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THE REACTION AND SOME PROPERTIES OF SOILS UNDER DIFFERENT LAND USE*

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A b s t r a c t. The results of the research pertaining to the long-term effect of various ways of soil utilizing on their reaction as well as some of their physical and chemical properties are presented in this paper. The research comprised six soil units (grey-brown podzolic soils, rusty soils and chernozems formed from silt formations, loams and sands). The properties of soils occurring in the natural forest habitat were compared with the properties of soils agriculturally utilized in the farms of various levels of agrotechnics as well as with the properties of orchard soils.

In was noted that the soils agriculturally utilized in comparison to forest soils have different profile structure, different distribution of humic compounds in the profile and are more compacted. The effect of agricultural utilization on the soil reaction was the diminishing of acidification in soils formed from loess and loam. In large farms the increase in the reaction resulting from proper agrotechnics was larger than in small farms extensively utilized. In the soils formed from sand and sandy loam the positive effect of agrotechnics on the reaction of soils was small.

K e y w o r d s: soils, pH, humus content, density, land use

INTRODUCTION

The change of the utilization of soil from the forest or meadow one to the agricultural one, caused the change in the morphological structure and basic chemical and physical properties of soils. Many authors have noted the occurrence of this process [1,2,10,11]. The complex research that we have carried out supplied new data allowing the precise determination of the direction and range of the changes in the structure and properties of soils resulting from their agricultural utilization.

The agricultural utilization of the soils situated on the forest border lead to the formation of humic-arable layers with the depth usually corresponding to the depth of ploughing [4-6]. It was also noted that these effects are not identical in the subsequent soil units, because of the various character of the material, the differentiation of the level of agrotechnics, the degree of field works mechanisation and kind of the applied organic and mineral fertilizers. These factors had a significant effect on the composition and properties of soil. Numerous results of measurements prove that, in spite of the application of measures loosening the soil, the increase in the density of the arable layer occurs [4]. The increase in the surface layer density of the arable soils is the result of the effect of the wheels of heavy equipment applied in agriculture [5,6,12,13].

The changes in the composition and properties of soils agriculturally utilized do not limit themselves only to the changes of structure and the increase of the soil density. The results of the research prove the deterioration of many physical properties including the total porosity, water and air capacity and soil air diffusivity in the humic-arable layer in comparison to the

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layers of forest soils corresponding to them [5]. Not only the way of soil utilization has the effect on the directions and range of changes occurring in soil but also its intensity. In spite of the fact that a farmer makes effort to improve soil properties and to achieve higher crop, these objectives are not easy to achieve.

There exist data proving that agriculture became one of the main factors of soil degradation including chemical degradation. For the total surface of 240 Mha of chemically degraded soils in the world, 56 % has been caused by the agriculture [10].

One of the most important factors of chemical degradation of soil in Poland is the soil acidification. Over half of Polish soils is acidified and demands liming [14].

There also exist data indicating that the intensive mineral fertilizing combined with herbicide applying leads to the occurrence of chemical and biological degradation processes. As the result of those processes the lowering of humus content in soil and the deterioration of its quality [7] as well as very strong lowering of the biological activity of soil occurs [8]. The range of these phenomena is still not fully recognised and demands further study.

In the paper presented here, an attempt of the evaluation of the effect of various intensity of agricultural soil utilization on some of their properties including reaction was undertaken.

METHODS

Six soil taxonomy units occurring in the territory of Lublin Upland and Polish Lowland were included in the research:

a) Orthic Luvisols developed from loess;
b) Haplic Phaeozem developed from loess;
c) Orthic Luvisols developed from boulder loam;
d) Gleyic Luvisols developed from silts of water origin;
e) Orthic Luvisols developed from sandy loam;
f) Leptic Podzols developed from sand.

Within the subsequent soil taxonomy units the soils utilized in the following way were analysed:

1) Forest utilization - natural forest not showing the symptoms of strong human interference in the stand of trees composition.
2) Agricultural utilization - farms of low agricultural engineering level of field works and organic and mineral fertilization.
3) Agricultural utilization - farms with full agricultural engineering of field works and fertilization adjusted to the demands of subsequent plant species in crop rotation.
4) Orchard utilization - orchard attached to a homestead and allotments for at least 50 years.
5) Other utilization - park grassland, orchard, depending on the ways of utilization of soils occurring in given area.

In each soil unit, soil profiles located not far from each other were chosen. Soil samples were taken in all the cases in spring before starting the intensive plant vegetation. From the soils agriculturally utilized the samples were taken from the winter wheat fields (soils formed from loess and loam) or winter rye (soils formed from sand), that is typical plants cultivated in the given soils.

The following soil properties were analysed:

- morphological structure of soil profiles, paying special attention to the depth of humus-arable horizon, as the index of anthropogenic changes;
- the availability of the subsequent levels in humic compounds;
- the humus content was determined with Tiurin's method in Simakov's modification.
- soil reaction was determined with the electrometrical method in H_2O and in KCl.

RESULTS AND DISCUSSION

Orthic Luvisols developed from loess

Forest soils and arable soils differ in the morphological structure of their surface horizons and the distribution of organic matter in the soil profile. As the result of long-term agricultural utilization, the formation of humic-arable layer occurred, with the depth corresponding to the ploughing depth applied in a given type of farm. In the cultivated soils, a significant decrease in the content of humus compounds in the surface layer of profile occurred in comparison to the forest soil located nearby (Fig. 1). Higher compactness of the arable layer, especially in large scale farms having applied full mechanization of field works for a long time.

In the discussed group of soils favourable changes of the soil reaction occurred as the result of the agricultural utilization. Even in the farms with comparatively low level of agrotechnics the increase in soil pH was noted as compared to the forest soil. In the farms with high intensity of agricultural production, soil reaction can be described as slightly acid and, in the orchard soil, on the boundary of neutral one.

These examples indicate that proper agrotechnics combined with the proper fertilizing for a given group of soils leads Orthic Luvisols developed from loess to the lowering of the acidity of and thus to the improvement of their productivity.

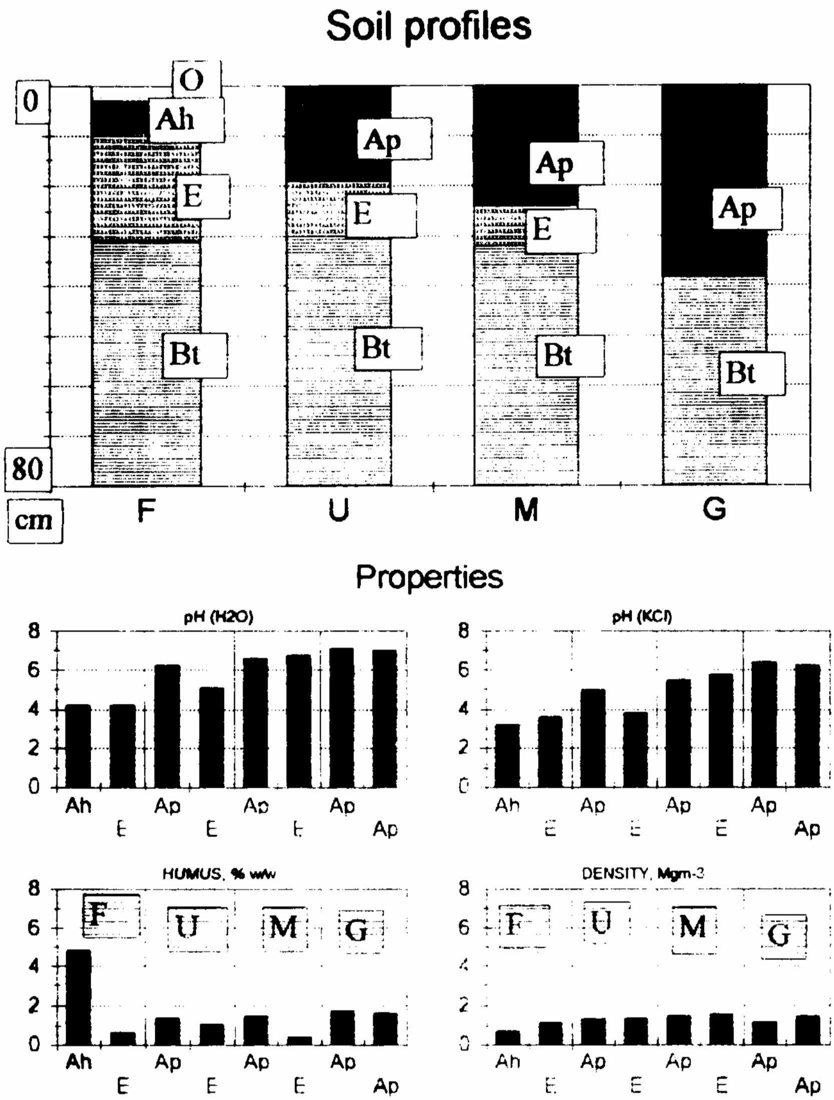

Fig. 1. Soil profile structure and some properties of Orthic Luvisols developed from loess. F - forest, U - unmechanized farm, M - full mechanized farm, G - garden.

Halpic Phaeozem developed from loess

Halpic Phaeozem soils are, as it is generally known, very humic and, therefore less dense (Fig. 2). In the analysed soil profiles of the cultivated soils similarly as in the previously discussed Orthic Luvisol developed from loess, higher density in the arable-humic layers was noted in comparison to the forest soils. However, no effect of the agricultural engineering on the density of these soils was noted, which may be connected with mechanical resistance of their structure to the effect of stress caused by the wheels of heavy equipment.

Because of the characteristic, for these soils, deep humic level the differentiation of the organic matter content in the humic-arable layers and sub-arable layers was not so distinct as in the soils belonging to the Orthic Luvisols type.

The highest humus content was noted in orchard soils. In these soils one can often come across different directions of the changes of the

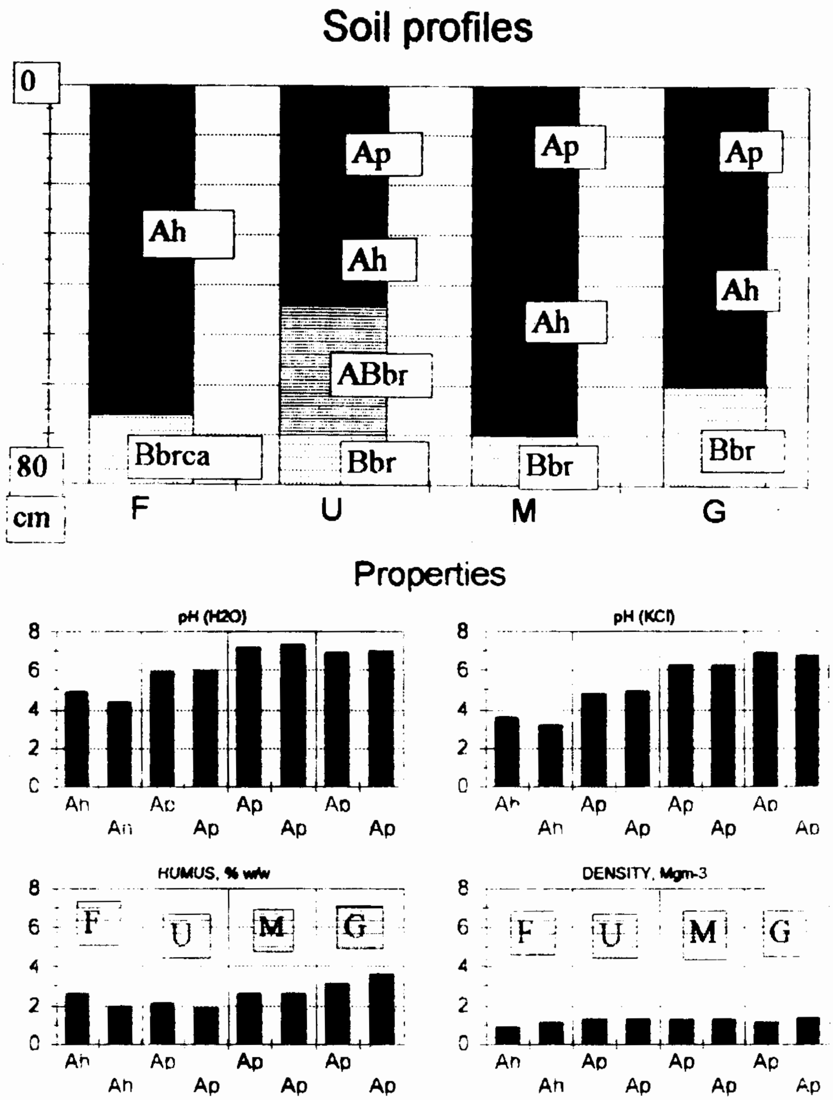

Fig. 2. Soil profile structure and some properties of Haplic Phaeozem developed from loess. Denotations as in Fig. 1.

organic matter content in the depth of soil profile. In some profiles, which is characteristic for soils in natural habitat, the content of organic matter diminishes with the depth, as it occurs in the profile of forest soil. In the cultivated Halpic Phaeozems, a diminished humus content in the humic-arable layer is noted. It is the result of the decomposition of the organic matter in strongly oxidated arable layer. The example of such soils is an orchard soil profile (Fig. 2).

The agricultural utilization of the examined soils influenced the decrease of their acidification. The comparatively smallest changes were noted in the soil of a peasant holding. In this case the acidity increased significantly from pH 3.6 to 4.8 which testifies to the fact that the liming of soils was very limited in these farms, if applied at all. In the soil of a large farm with intensive production, neutral reaction was noted, which proves the possibility of significant improvement of the productive ability of these soils. Similar changes of reaction were noted in the soil being under orchard for a long time.

Orthic Luvisols developed from boulder loam

The soils formed from the boulder loam of the mid-Polish glaciation are naturally poor in colloids and aluminosilicates in their surface layers. It results from the character of the mother rock, strongly sandy in the interglacial periods. This factor has a significant effect not only on the physical but also on the chemical properties of the discussed soils.

In the analysed profiles of soils utilized in various ways, the humus content is not very high and its distribution in the soil profile is similar to that in the Orthic Luvisols developed from loess.

The reaction of the upper layers of the studied soils was also similar to that in Orthic Luvisols developed from loess. Forest soil had strongly acid reaction. A slightly higher pH, although also within the range of strongly acid reaction occurred in the soils of small farms with small intensity of the agricultural production (Fig. 3). In the fields of large farms the reaction was significantly higher and can be numbered within the range of soils of slightly acid reaction to the neutral one. This proves the positive effect of agrotechnics which includes liming in the fertilizing components. In spite of high sand content and acidification of the surface layers of these soils, they are very grateful objects of agrotechnical activity, because the layers of medium or heavy clay lying at the depth of 30-50 cm prevent further leaching of soil and enable quick improvement of their reaction. The example of the soil profile of the large farm indicates this.

Gleyic Luvisols developed from silts of water origin

The silts of water origin are the formations of very poor mineral composition and very small colloid content. That is why soils formed from them have poor humus content and, by their nature, are very sensitive to the effect of acidifying factors. In the tested profiles of soils utilized in various ways, humus content in the surface layers did not exceed 2.5 %. The depth of the humus layer in the forest soil was very small (about 15 cm).

In the cultivated soils the depth of humus-arable layer corresponded to the depth of ploughing. In the analysed profiles acid reaction prevailed and the agricultural utilization influenced the pH of soil to a various extent (Fig. 4). In the soil of the large farm and in orchard soil the increase of reaction to slightly acid and even neutral one occurred as the result of long-term agricultural utilization. However, soils extensively utilized are still strongly acidified similarly to the forest soil.

Orthic Luvisols developed from sandy loam

In this group of soils a comparatively high content of humus was noted in the Ah horizon of forest soil. However, the contents of the organic matter diminishes quickly in the deeper horizons of soil profiles. In the cultivated soils the humus content was significantly lower, except for the orchard soil (Fig. 5).

Soils formed from sandy loam are very acid irrespective of the way of their utilization, similarly to the previously discussed soils formed from the boulder loam and silts of water origin. Only in the profile of orchard soil, higher pH was noted, testifying to the application of proper fertilization. In case of the discussed soils formed from sandy loam no differences of reaction were noted in the fields of small farm and those of the large farms. The heavy equipment applied in the large farms caused very strong increase of the compaction of soil (Fig. 5).

Leptic Podzols developed from sand

The examined soils showed, characteristic for sandy soils, low humus content and strong acidification. With the exception of the orchard soil the reaction of which was acid, in all the remaining soil profiles, both forest and the cultivated ones, the reaction of surface layers was strongly acid (pH<4.5). However, no differences in the reaction were noted be-

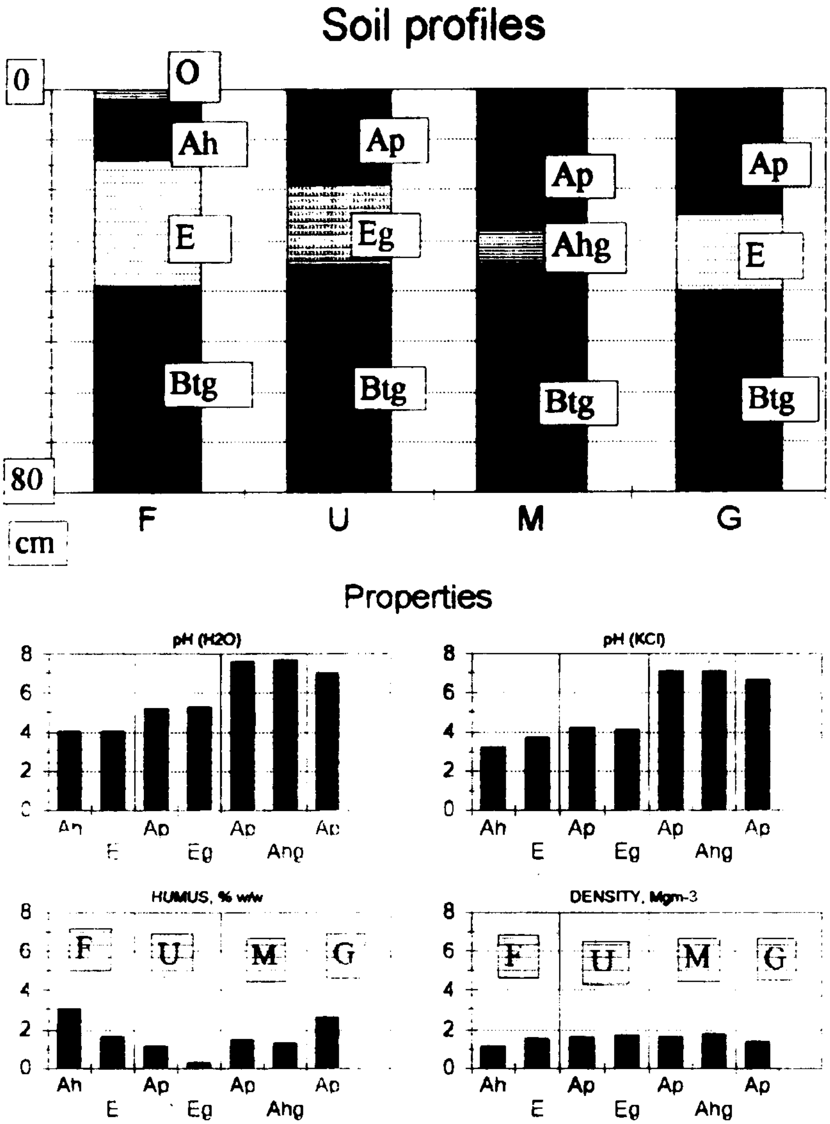

Fig. 3. Soil profile structure and some properties of Orthic Luvisols developed from boulder loam. Denotations as in Fig. 1.

tween the soils utilized by small, extensive farms and large farms with the proper level of agrotechnics (Fig. 6). This proves high vulnerability of light textured soils to the effect of acidifying factors.

CONCLUSIONS

1. Soils occurring in the natural forest habitat are characterised by a considerable high content of organic matter in the surface layers (Ah), with the simultaneous strong acidification irrespectively of their granulometric composition.

2. Agricultural utilization changes the morphological structure of soil through the shaping of the arable-humus layer and the change of organic matter distribution in the soil profile. The depth of humus-arable layer is dependent on the depth of ploughing, resulting

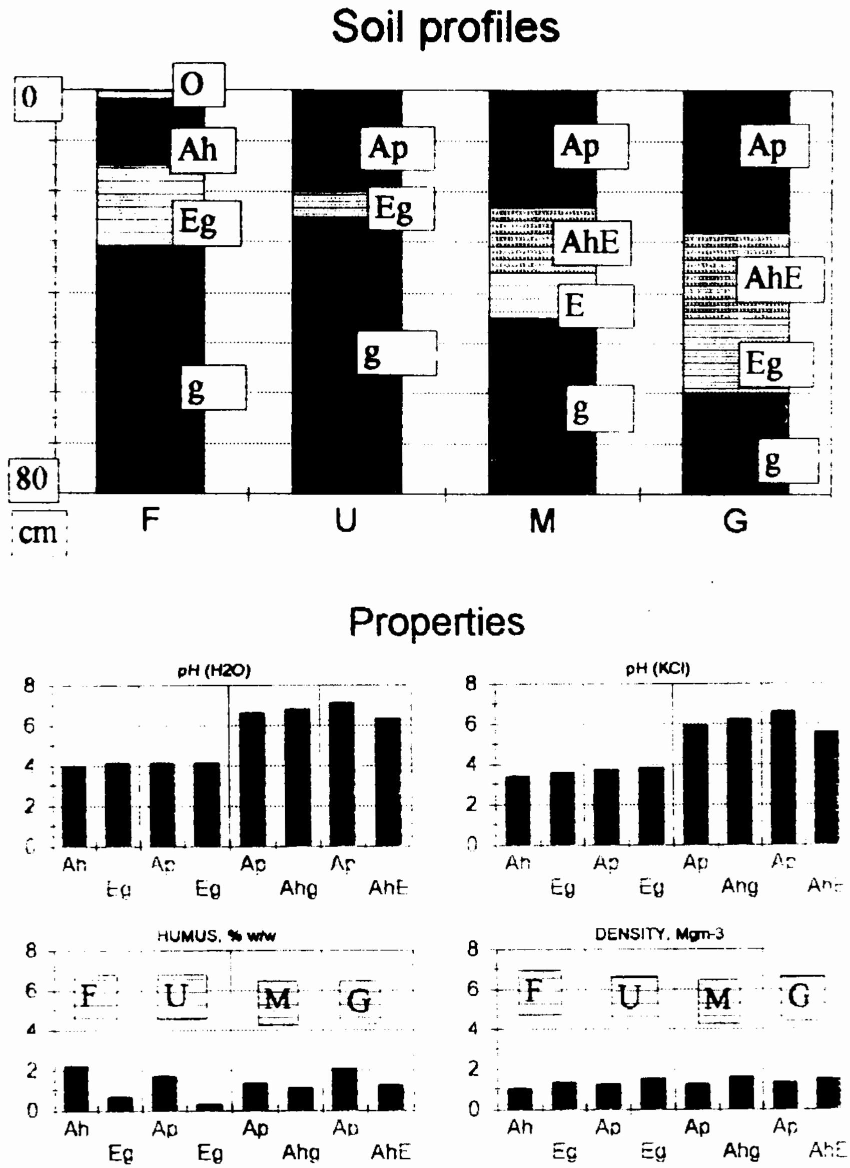

Fig. 4. Soil profile structure and some properties of Gleyic Luvisols developed from silt of water origin. Denotations as in Fig. 1.

from the intensity of its utilization and the applied technology of cultivation.

3. Soils agriculturally utilized show, in general, lower acidification than forest soils. It pertains especially to the soils formed from loess and loams rich in colloids and less permeable. Thus, they are more resistant to the effects of acidifying factors.

4. Soils formed from sandy loams and sands are strongly acidified irrespectively of the way of their utilization. Even in the farms with generally high level of agrotechnics no significant lowering of acidification of these soils is noted. Thus, there exists the need of their intensive deacidification for achieving good productive properties.

5. In all the analysed soils, long-term orchard utilization leads not only to the increase in soil tilth but also to the lowering of acidification. Thus, there exist the possibilities of

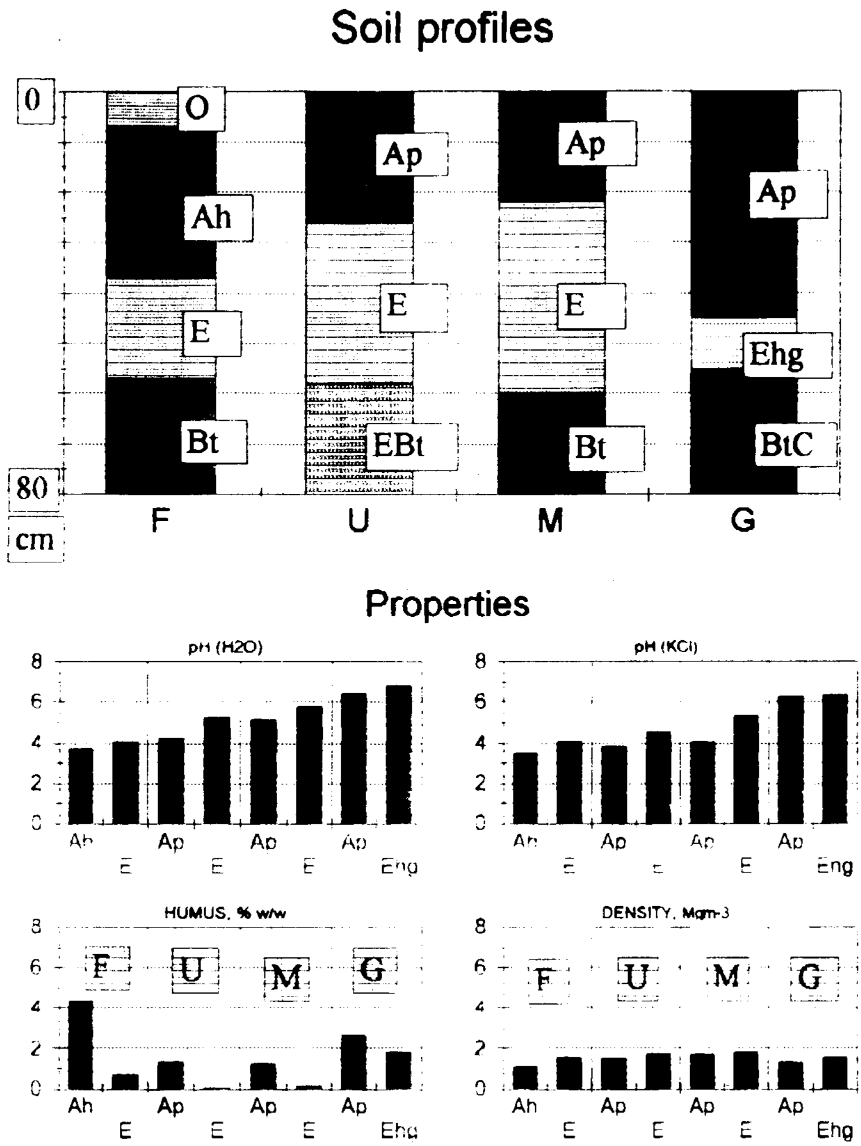

Fig. 5. Soil profile structure and some properties of Orthic Luvisols developed from sandy loam. Denotations as in Fig. 1.

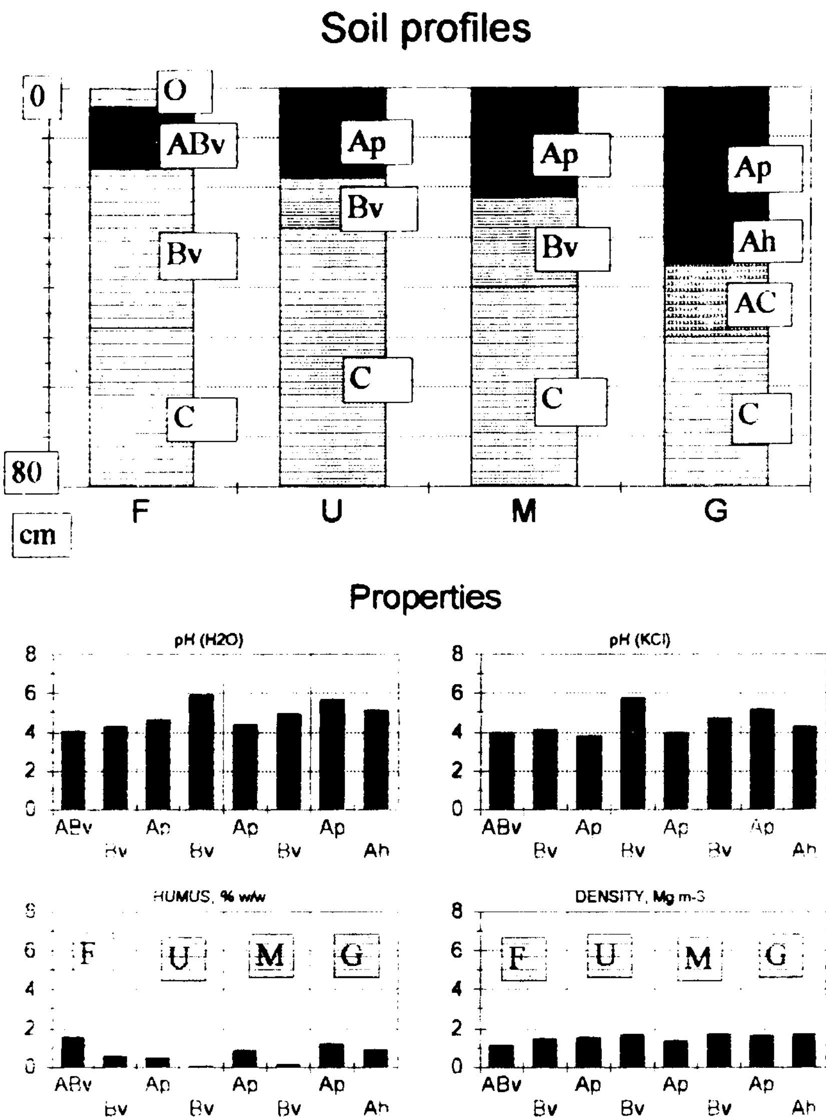

Fig. 6. Soil profile structure and some properties of Leptic Podzols developed from sand. Denotations as in Fig. 1.

improving the chemical properties of soils agriculturally utilized. However, they are dependent on the application of proper agrotechnics and fertilizing for a long period of time.

6. The deacidification of soils connected with regular liming applied in large farms is undoubtedly the positive effect of this type of utilization. However, it is accompanied by an unfavourable effect also, that is the increase of the arable layer density connected with the excessive kneading of soil. Therefore, the tusk of the modern agriculture should be to increase of the positive tendencies in the shaping of chemical properties and preventing or al least reducing the physical degradation of soil.

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ODCZYN I NIEKTÓRE WŁAŚCIWOŚCI GLEB RÓŻNIE UŻYTKOWANYCH

W pracy przedstawiono wyniki badań wieloletniego wpływu różnych sposobów użytkowania gleb na odczyn i niektóre właściwości fizyczne oraz chemiczne. Badaniami objęto 6 jednostek glebowych (gleby płowe, rdzawe i czarnoziemy wytworzone z utworów pyłowych, glin i piasków). Porównywano właściwości gleb występujących w naturalnym siedlisku leśnym z właściwościami gleb użytkowanych rolniczo w gospodarstwach o różnym poziomie agrotechniki oraz z właściwościami gleb ogrodowych.

Stwierdzono, że gleby użytkowane rolniczo, w porównaniu do gleb leśnych mają odmienną budowę profilu, inne rozmieszczenie związków próchnicznych w profilu oraz są bardziej zagęszczone. Wpływ użytkowania rolniczego na odczyn gleb wyrażał się zmniejszeniem zakwaszenia w glebach wytworzonych z lessu i gliny. W gospodarstwach wielkotowarowych wzrost odczynu wynikający z właściwej agrotechniki był większy niż w gospodarstwach małych, prowadzonych ekstensywnie. W glebach wytworzonych z piasku i gliny piaszczystej pozytywne oddziaływanie agrotechniki na odczyn było znikome.

S ł o w a k l u c z o w e: gleby, pH, zawartość próchnicy, gęstość gleby, użytkowanie ziemi.