NOTES ON THE INFORMATION STORED IN THE LOWER LEVELS OF THE HUNGARIAN SOIL TAXONOMY

MEGJEGYZÉSEK A MAGYAR TALAJOSZTÁLYOZÁSI EGYSÉGEK INFORMÁCIÓTARTALMÁRÓL

TÓTH, Gergely[1]*, HERMANN, T[2] and MÁTÉ, F[2]

[1]Land Management and Natural Hazards Unit, Institute for Environment and Sustainability, Joint Research Centre, 21027 Ispra, Via Fermi 2749, Italy

[2]University of Pannonia, Georgikon Faculty of Agricultural Sciences H-8361 Keszthely, P.O. Box 71. Hungary

*Corresponding author: tel./fax: 0039-0332-786453 gergely.toth@jrc.it

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ABSTRACT

This paper examines the information transfer of the units in the general purpose Hungarian soil classification in relation to land productivity evaluations. Statistical analyses of a national soil and plant production database have been applied.

Results show that in some cases soil groupings, both in the general purpose taxonomy and productivity classifications, may be incorrect. Taxonomic misclassification can occur at higher levels of soil classification. Without a more specified classification of soil characteristics in the lower taxonomic units important information can be lost.

Keywords: soil classification, land evaluation, soil organic carbon (SOC) dynamics, productivity

ÖSSZEFOGLALÓ

A genetikai talajosztályozás egységeinek információ tartalma számos gyakorlati alkalmazáshoz nyújt alapot, köztük a talajbonitációhoz is. Vizsgálatainkkal arra kerestünk választ, vajon az osztályozási egységek elkülönítésére szolgáló kategória-határok valóban megfelelő felosztást eredményeznek-e, ha gyakorlati szempontból vizsgáljuk azokat. A statisztikai vizsgálatokkal nyert eredményeink azt mutatják, hogy a rendszertani kategóriák gyakran félrevezetők lehetnek a valós talajtulajdonságokat illetően, így a kategóriák interpretációs alkalmazásával nagymértékű információvesztés történhet.

Kulcsszavak: talajosztályozás, földminősítés, talaj szerves anyag, produktivitás

INTRODUCTION

When talking about soil classification, there are many different approaches to take: pedologists focus on the soil's scientific classification; agronomists use the classification for crop selection; agrochemists are interested in the classification to assess fertilizer reaction; hydrologists look for conductivity patterns; agricultural engineers classify the land for workability and economists for economic land evaluations.

Different classification schemes can have compatibility problems. However, the soil's general purpose scientific taxonomy should provide the basis for information transfer for both scientific and practical use.

Practical applications are usually carried out in a spatial context where information is visualized by maps of different scales.

Soil maps show spatial soil classification information using data collected by standard soil survey methods. Soil surveys are usually conducted using the scientific soil taxonomy . The resulting soil maps not only display soil type, but also soil attributes categories.

Land productivity classification for land use planning purposes (or land evaluation) is one of the most widespread applications for the interpretation of soil data from soil surveys (soil maps) . Further applications include classifications for water- or nutrient regime [6, 16].

Besides the methodological and implementation aspects, the applicability of any land evaluation system - - depends on the accuracy of the information provided by the soil maps.

The main requirements of land evaluation towards soil taxonomy are:

(1) an easy-to-handle system on the higher levels of the soil classification and (2) focus on the characteristics that are important for soil fertility on the lower taxonomic levels.

Problems may appear as discontinuity in the productivity classification are caused by the taxonomic misclassification of soil units on higher taxonomic levels, and can be eliminated by:

(1) well defined diagnostic criteria for soil type designation and

(2) a well structured transfer of classification properties for the representation on soil maps.

General purpose classification and productivity classification need to be harmonized and supported with an adequate soil mapping procedure when handling soil information for land evaluation. In the mapping process general and specific rules have to be followed. The choice of soil mapping method depends on the purpose and on the available data and tools. For land evaluation purposes, for example to support field-scale land use planning, maps at a scale of 1:10,000 are required.

Although soil maps are very valuable to scientists for the description of the ecological conditions of a given area, the maps by themselves do not provide readily applicable information for decision making on land use.

In the land evaluation process, soil maps can help to convert raw data to readily applicable information for decision makers. While the theoretical basis of continuous soil mapping is available [22, 5], raw data of soil maps usually comes in pregrouped properties (into discrete categories).

During land evaluation, the effect of these soil properties on soil productivity are taken into account. This means the soil classification properties are weighted to describe the fertility of a given soil unit.

This paper aims to reflect on the dependency of a land evaluation system on the original soil taxonomy and mapping information. This dependency is illustrated through the commonly used Hungarian land evaluation system [4, 7]. This system contains many land evaluation characteristics developed in other countries [11, 20, 21], and uses soil type as the basis for productivity classification.

The validity of the information was assessed by the results of the analysis of farming databases, including soil and yield data.

MATERIAL AND METHODS

The Hungarian land evaluation method builds on large scale genetic soil maps, based on soil general purpose soil classification. The structure of the soil taxonomy is hierarchical and follows: main type – type – subtype - variety – local variety elements [13]. The information of soil maps for land evaluation has been analyzed with actual yields of cultivated fields. This method includes analyses of the effects of soil attributes on the productivity of soil subtypes with statistical tests measuring the yields of the different soil varieties.

The soil maps, the structure of the land evaluation system and the database applied for the analyses are described below.

Large scale (1:10,000) soil maps applied in land evaluation. 1:10,000 (or larger) resolution soil maps are used for field-scale land evaluation in Hungary. These maps contain information on soil types (subtypes), parent material and texture. Five additional map sheets complement the soil map:

- humus (with information on depth of humic layer and humus content of the plough layer)

- pH and calcium carbonate content
- soil water (depth of soil water level)
- soil salinity (with information on salt content and distribution of soil profile)
- soil characteristics important for soil fertility and management (rooting depth, erosion, stone content, etc.)

Figure 1 introduces the coding system of the humus map sheet. Soil sampling locations are shown as rounded points. The registration number of the sampling location is indicated above the sampling point, while information on soil humus is shown below the points.

The humus map sheet is coding two soil attributes with one digit each. The first digit codes the depth of the layer with humus content and the second digit codes the humus content of the plough layer (upper 30 cm of the profile) [1]. The humus coding includes the following elements:

a) Depth of humic layer: 1- no humus, 2- shallow, 3- intermediate, 4- deep humus layer, 5- very deep humus layer;

b) Humus content: 1-no humus, 2- low humus content, 3- intermediate humus content, 4- high humus content, 5- very rich in humus.

The humus content code depends on soil type and is

Table 1. Categories of humus content of non-sandy Calcic Chernozem (Vermic Chernozem) [1]. Mészlepedékes csernozjom humusz kategóriáinak határértékei [1]

Code of humus content humusz ellátottság kategórák kódjai	Meaning of the code a humuszkategória kódok jelentése	Humus % intervals Humusz % határértékek
2	low humus content	< 2%
3	intermediate humus content	2- 3,5%
4	high humus content	> 3,5 %

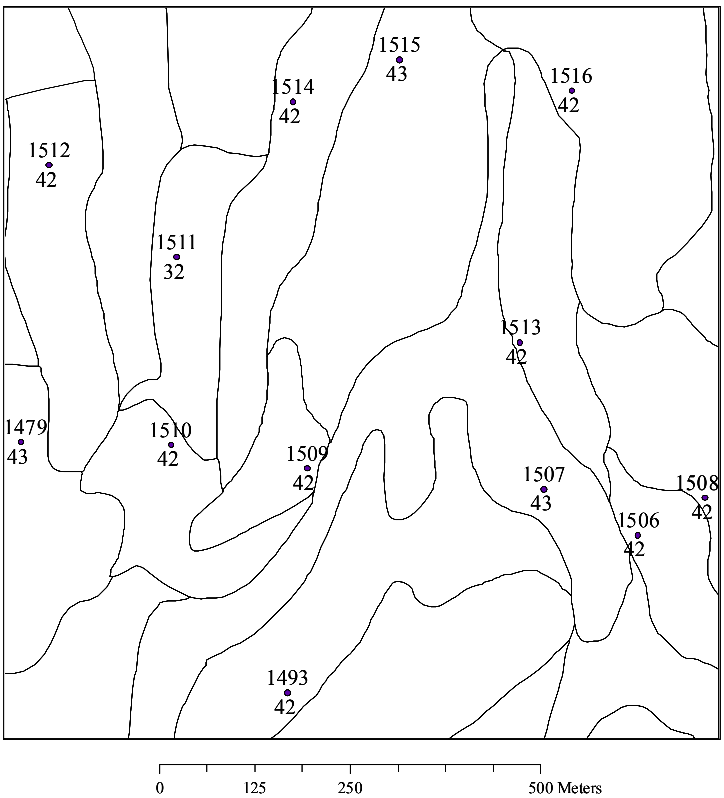

Fig. 1. Humus cartogram of a soil map. A talajtérkép humusz katrogramja

Table 2. Example of the productivity index calculation for the Lessivated Brown Forest soil (Haplic Luvisol) [7].
A talajbonotácoós viszonyszám számolásának példája, az agyagbemosódásos barna erdőtalaj esetében [7]

possible productivity index range
a talajbonitációs index lehetséges szélső értékei
maximum : 80
minimum: 35

Soil attribute *Talajjellemző*	**Soil characteristics** *Talajtulajdonság*	**Point reduction from the maximum productivity index** ***Pontlevonás a bonitási értékszámból***
Parent material *Talajképző kőzet*	Loess; *Lösz*	0
	Sandy loess, sand; *Löszös homok*	5
	etc. *stb.*	
Texture *Fizikai féleség*	Sand; *Homok*	5
	Sandy loam; *Homokos vályog*	3
	Loam; *Vályog*	0
	Clay; *Agyag*	10
Thickness of humus layer *A humuszos retag vastagsága*	Shallow; *Sekély*	10
	Intermediate; *Közepes*	5
	Deep; *Mély*	0
Humus content *Humusztartalom*	Low; *Alacsony*	8
	Intermediate; K*özepes*	4
	High; *Magas*	0

Table 3. Taxonomic classification and codes of the studied soils.
A vizsgált talajok rendszertani besorolása

Soil code Talajkód	Soil name according to the Hungarian classification [1] Talajnév a magyar rendszertanban [1]	Soil name According to the WRB [3] A WRB szerinti rendszertani besorolás [3]	Soil name According to the US Soil Taxonomy [19] Az amerikai talajosztályozás szerinti renszertani besorolás [19]
112	Lessivated brown forest soil agyagbemosódásos barna erdőtalaj	Haplic Luvisol	Hapludalfs
191	Typic chernozem típusos csernozjom	Vermic Chernozem	Vermustolls
391	Humic alluvial soil (calcaric) karbonátos humuszos öntéstelaj	Calcari – Mollic Fluvisol	Endoaquolls

Table 4. Productivity differences between varieties of Lessivated brown forest soils (Haplic Luvisol) with different humus content (result of Tukey test)
A különböző humusztartalmú agyagbemosódásos barna erdőtalajok termékenységének különbségei (Tukey próba eredményei)

humus % (A)	humus % (B)	humus category	humus category	Mean Difference (A-B)	Std. Error
0-1	1.0-1.5	II.	II.	-4.619*	1.216
1.0-1.5	1.5-2.0	II.	III.	0.218	0.373
1.5-2.0	2.0-2.5	III.	III.	3.909**	0.447
2.0-2.5	2.5-3.0	III.	III.	0.088	0.759
2.5-3.0	3.0-3.5	IV.	IV.	-0.587	1.483

*The mean difference is significant at the .05 level. **The mean difference is significant at the .01 level.
*$SzD_{5\%}$; **$SzD_{1\%}$*

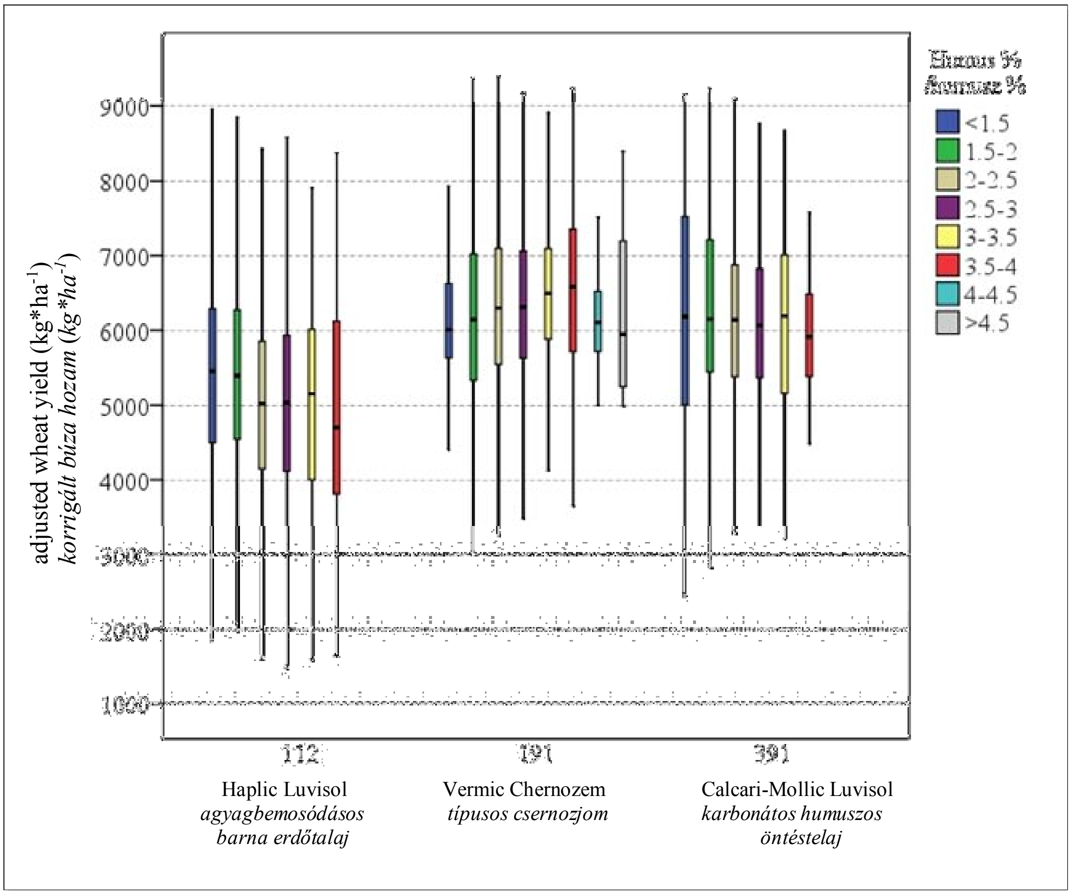

Fig. 2. Land productivity of three different soil types according to humus categories represented on soil maps.
Három különböző talaj eltérő humusztartalmú változatainak produktivitása

provided in additional tables [1] that supplement the maps. In addition to humus codes for soil subtype, the texture of the subtype can also be used to refine humus classes. An example of humus content coding is given in Table 1.

Neighbouring soil plots (polygons on the map) differ in at least one of their attributes. In humus map sheets, polygons divide soil plots of different humus content or plots with a difference in depth of the humic layer. About 60 % of the agricultural area of Hungary is mapped at a 1:10,000 scale [17]. Many of the maps are digitized, georeferenced and are integrated into GIS systems.

Structure and data requirements of the Hungarian land evaluation system [4]. Land productivity indices are based on the soil taxonomy that also provides the basis for soil mapping information. Soil varieties of the classification system are characterized by their relative fertility (related to the fertility of all other soils in the classification system) with regards to the major cultivated crops. A standard fertility index was developed for each genetic soil subtype, which corresponds to the relative fertility of the most productive variety of the considered soil subtype. During the productivity evaluation process, different soil attributes (texture, humus content, thickness of humus layer, pH, parent material, etc.) have been characterised by numeric values (correction factors), according to their relative importance in the production potential of the different genetic soil subtypes. By deducing the initial productivity values using the above mentioned correction factors the actual relative fertility of the soil variety can be described quantitatively. An example of a productivity evaluation scheme is presented in Table 2.

Land productivity analyses of different taxonomic soil units.

Crop yields are the most reliable parameters for agricultural land evaluation [2, 8]. The measured yield levels were first matched with soil units, then with the soil parameters of the fields.

A series of analyses was used to test the productivity of soil varieties. The analyses relied on the statistical processing of pedological, climatic, plant production, soil and fertilizer application data using a national plot-level database . This National Pedological and Crop Production Database was compiled in the 80’s and was made available for research by the Plant and Soil Protection Service in Budapest. The database contains soil, fertilization and yields information for 80,000

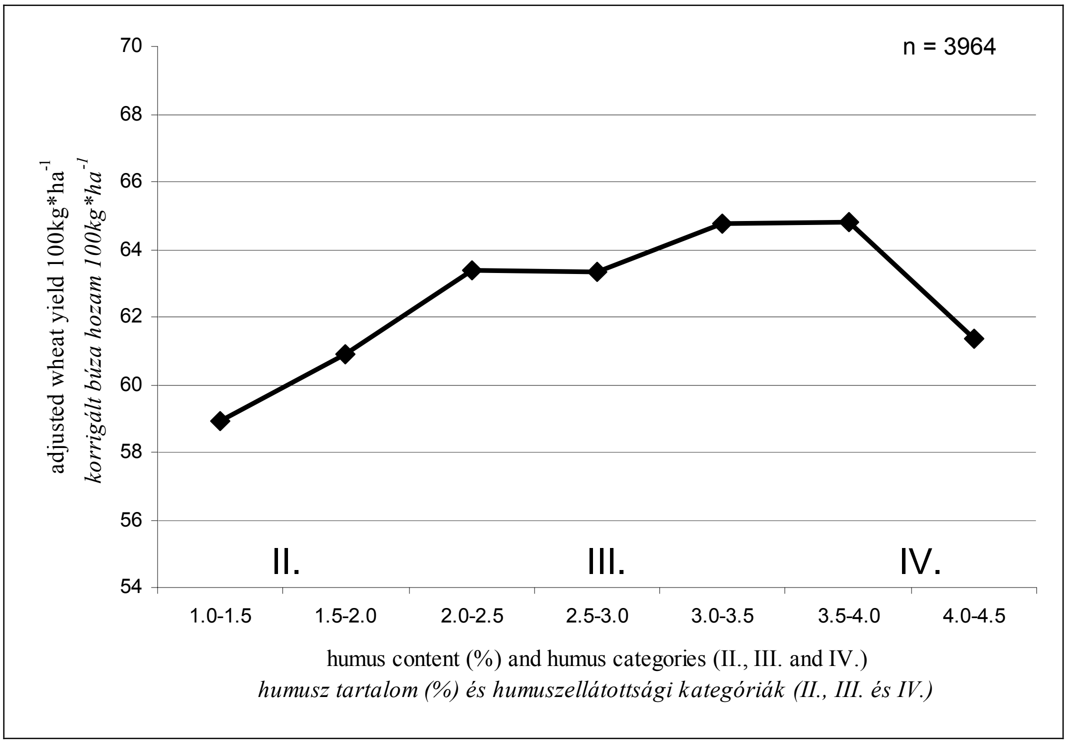

Fig. 3. Productivity of Typic chernozems (Vermic Chernozem) of different humus content (in % and in categories; non-sandy chernozems). Eltérő humuszellátottságú típusos csernozjom talajok produktivitása (százalékos humusztatralom és humuszkategóriák szerint; nem homokos változatok)

cultivated fields for 5 consecutive years on each plot.

The data include:

- Basic data (location, meteorological region, size, slope, exposure, meteorological area, etc.)
- Soil analysis data (SA) (pH, texture, humus, N, P and, K content)
- Plot registry data (plant, succession, yields, fertilizer application)

Before testing the productivity of soil varieties a series of data preparation was carried out. The meteorological factors determining land productivity were taken into consideration using the ratios reported by Szász [15]. These ratios characterize the differences in yield, expected on the basis of the weather conditions in various years, in different bioclimatic regions and for major crops. The ratios were used to factor the Crop yields recorded in plots in different bioclimatic regions were factored in by the ratios of Szász [15].

In the next step of the data preparation crop fields with intensive fertilization (N> 125 kg/ha) have been selected.

Validation of the soil map information . After minimizing the meteorological impact, the effect of soil texture and humus content on wheat yields was analyzed for the most common soil types (suborder or great group level according to the US system) considering only fields of intensive fertilization. The taxonomy classification of the examined soil types and their correlation to international systems [3, 9, 19] are summarized in Table 3.

To explore the connections between soil classification, soil mapping and land evaluation shortcomings, descriptive statistics and Tukey test have been performed using the SPSS software package [12, 14].

In this paper we present the results of the comparative analyses on the effect of texture and humus on the fertility of different soil types. In these analyses different soil types have been studied according to the fertility of their local varieties.

To validate the soil map information for land evaluation purposes, percentual values of humus content and category values of soil maps (Table 1) were compared in connection with actual productivity of the selected fields.

RESULTS AND DISCUSSION

According to the land evaluation model, computational shortcomings may originate in the incongruity of soil

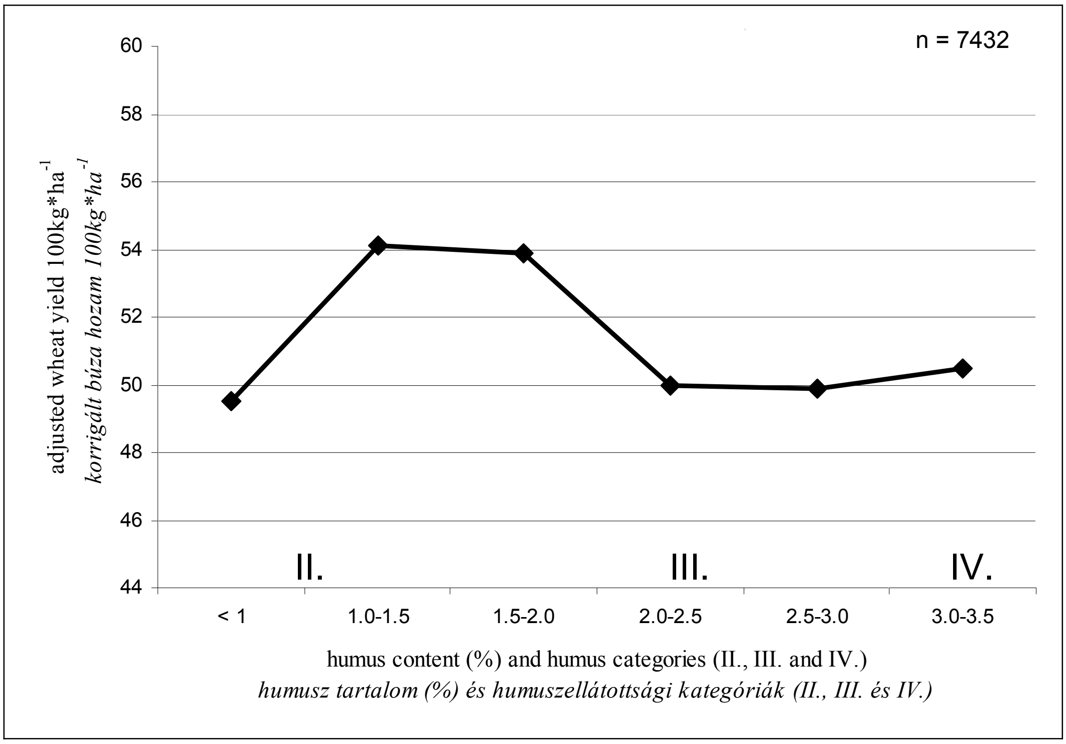

Fig. 4. Productivity of Lessivated brown forest soils (Haplic Luvisol) of different humus content (in % and in categories). Eltérő humuszellátottságú típusos agyagbemosódásos barna erdőtalajok produktivitása (százalékos humusztatralom és humuszkategóriák szerint

fertility evaluation and soil map information. Soil map information is basically the information of categorized taxonomy classification.

During the validation of the land evaluation system the misclassification of some soil attributes has been discovered. Earlier results [17, 18] indicate that the difference in productivity of soil varieties can be statistically proven. Results of the present analyses show that some soil subtypes might have been classified incorrectly. This can be seen from Figure 2 which shows the expected yields and spread of yields of different soil subtypes, according to their humus content. One possible anomaly in the classification is the presence of soil varieties with a low humus content in Typic Chernozems soil unit. Although in the present Hungarian soil taxonomy humus content is not a classifying criteria for Typic Chernozems, typical morphological characteristics of these soils are formed when a certain amount of humus material is present. The indirect assumption of misclassification of low humus content soils to the subtype of Typic Chernozems is underlined by the fact of discontinuity in productivity series of soils (grouped to this subtype) with different humus content. This misclassification appears on the soil maps and lessens the validity of the land evaluation system.

Figures 3-5 display expected wheat yield of the examined soils separately. Expected wheat yields are mean values calculated from the database, after neutralizing the effect yearly climatic variation. Besides the actual humus content (in %) the humus categories represented on soil maps are also displayed, as these categories serve for differentiating soil varieties, both in the taxonomic and in productivity classification [1, 13]. For Chernozems, the categorization is performed for non-sandy varieties (Figure 3).

According to Figures 3-5 soil map information may not be refined enough for land evaluation purposes, even if the classification is correct. This is explained by inappropriately large categories of attributes. This statement is supported by the diagrams; as they highlight that productivity of soils classified into the same category on the lowest taxonomic level differs (Figure 4). As table 4 shows, these differences were statistically significant within the cases of categories II. and III. of Lessivated brown forest soil. In other cases (Figures 3 and 5) detailed taxonomic classification does not necessarily provide useful information for land productivity evaluation. However, the classification scheme can be correct.

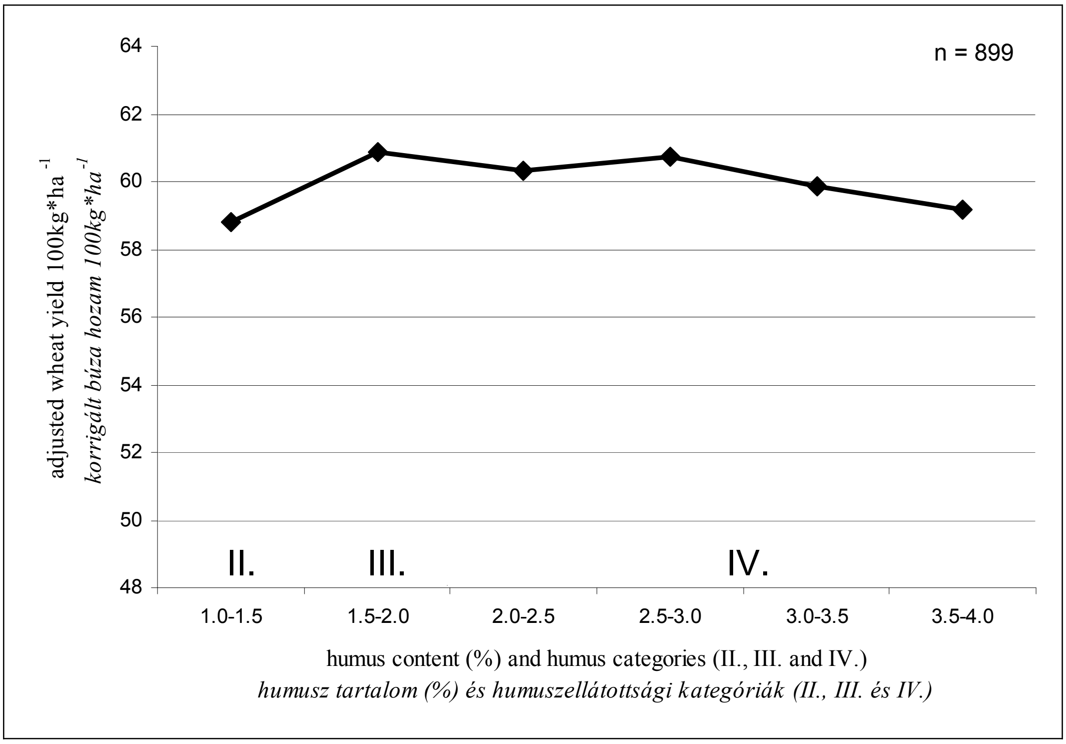

Fig. 5. Productivity of Humic alluvial soil (non- calcaric) (Mollic Fluvisol) of different humus content (in % and in categories). Eltérő humuszellátottságú humuszos öntéstalajok produktivitása (százalékos humusztatralom és humuszkategóriák szerint; meszes válozatok)

As can be seen from the above described examples, reliable soil information is one of the most important aspects in land evaluation. During soil mapping most of the soil information is available in precise numeric data from accredited soil laboratories. However, classification and category designation have to be precise, and have to be suitable for multi-purpose interpretation.

In addition to taxonomic misclassification and sometimes the misleading grouping of soil characteristics, a third source of mismatching originates from the heterogeneity of soils, and a sampling density inconsistent with the soil's spatial heterogeneity. Soils are spatial objects with continuous variation, thus new advanced mapping methods are required for adequate modeling. Fuzzy classification and mapping [22, 5] is one of the methods that can help to improve the quality of soil maps, and thus land evaluations. Other mathematical and geo-statistical methods, such as interpolation may also help to improve the quality of soil maps [10]. However the application of these methods within the framework of the current Hungarian soil classification and mapping needs to be developed.

Furthermore, to enhance the relevance of land evaluation it is necessary to systematically extend the research on land productivity with soil classification and mapping information, including research on the relationships of all soil properties taken into account in land evaluations.

CONCLUSIONS

Two major components of soil surveys contribute to the accuracy of information used for land evaluation: Taxonomic classification of the soil units presented on the maps and mapping techniques. Although present science provides an adequate background for the development of a comprehensive land evaluation system, the automatic acceptance and application of conventional soil classification and traditional soil maps may lead to errors in assigning land productivity indices.

Anomalies in productivity classification can be caused by taxonomic misclassification of soil units at higher taxonomic levels (subtypes), and by the inadequate categorization of soil units on lower taxonomic levels (varieties).

These anomalies can be minimized by

- Consistent use of well defined diagnostic criteria for soil unit designation and
- A well structured method for the transfer of classification properties onto soil maps.

In order to overcome the information loss resulting from the misclassification of soil characteristics for land evaluation purposes, metadatabases of soil information should store information for special purpose groupings (interpretive classifications). Development of soil mapping techniques can also contribute to the improvement of land evaluation systems and processes.

This paper highlights some of the structural shortcomings in the present Hungarian classification and mapping techniques. Further analyses of different databases are necessary to develop and sophisticate the harmonization of different classification schemes.

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