ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH, 1995, 419, 9-14

# PEDOLOGICAL CHARACTERISTICS OF A RESEARCH SITE FOR STUDYING CLIMATE OF THE CULTIVATED FIELD

*H. Domżał, J. Pranagal*

Institute of Soil Science and Environment Management, University of Agriculture
Kr. Leszczyńskiego 7, 20-069 Lublin, Poland

A b s t r a c t. Investigations of the cultivated field climate and its complex evaluation require determining soil conditions in which the above research is based on. The maintenance of soil retention capacity, water filtration rate, gas exchange between atmospheric and soil air, and soil temperature dynamics are considerably conditioned by the physical state of the soil and its properties.

The object selected for the study is located in the field of the agrometeorological observatory at Felin, near Lublin on brown earth, of a grey-brown type (Orthic Luvisol), derived from silt formations, non-uniform on chalk marl. Granulometric composition of the soil classifies it within loamy silt formations. Soil contains a medium amount of organic carbon (980 mg/100 g of soil) in the arable layer. The soil reaction is acid (pH 4.85), and the saturation of sorption complex with basic cations is higher then 50 %. Compaction of the plough-humus layer reaches on average 1.39 $g/cm^{-3}$, and total porosity exceeds 45 % v/v. Field water capacity is higher than 26 %, w/w, while field air capacity is 7.9 % v/v. Wilting point of plants corresponds to water capacity at pF 4.2 and accounts for 5.8 % w/w on the average. The content of water-stable aggregates, valuable from the agronomic point of view, i.e., bigger than 1 mm in diameter exceeds 22 % w/w. The soil analyses did not show any signs of gleying or other unfavourable signs limiting the possibility of cultivation of basic plant species.

K e y w o r d s: parent rock, systematic unit, agricultural land use, soil state

## INTRODUCTION

The research site is located in the Agricultural Experimental Station at Felin, near Lublin, on the Świdnicki Plateau. This area consists partly of the Lublin Upland on the right bank of the Bystrzyca River, free of ravines, elevated 205-215 m a.s.l., with a ground water table at a depth of 15 m. Because of that, crops can use water mainly from precipitation.

For a detailed analysis, the field within the agrometeorological observatory has been chosen. It has a slight north-east inclination with a small water erosion risk. The soils of the research area were subjected to many studies in the past. Attempts of their explicit classification provoked heated scientific discussion, especially on the background of different interpretations of the same formations in various cartographic, geological, or pedological works [10,11,14]. Some earlier elaborations pointed out that the existence on this area's soils derived from loessial materials lying on loam and marl [11,14], while others described these soils as podzols formed from loess and loess-like formations [10]. Yet other papers clearly showed that in this part of the Lublin Upland the loess cover does not occur at all [2,3,9,15]. The prevailing soil material consists of silt loams, which has been proven, among others, by granulometric analysis [1,3]. They contain much more sand fraction (*ca.* 20 %) and much less silt fraction (below 50 %) than soils formed from a typical loess. However, it should be pointed out that silt formations, only looking like loess, occur more often than it is commonly assumed [1,9].

The aim of this paper was to fix the soil studied among actual systematic units and to characterize soil conditions of the site of studying the climate of the cultivated field.

## MATERIALS AND METHODS

The field chosen for the study is a part of the research site of the Department of Agrometeorology of the University of Agriculture in Lublin, located in the Agricultural Experimental Station at Felin. For 30 years, a permanent six-field crop-rotation system has been used on this field as follows: potatoes on farmyard manure (FYM), spring barley with red clover as a companion crop, winter wheat, horse bean and winter rye.

Mineral fertilization was applied in doses adjusted to particular crop requirements by using: ammonium nitrate, super-phosphate and potassium salt. Farmyard manure served as organic fertilizer in an average dose of 4 t/ha. The soil was sampled in spring from the field under winter wheat, where the following agrotechnical measures have been taken:

- Autumn: skimming after red clover, deep ploughing, harrowing, fertilizing and wheat sowing;
- Spring: harrowing.

Pesticides were applied sporadically and in small amounts.

To analyse physical, chemical and biological properties, soil samples were taken from the following genetic horizons and layers:

- arable-humic horizon Ap - 2-7 cm and 12-17 cm;
- illuvial horizon Bt - > 22 cm.

In order to avoid accidental results, samples were taken from three different, randomly selected points (soil pits), receiving in this way 10 replicates. The characteristics of soil conditions were based on the following analyses:

1. Granulometric composition of soil, by Casagrande method in Prószyński's modification (Table 1).
2. Basic physical properties of soil (Tables 2 and 3), in undisturbed samples of 100 $cm^3$ capacity:
   - density,
   - total porosity,
   - field water and air capacity,
   - air permeability: actual and at the field water capacity (pF = 2.2), with the use of LPiR apparatus manufactured by WADAP Poland,
   - content of pore groups of diameters >300 μm, 300-30 μm, 30-10 μm, >10 μm, and <10 μm, calculated on the basis of water retention curve,
   - water capacity at pF 4.2, and
   - density of solid phase, with pycnometric method.
3. Water stability of soil aggregates with Baksheiev's method in the apparatus modified by the Institute of Agrophysics, Lublin (Table 4).
4. Chemical properties (Tables 5-7):
   - soil reaction, pH in 1 M KCl, electromagnetically,
   - hydrolytic acidity, sum of basic cations, sorptive capacity and base saturation, according to Kappen's method,
   - content of various forms of organic carbon, including total carbon with Tiurin's method,
   - mobile forms of humus, extracted in 0.05 M NaOH,
   - susceptibility to oxidation, with Łoginow-Wiśniewski's method,
   - content of macroelements: total nitrogen after Kjeldahl, available $P_2O_5$ and $K_2O$ according to Egner-Riehm, and available Mg according to Schachtschabel,
   - content of microelements: Cu, Zn, Pb and Mn by AAS method.
5. Biological properties (Tables 8 and 9):
   - number of macrotrophic and oligotrophic bacteria according to Hattori's method,
   - enzymatic activity: neutral phosphatase (pH=6.5) after Tabatabai *et al.*, dehydrogenase after Thalmann, and urease after Zantua *et al.*

Determinations of biological properties were carried out for two years, and three times during the vegetation season.

**Table 1.** Granulometric composition of the soil and content of organic matter

| Genetic horizon | Organic matter | Content of granulometric fractions (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1.0-0.1 | 0.1-0.02 | <0.02 | 0.1-0.05 | 0.05-0.02 | 0.02-0.005 | 0.005-0.002 | <0.002 |
| | (%, w/w) | (mm) | | | | | | | |
| Ap | 1.69 | 17 | 49 | 34 | 12 | 37 | 20 | 10 | 4 |
| Bt | 0.31 | 14 | 45 | 41 | 10 | 35 | 18 | 7 | 16 |

**Table 2.** Physical properties of the soil

| Genetic horizon and sampling depth | Density of solid phase | Soil density | Total porosity | Field water capacity | Water capacity at pF 4.2 | Field air capacity | Actual air permeability | Air permeability at pF 2.2 |
|---|---|---|---|---|---|---|---|---|
| (cm) | ($g/cm^3$) | | (%, v/v) | (%, w/w) | (%, w/w) | (%, v/v) | ($10^{-8} m^2/Pa\ s$) | |
| Ap 2 - 7 | 2.61 | 1.38 | 47.1 | 28.4 | 5.9 | 7.9 | 99.2 | 23.1 |
| Ap 12 - 17 | 2.61 | 1.40 | 46.2 | 26.7 | 5.8 | 8.8 | 141.2 | 63.9 |
| Bt 25 - 30 | 2.62 | 1.55 | 40.8 | 21.8 | 7.2 | 7.0 | 64.4 | 48.8 |

**Table 3.** Content of selected groups of pores

| Genetic horizon and sampling depth | Content of pores (%, v/v) | | | | |
|---|---|---|---|---|---|
| | >300 | 300-30 | 30-10 | >10 | <10 |
| (cm) | (μm) | | | | |
| Ap 2 - 7 | 3.7 | 3.5 | 2.2 | 9.4 | 37.7 |
| Ap 12 - 17 | 4.1 | 3.8 | 1.7 | 9.6 | 36.6 |
| Bt 25 - 30 | 3.1 | 4.3 | 2.2 | 9.6 | 31.2 |

**Table 4.** Contents of water-stable aggregates

| Genetic horizon and sampling depth | Content of water stable aggregates (%, w/w) of diameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | >7 | 7-5 | 5-3 | 3-1 | 1-0.5 | 0.5-0.25 | <0.25 |
| (cm) | (mm) | | | | | | |
| Ap 2 - 7 | 2.8 | 3.5 | 6.4 | 10.7 | 7.9 | 20.0 | 48.7 |
| Ap 12 - 17 | 6.0 | 3.6 | 4.0 | 8.1 | 16.9 | 28.7 | 32.8 |
| Bt 25 - 30 | 0.1 | 0.1 | 0.3 | 0.1 | 4.3 | 18.8 | 76.3 |

**Table 5.** Soil reaction and sorptive properties

| Genetic horizon and sampling depth | pH | Hydrolytic acidity | Sum of cations | Sorption capacity | Base saturation |
|---|---|---|---|---|---|
| (cm) | (M KCl) | ($cmol^{(+)} kg^{-1}$) | | | (%) |
| Ap 2 - 7 | 4.9 | 3.77 | 3.95 | 7.72 | 51.1 |
| Ap 12 - 17 | 4.8 | 3.46 | 4.15 | 7.61 | 54.5 |
| Bt 25 - 30 | 4.9 | 1.95 | 8.65 | 10.60 | 81.6 |

**Table 6.** Content of various forms of organic carbon

| Genetic horizon and sampling depth | $C_t$ | Forms of organic carbon % $C_t$ | | | |
|---|---|---|---|---|---|
| (cm) | (mg/100 g soil) | mobile | liabile | oxidizable | non-oxidizable |
| Ap 2 - 7 | 976 | 37.81 | 1.29 | 38.93 | 61.07 |
| Ap 12 - 17 | 984 | 34.86 | 1.36 | 41.67 | 58.33 |
| Bt 25 - 30 | 177 | 32.77 | 4.17 | 59.32 | 40.68 |

**Table 7.** Content of macro- and microelements in the soil

| Genetic horizon and sampling depth | Macroelements | | | | Microelements* | | | |
|---|---|---|---|---|---|---|---|---|
| | N-tot. | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | Pb | Mn |
| (cm) | (%, w/w) | (mg/100 g soil) | | | (mg/kg) | | | |
| Ap 2 - 7 | 0.08 | 15.6 | 25.0 | 4.8 | 2.50 | 8.65 | 14.5 | 132 |
| Ap 12 - 17 | 0.08 | 15.0 | 18.3 | 6.0 | 2.50 | 8.40 | 16.0 | 115 |
| Bt 25 - 30 | 0.02 | 6.6 | 5.0 | 7.4 | 1.95 | 5.55 | 14.0 | 116 |

* Soluble in 1 M HCl.

**Table 8.** Number of bacteria in the soil Ap horizon

| Macrotrophic bacteria (million g soil d.m.) | | | Oligotrophic bacteria (million g soil d.m.) | | |
|---|---|---|---|---|---|
| 1992 | 1993 | $\bar{x}$ | 1992 | 1993 | $\bar{x}$ |
| 30.89 | 18.08 | 24.49 | 10.57 | 15.17 | 12.87 |

**Table 9.** Enzymatic activity in the soil Ap horizon

| Neutral phosphatase (mcg $PO_4$/1 g soil d.m./1 h) | | | Dehydrogenase (mcg TPF/1 g soil d.m./24 h) | | | Urease (mcg N-$NH_4$/1 g soil d.m./24 h) | | |
|---|---|---|---|---|---|---|---|---|
| 1992 | 1993 | $\bar{x}$ | 1992 | 1993 | $\bar{x}$ | 1992 | 1993 | $\bar{x}$ |
| 138.34 | 113.77 | 126.06 | 4.62 | 5.45 | 5.03 | 486.03 | 447.22 | 466.62 |

## RESULTS AND DISCUSSION

Soil conditions of a site for studying the climate of the cultivated field are determined, first of all, by soil material, its granulometric composition, the quantity and quality of organic substance, and next by the kind and intensity of the applied agrotechnical measures.

The analysis of the soil granulometric composition (Table 1) definitely excludes this soil from loess formations, because of a high content of sand fraction. It classifies the soil of Ap horizon as loamy silt and that of Bt horizon as clay silt.

The results of basic physical properties (Tables 2 and 3) point out to favourable conditions occurring especially in the arable-humus layer. The physical state of the soil is characterized by a little compaction, good air-water relations at an extremely good share of water-stable soil aggregates (Table 4).

The most valuable, from the agricultural point of view, water-stable aggregates of diameters:

7-5, 5-3 and 3-1 mm reached the values considered to be very high for this type of soil. This may suggest the existence of good quality organic substance, or intensive biological life [5,6].

The sorptive capacity (Table 5) of the arable layer is on a very low level. Hydrolytic acidity consists of 50 % sorptive capacity which, together with acid reaction of soil, points to the necessity of liming [16]. Data on sorptive properties lead us to conclude that the processes of its chemical degradation are very weak [7].

The content of total carbon (Table 6) does not wander away from the average and is typical for this type of soil. About one-third of total carbon ($C_t$) falls to mobile forms, which testifies to a relative stability of organic substance. It was also evident by the results of other studies, where the $C_{HA}/C_{FA}$ ratio was 1.46, and the content of humins reached 57.6 % $C_t$ [4].

Basing on boundary values for the evaluation of macro- and microelement contents in soils [16], the studied soil can be classified as having high content of available phosphorus and potassium (Table 7), medium content of magnesium and low content of total nitrogen. The soil was also characterized by medium contents of copper, zinc and manganese, and a low content of lead.

The results of biological analyses (Tables 8 and 9) testify to a vital biological life going on in the arable-humus layer of the soil studied. Both the number of bacteria and enzymatic activities were on a very high level. It has also been certified by the results of studies carried out in co-operation with the Department of Agricultural Microbiology of the University of Agriculture in Lublin [5,6].

## CONCLUSIONS

The soil properties of the site chosen for studying the climate of the cultivated field classify it into brown earth, of the grey-brown type (Orthic Luvisol), formed from silt formations, non-uniform laying on chalk marl [12,13]. It probably had the following profile structure: O-A-E-Bt-C/D. However, the former leaching horizon (E) disapeared because of cultivation. This horizon, together with organic (O) and humic (A) horizons, has been transformed into plough-humus layer (Ap). Below Ap layer there is an illuviation horizon (Bt) of a brown colour, which gives the soil studied morphological traits characteristic for brown earth soils. After many years of cultivation, this soil shows the following profile layering: Ap-Bt-C/D. The distinguished genetic horizons had the depth as follows: Ap - 0-22 cm, Bt - 22-75 cm, and C/D >75 cm. In the soil profile, there was no sign of gleyization processes. Though chemical degradation was observed, it was of little intensity. The results of all the physical, chemical and biological analyses allow us to state that the soil of the studied object is characterized by favourable conditions. It also does not give any signs which would limit the possibility of cultivation of basic plant species.

## REFERENCES


1. **Borowiec J., Nakonieczny S.:** Characteristics of the shallow loess-like formation on left side of the river Wieprz basin (in Polish). Ann. Univ. Mariae Curie-Skłodowska, B, 20, 159-175, 1965.
2. **Dobrzański B., Zawadzki S.:** The soils of the scientific-experimental station at Felin (in Polish). Ann. Univ. Mariae Curie-Sklodowska, E, 6, 231-250, 1951.
3. **Dobrzański B.:** A study of the soils formed from shallow pseudoloess in the Lublin upland. Ann. Univ. Mariae Curie-Skłodowska, B, 15, 1-9, 1960.
4. **Domżał H., Flis-Bujak M., Baran S., Żukowska G.:** The effect of orchard use on organic matter of soil developed from silt loam (in Polish). Zesz. Probl. Post. Nauk Rol., 411, 91-95, 1993.
5. **Domżał H., Gostkowska K., Furczak J., Bielińska J., Pranagal J.:** Physical, chemical and biological degradation of agriculturally utilized soil. Proc. 13 ISTRO Conf., Aalborg-Denmark, 1, 31-36, 1994.
6. **Domżał H., Pranagal J.:** Water resistance of soil aggregates as an index of soil degradation caused by the agricultural utilization (in Polish). Fragmenta Agronomica, 3, 22-34, 1994.
7. **Domżał H., Wójcikowska-Kapusta A., Pranagal J.:** The degrading effect of agrotechnical measures on the reaction and chemical properties of soil. Zesz. Probl. Post. Nauk Roln., 413, 99-103, 1994.
8. **Gostkowska K., Domżał H., Furczak J., Bielińska J.:** Effect of differentiated long-term agricultural utilization of brown soil on its microbiological and

biochemical properties. Polish J. Soil Sci., 26(1), 66-75, 1993.

9. **Malicki A.**: The origin and distribution of loess in central and eastern Poland (in Polish). Ann. Univ. Mariae Curie-Skłodowska, B, 4, 195-228, 1949.
10. The Soil Map of Poland 1:300 000, section D5 (in Polish). Lublin-Warszawa, 1959.
11. **Pożarski W., Ruhle E.**: General Geological Map of Poland 1:300 000, section D5 (in Polish). Lublin P.I.G., Warszawa 1949.
12. **PTGleb.**: The systematics of soils of Poland (in Polish). Roczn. Glebozn., 40(3/4), 1989.
13. Soil Map of the World. 1:5 000 000. FAO-UNESCO, Paris, 1974.
14. **Tomaszewski J. et al.**: The soil of Poland 1:1 000 000 (in Polish). Warszawa, 1959.
15. **Turski R., Uziak S., Zawadzki S.**: Soils. Natural environment of Lublin upland (in Polish). LTN, 106, 1993.
16. The Fertilizer Recommendations, part 1 (in Polish). IUNG, Pulawy, 26, 1990.

## GLEBOZNAWCZA CHARAKTERYSTYKA OBIEKTU BADAŃ KLIMATU POLA UPRAWNEGO

Prowadzenie badań klimatu pola uprawnego oraz dokonanie kompleksowej jego oceny wymaga określenia warunków glebowych, w których prowadzone są te badania.

Kształtowanie zdolności retencyjnych gleby, szybkości filtracji wody, wymiany gazowej pomiędzy powietrzem atmosferycznym a glebowym, dynamiki temperatury gleby są w znacznej mierze uwarunkowane stanem fizycznym gleby i jej właściwościami.

Wybrany do badań obiekt zlokalizowano na polu obserwatorium agrometeorologicznego w Felinie, na glebie brunatnoziemnej, typu gleby płowej (Orthic Luvisol) wytworzonej z utworów pyłowych, niecałkowitych na marglu kredowym.

Sklad granulometryczny gleby kwalifikuje ją do utworów pyłowych gliniastych o średniej zawartości węgla organicznego, 980 mg/100 g gleby w warstwie uprawnej. Odczyn gleby jest kwaśny pH 4,85, a wysycenie kompleksu sorpcyjnego kationami o charakterze zasadowym jest wyższe niż 50 %. Zagęszczenie badanej gleby wynosi średnio w warstwie orno-próchnicznej 1.39 Mg m$^{-3}$, a porowatość ogólna przekracza 45 %, v/v. Polowa pojemność wodna jest wyższa od 26 %, w/w, zaś polowa pojemność powietrzna wynosi 7,9 %, v/v. Punkt trwałego więdnięcia roślin odpowiada pojemności wodnej przy pF 4,2 i wynosi średnio 5,8 % w/w. Zawartość wodoodpornych agregatów o korzystnie rolniczym charakterze (średnica większa niż 1 mm) przekracza łącznie 22 %, w/w.

Badana gleba nie wykazuje cech oglejenia, ani też innych niekorzystnych oznak ograniczających możliwości uprawy podstawowych gatunków roślin.

S ł o w a k l u c z o w e: Skała macierzysta, jednostka systematyczna, użytkowanie rolnicze, stan gleby.