crust and created a big, 1 cm deep furrow, which was in the range of the harrow action (Fig. 1c). Below this level the structure did not change. Total porosity and macropores content reached the highest values at this point. The density reached the lowest value in the whole analysed period. This though did not cause any radical increase in airpermeability, because of the absence of big, vertical pores.

43.8 mm of rain fell during the last day of June and first day of July. A crust of less than 12 mm appeared again, which is clearly visible on the photogram (Fig. 1d). Below this level, at approximately 7 cm, an aggregate structure was dominant. At a deeper level a fissure structure appeared. A signifficant decrease was observed in the number of macro-pores and the actual air volume, however, air-permeability remained almost unchanged.

Killing weeds and loosening the soil with hand hoes removed the crust and created a furrow in the 0-2 cm level (Fig. 1e). The physical condition of the analysed layer did not change, even after loosening the soil.

Immediately after loosening 13 mm of rainfall, followed by a further 28.1 mm of rain during the next 5 days. The crust, removed earlier, reappeared, to a depth of 20 mm (Fig. 1f). Density also increased at deeper layers. Layers with non-aggregate structures were a lot bigger here than on the photograms described before.

Repeated hoeing of the soil gave an interesting result. The soil was hoed close to the plasticity limit, which is considered favourable for cultivation because of its sensitivity to external forces. In this specific case shallow loosening performed unproperly did not remove the whole crust. The working element of hoe sliding on top of the surface closed the openings of soil pores (Fig. 1g). Despite loosening the soil, and significantly increasing the actual air-volume, the actual air-permeability decreased.

Eight days (5 with rain) after hand loosening, the soil was treated with a horse-pulled weeder. Before cultivation the soil was compacted and contained many biopores, which improved the physical state of the soil (Fig. 1h). The action of the weeder caused a change in the soil structure, especially in the dense 0-3 cm layer (Fig. 1i). Working elements of the weeder reached even deeper, making wide cracks. As a result the soil density decreased, however, total porosity, the content of macropores and, for the first time during the whole analysed period, air-permeability increased.

DISCUSSION AND SUMMARY

In the earlier paper [6], concerning the structure and physical properties of the surface layer of typical lessivé soil derived from silt formation during spring cultivation works, it was shown that in a short period of 11 days the physical condition of the soil changed significantly. The changes were related to the activity of working elements of cultivation tools (harrow, active harrow and roller) as well as rain. During onion vegetation the soil structure and its physical properties also changed. However, compared to a period of intensive cultivation some differences were observed.

Regularly, during the analysed period, the crust appeared on the soil surface. Despite systematic removal with hand and horse tools, the crust reappeared within a few days, subject to the intensity of rain.

Rain destroyed the aggregate structure and caused the density to increase in the 0-8 cm layer. This phenomenon was successfully prevented by loosening the soil, but not for long.

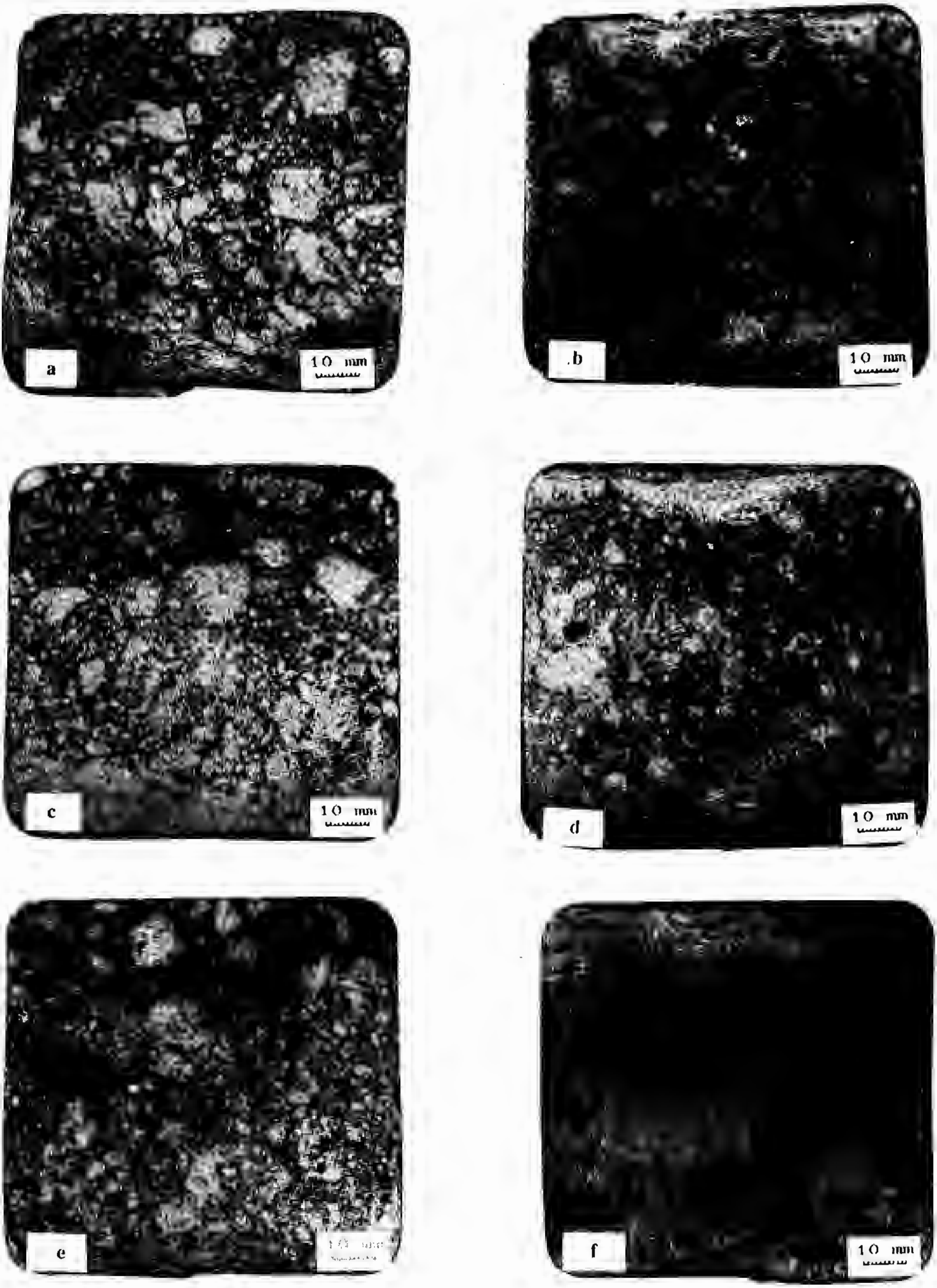

Fig. 1. Structure of arable layer of soil (0-8 cm): a - immediately after sowing and rolling with a smooth roller (12.04.1990), b - after a month from sowing (16.05.1990), c - after harrowing with a light harrow (16.05.1990), d - after intensive rainfalls (4.07.1990), e - after loosening with hoe (4.07.1990), f - after rainfalls (12.07.1990), g - after loosening with hoe (12.07.1990), h - after rainfalls (20.07.1990), i - after cultivating with horse weeder (20.07.1990).

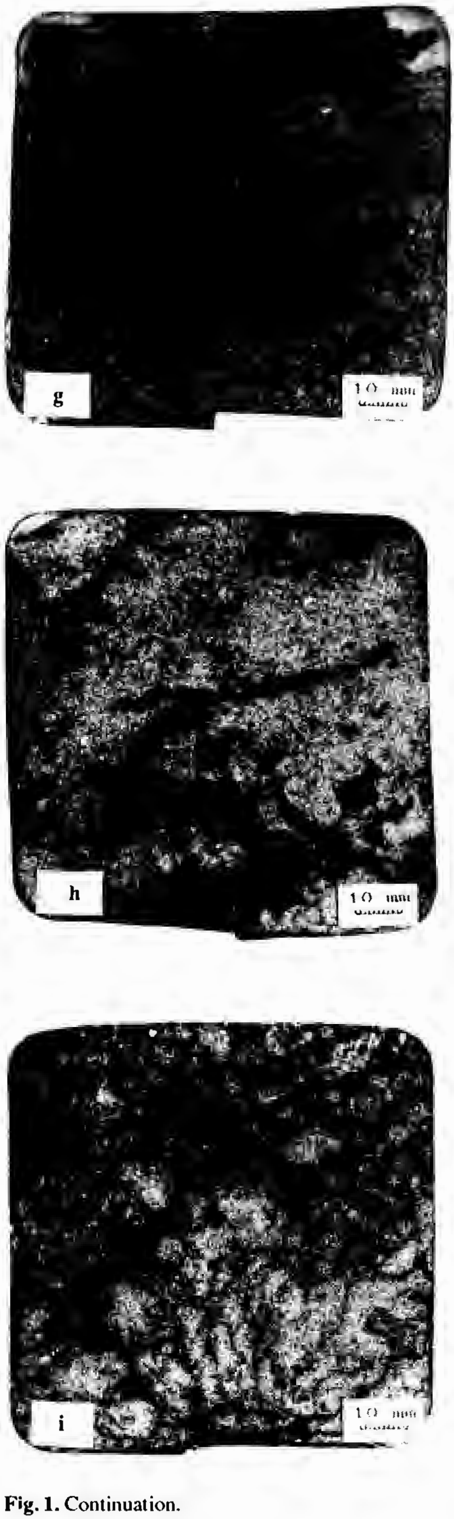

Fig. 1. Continuation.

Of all the physical properties investigated during spring cultivation, the actual air-permeability changed the most.

During onion vegetation, only once after loosening the soil with a horse weeder - was a statistically significant increase in air-permeability observed. The crust decreased air-permeability a little, good careful loosening - increased it, but insignificantly. These observations agree with the data of Dechnik and Dębicki [1], according to which a crust mostly decreases the soil's ability to breath. Earlier research shows that the limit value of air-permeability, below which gas exchange may be harder, is $35 \cdot 10^{-8}$ $m^2Pa^{-1}s^{-1}$ [7]. The lowest value of air-permeability of the soil observed during onion vegetation was twice as high. This value is not negative for plant growth during this period.

In conclusion, the physical condition of the soil can be estimated as positive. This can be related to careful agrotechnics and high agricultural culture of the farmer.

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WPŁYW OPADÓW DESZCZU I UPRAWEK PIELĘGNACYJNYCH NA STRUKTURĘ I WŁAŚCIWOŚCI FIZYCZNE GLEBY PŁOWEJ (HAPLIC LUVISOL) WYTWORZONEJ Z UTWORU PYŁOWEGO

Przeprowadzono badania zmian struktury i właściwości fizycznych warstwy uprawnej gleby płowej (Haplic Luvisol) wytworzonej z utworu pyłowego w czasie wegetacji cebuli (*Allium cepa* L.). Stwierdzono, że w całym analizowanym okresie (12.04.-20.07.1990) na powierzchni gleby tworzyła się skorupa. Mimo systematycznego niszczenia za pomocą narzędzi ręcznych i konnych, regeneracja skorupy następowała szybko, czemu sprzyjały intensywne opady deszczu. Obecność skorupy nie wpływała jednak na zdecydowane pogorszenie zdolności gleby do wymiany gazowej. Deszcz powodował również zanik struktury agregatowej i wzrost zagęszczenia w całej warstwie 0-8 cm, co skutecznie można było zlikwidować wykonując zabiegi spulchniające. Stan fizyczny gleby w analizowanym okresie należy ocenić jako korzystny dla wzrostu i rozwoju roślin.

S ł o w a k l u c z o w e: struktura gleby, właściwości fizyczne, skorupa glebowa, opady deszczu, uprawa gleby.