OPTIMIZING THE NUTRIENT MANAGEMENT WITH AN ON-LINE LAND VALUATION SYSTEM

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Abstract

In Hungary the obsolete "Gold Crown" land valuation system must be replaced. In spite of using the old index based on the "long-term return" earlier for land-taxation, than for reprivatization of the land, at present for various land related transactions, now a complex index of land value is suggested. The new evaluation is based on the agroecological assessment of the plot expressed by a soil quality index ("D-*e*-METER" soil bonitation value) and on the economics of cultivation as well. The system is organized in an on-line Geographical Information System, and provides continuously updated, easily accessible and comparable information for everyone. The map database is composed of the 1:10,000 scale "genetic soil type" map and its cartograms, digital elevation model, topographical map sheets, aerial ortophotos and soil survey data. The core of the calculation of "D-*e*-METER" soil quality index is the statistical evaluation of agronomic field records (crops, crop rotations, yields, application of fertilizers and manure) and soil and climate data. The nutrient management module of the on-line system is based on the information collected in the framework of the Hungarian National Pedological and Crop Production Database during several years. This same data set was used for the calculation of the nutrient factor of the soil quality algorithm. The existence of this module can also contribute to the - planning of agrotechnical operations, including fertilization.

Our results showed that it is worthwhile to extend fertility evaluation to nutrient availability of soil types grouped by similar characteristics in their nutrient dynamics. The difference between the effects of nutrient dynamics due to climatic variation was also quantified.

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Introduction

Soil quality remains a central topic for research all over the world (Tóth et al., 2005, 2007). There is a clear linkage between long-term sustainability of agricultural production and soil quality. Consequently soil evaluation should provide a framework not only for assessment of soil quality per se, but to provide a framework for optimal management of the land.

In the land productivity assessment not only stable soil characteristics, but temporary ones are also included. The effect of nutrient regime on the site-specific yield potential is considered in a uniform system, which provides options to optimize land use planning and nutrient management with environmental and economic criteria (Gaál et al., 2003).

Taking into consideration Hungarian ecological conditions, scientific antecedents and background, as well as the existing databases, the objective of the research was to incorporate the factor of soil nutrient level to a newly developed "D-*e*-METER" land evaluation model (Gaál et al., 2003), that can be suitable for practical use at field level. As part of this work, the first step was the classification of soils according to their known nutrient dynamics properties, followed by the analysis of the effect of nutrient levels influencing fertility.

Since the land evaluation model was designed for practical field-scale use, the scope and quality of the data already available or easily obtainable for every field had to be taken into consideration. The most detailed information on soil properties is to be found in 1:10,000-scale soil maps, which can thus be used as the basis for land evaluation. Another source of information is provided by regular soil tests that can help to adjust the actual land productivity indices by the nutrient factor.

Materials and methods

In order to achieve the aims to include soil nutrient level into a land evaluation model a national field-level soil, fertilization and yield database, the so-called National Pedological and Crop Production Database (NPCPD; AIIR) was analyzed.

In addition to yield data for five consecutive years (1985-1989) for an average of 80,000 cultivated plots covering about 4 million hectares of arable land each year, the NPCPD also contain data on the soil type of the plots, information on major soil attributes, results of nutrient tests and the amounts of fertilizers applied.The meteorological factors determining land productivity were taken into consideration using the ratios reported by Szász (2002).

In the next step of the data preparation fields with intensive fertilization (N> 125 kg/ha) have been selected. The selected fields were grouped by their soil types and major soil characteristics (soil texture, pH and carbonate) to so-called 'Terrain Groups' according to the procedure laid down in MÉM (Patócs, 1987). Basic concept of this grouping is that certain taxonomic soil units show similarities in their nutrient regime and these similarities determine their fertilization response and yield capabilities. 126 units of the Hungarian taxonomic soil classification were grouped to 6 (I-VI) 'Terrain Groups' based on the material and energy flow and attribute characteristics of soils.

During the analysis of the effect of nutrient level, expected (mean) wheat yields have been calculated for the six different nutrient level classes for N, P, K separately, for each Terrain Group. From the mean yield levels of the nutrient classes, an overall mean yield level has been calculated, as a reference yield level for further comparisons. This paper present the results of Terrain Groups I and II. (I. Soils with balanced material regime; II. Soils with leaching material regime).

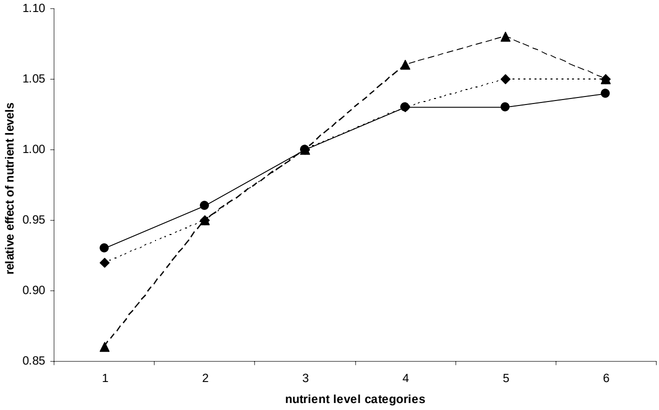
Results and discussion

The differences between the characteristics of nutrient effects of the two Terrain Groups (I. and II) may originate from the differences in structure, texture, pH, organic matter content and consequent influences of these soil-specific characteristics.

Mean yield levels of soils with similar nutrient level categories were higher in Terrain Group I in each case, underlying the importance of other factors. The most precise land evaluation model can be achieved by studying and quantifying the soil attributes with the greatest influence on the capacity of the soil to supply water and nutrients, for each soil type.

Our results demonstrate that the difference between expected crop yields – and consequent land evaluation factor – vary across the years. Yield performance and consequent coefficient value (Figure 1) under optimal climatic conditions is considerably higher in the upper zone of nitrogen availability in both Terrain Groups. However saturation points are different for soils with different material regimes. The lower level of nitrogen availability decreases yields in a relatively larger extent in years with suboptimal climate in both Terrain Groups and this phenomenon is reflected in low coefficient values. The spread of coefficient values are larger in both Terrain Groups in the suboptimal years compared to the “average” years, indicating that increasing nutrient content - besides under favorable conditions (optimal year) - are also important under climatic constrains (suboptimal year). In an ‘average’ year there is a constant increase of yields with increasing level of nitrogen content in Terrain Group I up to excessive nutrient level, however in Terrain Group II the yield reaction follows a saturation and a decline after a maximum value of nutrient availability. Since group I contains soils with balanced material regime there is an overall increase in the curve due to large nutrient buffering capacity (as defined by J.S. Owen). On the other hand in the group II of soils with leaching material regime there is a decline in the yields even at relatively lower nutrient levels, since there is leaching of nutrients and the unfavourable consequences, such as physiological traits, unbalanced nutrition in this group contribute to a decrease at higher nutrient levels (Table 1).

a) Terrain Group I (soils with balanced material regime)



b) Terrain Group II (soils with leaching material regime)

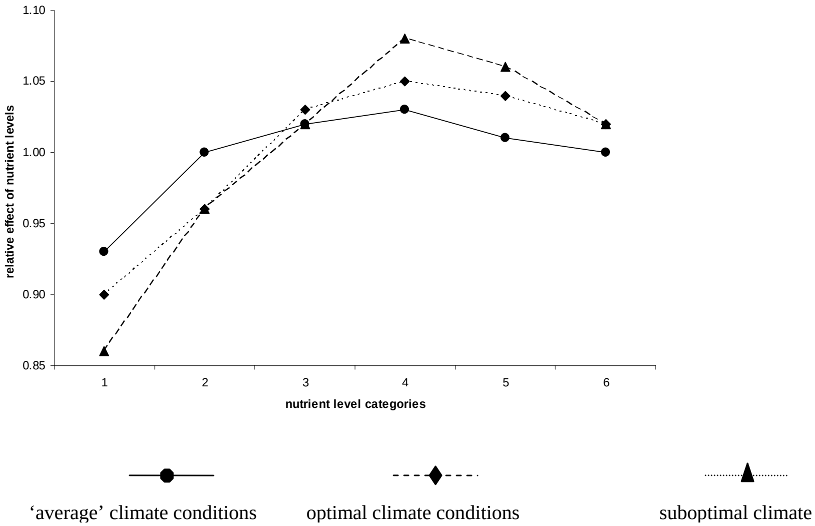


Figure 1. The effect of nitrogen level and climatic year type on wheat yields

In Terrain Group I the difference between the impact of low and high amount of available P is largest in optimal years, meaning an increasing positive yield reaction to P up to level 5. In suboptimal years, on the contrary, there can hardly be observed any impact of increasing level of P. Terrain Group II shows different phosphorous reaction: meteorological effects show little impact. The increase with the higher amount of nutrient in soil is observed to P level 4 (optimal years) and 5 (average and suboptimal years) followed by a decrease at the excessive levels (further data in Tóth et al., 2007).

Potassium effects show different trends, throughout the years and in comparison to different Terrain Groups. In Terrain Group I in optimal year the spread of the relative effect of nutrient level is larger over the spectrum of different K contents showing that the dynamics of K is strongly linked to available water. In years when water is not a limiting factor the higher K levels will positively influence yields until a saturation point at category 5 of the K level. On the contrary under suboptimal climate conditions the effect of higher K levels on yields stay at a surplus of only 2-3 percentage, showing the influence of dry fixation of potassium (further data in Tóth et al., 2007).

Theoretically, the actual productivity index of any crop field can be modified by factor values calculated with the method introduced in this paper. However, the fertilizer response of different soil types within the same Terrain Group may be different. Therefore, further studies will be necessary to calculate the parameters and to validate the method for different soil types.

Table 1. The effect of different nutrient levels on the productivity of soils in Terrain Groups I and II with different material regime

a) the effect of different N levels

Terrain Group	N level[1] (based on organic matter %)	Mean wheat yield (adjusted by climate factor) (kg/ha)	SD	n	Mean yield of Terrain Group (kg/ha)	Weighted average yield of Terrain Group[2]	Coefficients of nutrient level effect
I	1	5766	1478	1706	6294	6180	0.93
	2	5948	1365	5064			0.96
	3	6209	1307	20133			1.00
	4	6347	1254	29448			1.03
	5	6381	1245	15325			1.03
	6	6427	1309	11178			1.04
II	1	5001	1375	1188	5469	5365	0.93
	2	5357	1348	5272			1.00
	3	5494	1347	23331			1.02
	4	5525	1416	18812			1.03
	5	5443	1419	7335			1.01
	6	5368	1338	3012			1.00

[1]Nutrient levels

1- very low
2- low
3- medium
4- sufficient
5- good
6- excessive

[2]mean value of the average yields on different nutrient levels

b) The effect of different P_2O_5 levels

Terrain Group	AL-soluble P_2O_5 level[1]	Mean wheat yield (adjusted by climate factor) (kg/ha)	SD	n	Mean yield of Terrain Group (kg/ha)	Weighted average yield of Terrain Group[2]	Coefficients of nutrient level effect
I	1	5909	1387	3278	6294	6200	0.95
	2	6069	1328	5442			0.98
	3	6176	1312	11774			1.00
	4	6295	1242	15150			1.02
	5	6370	1277	20796			1.03
	6	6382	1286	26414			1.03
II	1	4955	1423	2788	5469	5407	0.80
	2	5285	1399	10914			0.98
	3	5530	1359	15051			1.02
	4	5587	1344	13648			1.03
	5	5617	1382	6045			1.04
	6	5471	1381	10504			1.01

c) The effect of different K_2O levels

Terrain Group	AL-soluble K_2O level[1]	Mean wheat yield (adjusted by climate factor) (kg/ha)	SD	n	Mean yield of Terrain Group (kg/ha)	Weighted average yield of Terrain Group[2]	Coefficients of nutrient level effect
I	1	6061	1326	4271	6294	6255	0.97
	2	6135	1346	10426			0.98
	3	6223	1289	15349			0.99
	4	6345	1269	14098			1.01
	5	6410	1323	11291			1.02
	6	6358	1254	27419			1.02
II	1	5195	1433	2952	5469	5426	0.96
	2	5356	1358	5172			0.99
	3	5481	1368	8397			1.01
	4	5512	1351	10702			1.02
	5	5561	1346	12518			1.02
	6	5452	1417	19209			1.00

Conclusions

Nutrient reactions differ by nutrient levels, the inherent nutrient dynamic of soils and by climatic conditions. The effect of variation within Terrain Groups on the fertility for a specific crop can be described on the basis of crop yield, soil and nutrient level data. The relative influence of soil nutrient level on the crop productivity of different Terrain Groups (and soil types) can be expressed in a quantitative manner.

Our results underline that the nutrient factor used in the potential yield ratings of soils (land evaluation system) should be calculated separately for different Terrain Groups, nutrients and climatic year type.

It has been proved that it is possible to develop a land evaluation system that, apart from allowing field-scale applications, will also provide a more reliable and comprehensive method to incorporate the effect of measurable nutrient levels for making well-founded decisions on land use.

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