Pedo-ecological categorization of Slovakia rural countryside with aspect to rye (*Secale cereale* L.) growing suitability

Pôdno-ekologická kategorizácia poľnohospodárskej krajiny Slovenska vzhľadom k vhodnosti pestovania raže siatej (Secale cereale L.*)*

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Abstract: The work objective is to differentiate rural land of Slovakia with aspect to the possibility of effective rye growing. The differentiation is based on pedo-climatic and production economic parameters. At soil categorization, correlation relationships between the site properties (soil and climatic conditions) and crop biological and agro-technological requirements were considered. Rye requirements were included into yield databases using the software filters in the way that the given site property excluded or limited rye growing, what was reflected in predicted production. The prediction was subsequently interpolated into four suitability categories: soils not suitable for rye growing, less suitable soils, suitable soils and very suitable soils. The database was formed and each of the Bonited Soil-Ecological Units (BSEU) was added in it as well as particular category of suitability for rye growing. By mediation of the Geographic Information System on BSEU distribution in Slovakia, the map of categories of soil suitability for rye growing was also generated. In Slovakia, there is 21% of farmland very suitable for rye growing, 23% suitable, 24% less suitable and 32% non-suitable soils for rye growing according to our calculation. In the paper, these categories are characterized in details and specified from the view of geographic, soil, climatic, productivity, economic and energetic parameters.

Key words: rye; soil suitability for growing rye, agricultural landscape categorization

Abstrakt: Pri kategorizácii poľnohospodárskej krajiny podľa vhodnosti pre pestovanie raže sme zohľadňovali korelačné vzťahy medzi vlastnosťami stanovišťa (pôd, klímy) a biologickými i agrotechnickými požiadavkami tejto plodiny. Požiadavky plodiny boli pomocou softwérových filtrov rešpektované tak, že daná vlastnosť stanovišťa buď pestovanie raže vylučovala, resp. ho obmedzovala, čo sa odrazilo na výške predpokladanej produkcie. Táto bola následne interpolovaná do štyroch oblasti vhodnosti pôdy pre pestovanie raže - pôdy nevhodné, málo vhodné, vhodné alebo veľmi vhodné. Následne bola vytvorená databáza, v ktorej každej bonitovanej pôdno-ekologickej jednotke (BPEJ) bola priradená konkrétna kategória vhodnosti pre pestovanie raže siatej. Pomocou geografického informačného systému o rozšírení BPEJ na Slovensku potom bolo možné vytvoriť mapu rozšírenia kategórii vhodnosti pôd pre pestovanie raže. Podľa našich prepočtov je na Slovensku 21 % poľnohospodárskych pôd pre pestovanie raže veľmi vhodných, 24 % vhodných, 23 % málo vhodných a 32 % nevhodných. Uvedené kategórie sú v príspevku charakterizované z hľadiska pôdno-klimatických i produkčných i ekonomických parametrov.

Kľúčové slová: raž siata; vhodnosť pôd pre pestovanie raže, kategorizácia poľnohospodárskej krajiny

INTRODUCTION

Recently, rye (*Secale cereale* L.) is grown practically in all types of natural sites in Slovakia, ranging from lowlands to mountainous regions. Successful growing of rye, as well as of other crops, is fully dependent especially on environmental climatic and soil conditions. These chief factors influence production and economics of the crop assumptions to a great extent. Although a not negligible role is played by genetic and

breeding measures, with aspect to heterogeneity of soil-climatic conditions and considerable geomorphologic heterogeneity, various regions show different rates of rye growing suitability.

Soil categorization focused on the crop distribution was in the center of attention of several works. As early as 1921, economic farmland classification was applied and on this basis, the territory of Slovakia was divided into four production regions. After 1948, the system of so-called geonomical production types was established. In 1958, agricultural production zoning was finished, within which zones with different growing suitability were identified for the majority of crops. In the same year, production regions and sub-regions were identified for taxation purposes. They are still used, especially for statistical purposes. The system of soil suitability categories for selected crops, elaborated after 1971, is based on more exact pedological background obtained after the completion of Complex Soil Survey and subsequently Soil Appraisal. Important works, done in this area, were published by Korbíni and Facuna (1978) and Džatko (1980).

Recently, development of information technologies, especially Geographic Information Systems, enables processing of the existing and innovated soil databases and a more precise quantification and area division of soil suitability categories for crop growing. The aim of this paper is to show such methods for rye as an example.

MATERIAL AND METHODS

For outlining the regions of soil suitability for rye growing, the bases for us were the crop exact and potential data. Because growing suitability is predominantly judged on the basis of the really reached production, this factor played a decisive role at the categories formation. The particular data of yields and rye growing economics in Slovakia were obtained for the period 1990 to 2000 directly from the farms. Data of 281 agricultural subjects were assessed. They have been farming in various natural conditions on the total area exceeding 556 thousand hectares of farmland, which is approximately 23% of the total acreage of farmland in Slovakia.

Both production and economic parameters of successful rye growing are directly connected with pedo-climatic conditions. The data of Slovak climatic regions were analyzed and applied, as well as the data of sloping, stoniness, soil depth, soil types and subtypes, soil point values and typological-production soil categories. These data were obtained from the Evaluation Information Database of the Soil Science and Conservation Research Institute Bratislava, by mediation of the Bonited Soil-Ecological Unit (BSEU) planar presentation.

The dependence of the studied indicators on soil production potential in the analyzed farms (expressed by average point value in 100-point scale) was tested by non-linear polynomial regression analysis. Subsequently, the potentially possible yield of rye, its share in the cropping system as well as the potential economical parameters (yields, costs, profit, or loss) were calculated using the regression equations for each of the BSEU and added to the database. Soil rate of the suitability for rye growing was differentiated and qualified using the Geographic Information System ARC INFO, based on vector bonity maps (scale 1:5000) and area distribution of the studied factors. All economic indices used in the work were calculated without government subsidy.

Used background:

- Soil Science and Conservation Research Institute database of Bonited Soil-Ecological Unit (BSEU) data and their point evaluation in 100 point scale (Džatko 2002),
- soil categorization by their allegiance to climatic region, sloping category, texture and stoniness (Linkeš et al. 1997),
- typological-production farmland categorization (Džatko 2002) and database of production and economical parameters by the BPEU (Vilček 1999),
- real rye yields, their economical parameters (receipts, yields and costs) and real cropping system structure of arable land,
- energetic equivalents for rye growing energy production, calculated by the methodology of authors Strašil (1987) and Preininger (1987).

The following codes for the evaluating parameters were chosen:

- *Soil-climatic regions:*
  00 – very warm, very dry, plainly, 01 – warm, very dry, plainly, 02 – sufficiently warm, dry, hilly, 03 – warm, very dry, plainly, continental, 04 – warm, very dry, basin-like, continental, 05 – relatively warm, dry, basin-like, continental, 06 – relatively warm, moderately dry, highland-like, continental, 07 – moderately warm, moderately moist, 08 – moderately cold, moderately moist, 09 – cold, moist, 10 – very cold, moist.
- *Typological-productivity categories of soils:*
  O1 – the most productive arable soils, O2 – highly productive arable soils, O3 – very productive arable soils, O4 – productive arable soils, O5 – medium productive arable soils, O6 – less productive ar-

able soils, O7 – low productive arable soils, OT1 – medium productive arable soils and very productive grassland, OT2 – medium productive arable soils and medium productive grassland, OT3 – low productive arable soils and less productive grassland.

RESULTS AND DISCUSSION

Generally, the rate of successful rye growing is judged by real yields of the area unit (t/ha). This, however, with aspect of the unequal real energetic and material inputs into plant production process, can be sometimes confusing. Nowadays, production potential of our soils is used only at 60–70% by rye growing, as resulted from our previous work (Vilček 2001). Considerable reserves are particularly in the crop proper distribution within the conditions that are most suitable for it.

Objective results of the rural country categorization for cropping systems can be reached only by the analysis of satisfactory quantity of data and parameters. In spite of the statistically sufficient number of respondents, in the case of some parameters, there are some exceptions in the proposed categories that are not exactly in harmony with the scale chosen.

Starting point for formation of soil suitability categories for rye growing was poly-functional analysis of the selected pedo-ecological and economical parameters that remarkably affect the crop successful growing. This analysis showed significant dependence of production and economical characteristics on pedo-climatic conditions.

It is obvious that successful growing is influenced also by other factors that are not included in our analysis. For example, the actual soil reaction (pH) was not respected in the division of suitability zones. The optimum soil reaction for rye is 4.8–7.0 (Hraško, Bedrna 1988). At soils with pH lower than 4.5, rye growing is not recommended without liming. Therefore, genetically acid soils were classified as less suitable for rye growing. A similar principle was used in classifying compacted soils and soils with clayey gleyic horizon. Although rye is considered as a crop with minimum requirements for soil properties, economic profitability of its growing assumes acceptation of all pedo-climatic factors.

Based on the available data and using an inductive method, four regions were identified with respect to suitability for rye growing.

Rural country characteristics with regard to rye growing suitability

Soil category "very suitable" covers 21% of the total acreage of farmland. Primarily, soils of Danubian Lowland, Danubian Hilly Land, and southwest part of Chvojnická Hilly Land are included. The main soil types are Chernozems (45% of the category area), Fluvisols (37%, the largest area covered by subtype Mollic Fluvisols – 20%) and Orthic Luvisols (14%). Soils are texturally medium heavy (73%), deep (99%), without soil skeleton (98%), mostly on the plane (90%).

Figure 1. Very suitable soils for rye growing

The category is located within the climatic region 00 and 01 (30%). Soil fertility, expressed in 100-point scale, is between 76 and 100 points.

Mean yields were on the level 4.21 t/ha. Soils with productivity potential is above 4.01 t/ha were included into this category. The assumption of rational rye sowing on ploughed land in this category is up to 28%. According to the typological production categorization of farmland, first five soil production categories (O1 to O5) belong to this category. By rye growing, profit above 3 500 SKK/ha and profitability rate above 27% can be attained. Bio-energy produced by rye ranges from 63 to 70 GJ/ha (Figure 1).

Soil category "suitable soils" includes approximately 23% of Slovak farmland. Geographically, majority of these areas belong to South-Slovak Basin, Košice Basin, East-Slovak Lowland and marginal parts of Danubian Hilly Land. Dominant soil types are Fluvisols (44%, Mollic Fluvisols cover 13%) and Luvisols (23%). As for texture, soils are from medium heavy (63%) to heavy (21%), without soil skeleton (88%), deep (97%), on plane (62%) to medium slopes up to 7° (28%). The region is identical with climatic regions 00 to 05 (the highest proportion belongs to the region 01 – 24%). Soil point value range is 46–75 points.

Potential rye yields in the region were on the level 3.53–4.00 t/ha, with mean yield 3.77 t/ha. In the cropping system structure, rye can reach up to 22%. According to the typological-production Slovak soils division, the categories located here were identified as high productive arable land to low productive fields (O2 to OT3). The profit obtained by this crop can be assumed in the level 2 077–3 509 SKK/ha and profitability rate is presupposed within 23–27%. Rye generates 56–63 GJ/ha energy (Figure 2).

Soil category "low suitable" covers approximately 24% of Slovak farmland. It consists of Borská Lowland, Basin of Turiec, marginal parts of the Southslovakian Basin, parts of Subtatran Basin, Ondavská Highland, surroundings of Slánske Mountains and southern part of Vihorlatské Mountains. Dominating soil representatives are Cambisols (56%) and Dystric Planosols (28%). Texturally the soils are ranging from medium heavy (74%) to heavy (18%), from deep soils (62%) to medium deep (38%), with various stoniness, located on plane (21%), slopes 3–7° (39 %), and slopes 7–12° (40%). In this category, climatic regions from 05 to 10 (77% soils) dominate. The soils point value range is 18–45 points.

Rye per hectare yields were ranging 3.11–3.51 t/ha. Mean yield is 3.36 t/ha. Categories of productive arable land to low productive fields (O4 to OT3) can be found here according to the typological production division of Slovak soils. Rye growing economic parameters in this category are the following: presupposed profit is under 2 077 SKK/ha, and profitability rate up to 23%. 1 ha of rye produces 49 to 56 GJ of energy (Figure 3).

Soil category "non suitable" is spread approximately on 32% of Slovak farmland area. From the geographic point of view, it includes particularly Fatra-Tatry region, Eastern Beskyde, Levoča Mountains and Matransko-Slansky and Vihorlatko-Gutinský regions. From the pedological view, soil on slopes above 12°, light soils, as well as heavy, extremely acid, water-logged soils with non beneficial physical and

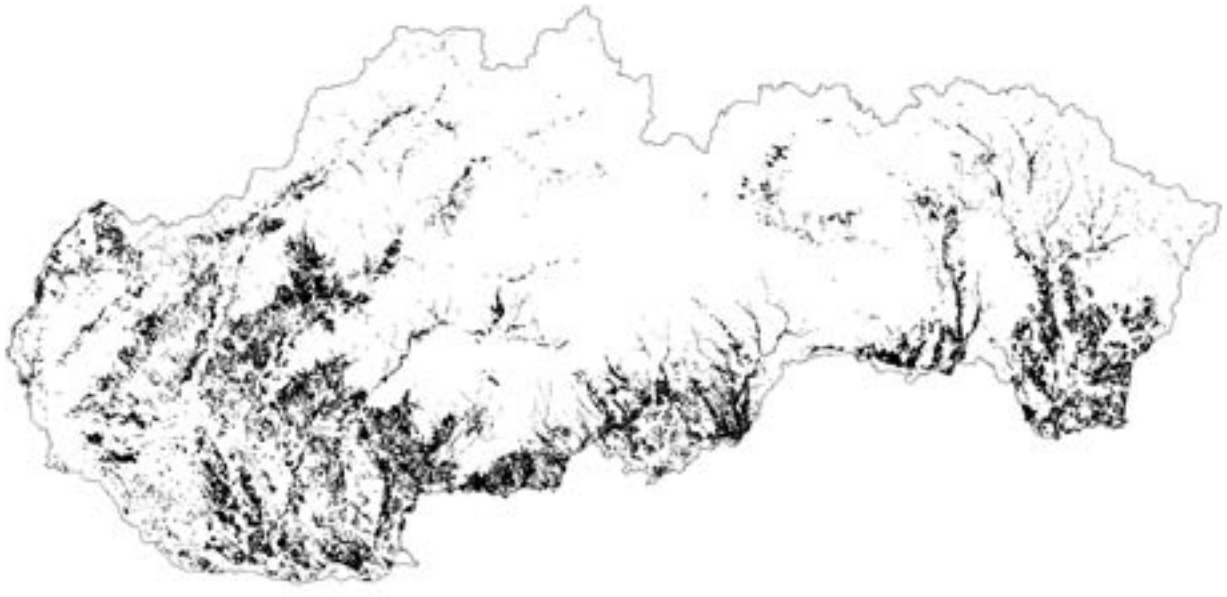

Figure 2. Suitable soils for rye growing

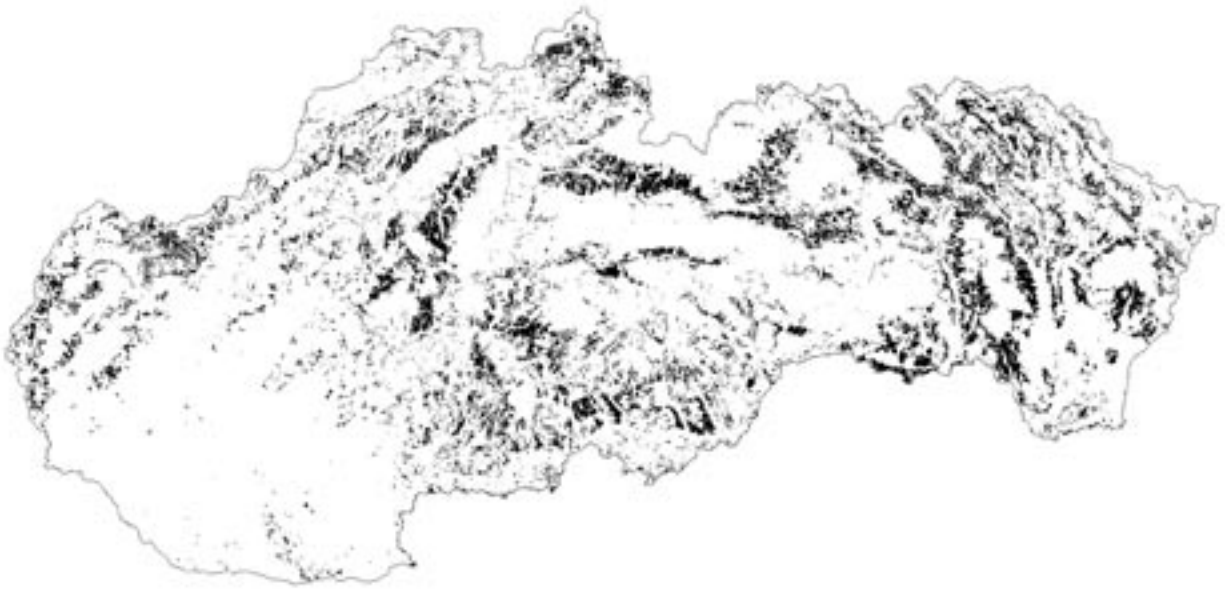

Figure 3. Less suitable soils for rye growing

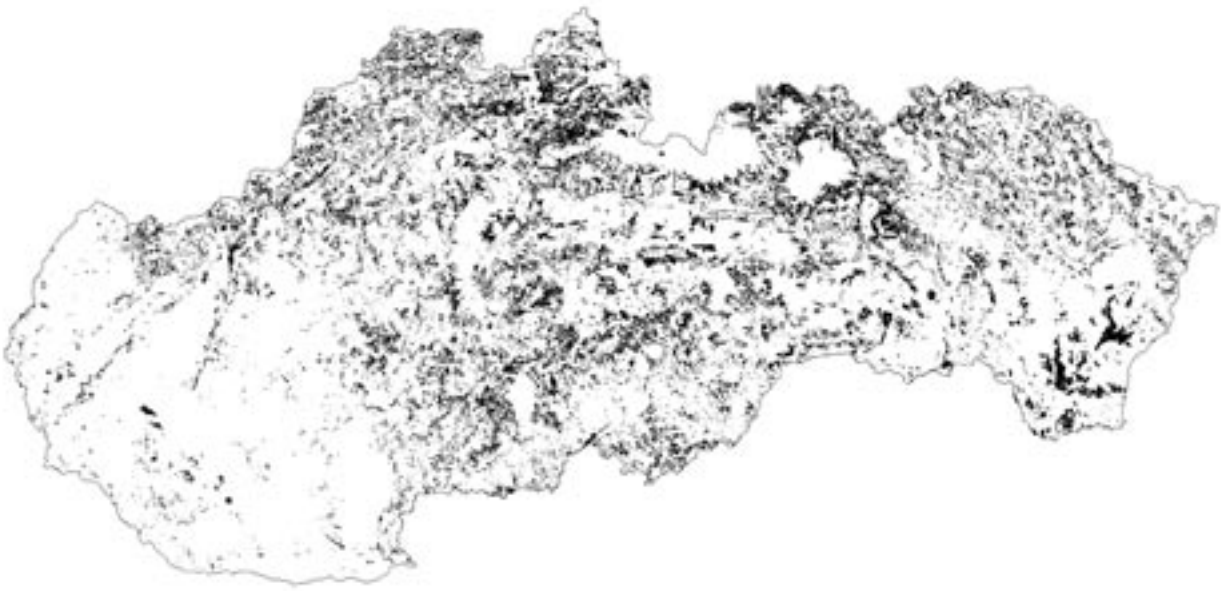

Figure 4. Soils non suitable for rye growing

chemical properties can be found here. Dominant soil types are Cambisols (65%), Rendzinas (11%), Haplic Gleysols (7%) and Fluvisols (5%). Texturally the soils are medium heavy (77%), with high content of soil skeleton (74%), shallow (74%), on slopes 12–17° (35%), on steep slopes above 17° (24%). Absolutely dominating are climatic regions 07 to 10 (73%). The soil point value is lower then 18 points.

The per hectare yield level of soils in this category is lower than 3.10 t/ha. Rye should not occur in cropping system structure on arable land of this category. According to the typological production categorization of Slovak soils, dominating are soils suitable more or less only for use as permanent grasslands and partially also alternating fields (categories OT and T). In the mentioned regions rye growing is associated with losses, and thus it is not profitable (Figure 4).

CONCLUSION

In comparison with other previously formulated territorial division systems of production regions and zones in Slovakia, this alternative brings a more

detailed analysis of pedo-climatic conditions of territory (based on BSEU basic mapping unit) and it associates economical and energetic aspects of the crop growing. Substantial is that the system enables the possible detailed area identification of the given category for any region of Slovakia by GIS help. It is obvious that in the territory identified by this method, further analysis is possible by using other supplementary parameters. Thus, the method is an open system that does not identify sharp borders of each category, but it creates them more or less mosaic-like based on particular conditions of the crop and site, respectively.

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