# WINTER WHEAT GROWING POTENTIAL IN SLOVAK RURAL LANDSCAPE

*(Triticum aestivum L.)*

***Jozef VILČEK*[1]**

***Abstract:*** *By computing techniques development, particularly by application of Geographic Information Systems was today enabled that based on existing soil databases as well as innovated databases on soil characteristics it is possible to quantify and mark off categories of soil suitability important for crop growing. The aim of this paper was to show just such methods on winter wheat (Triticum aestivum L.) example.*

*The work objective is to differentiate rural landscape of Slovakia with aspect to the possibility of effective winter wheat 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 these crop biological and agrotechnical requirement has been considered. Wheat requirement was elaborated in yield databases using the software filters so the given site property either excluded wheat growing or limited it; this was reflected in predicted production height. The prediction was subsequently interpolated into four suitability categories: soils not suitable for wheat growing, less suitable soils, suitable soils, and very suitable soils.*

*The database was formed subsequently and each of the Bonity Pedo-Ecological Unit (BPEU) was added in it as well as particular category of suitability for wheat growing. By mediation of the Geographic Information System on BPEU distribution in Slovakia the Map of Soil Suitability Categories Distribution for wheat growing was also generated. There is 29% of farmland very suitable for wheat growing, 25% suitable, 9% less suitable and 37% non suitable soils for wheat growing by our calculation in Slovakia. From potentially arable soils, proportion of the regions according to suitability of winter wheat growing is 42% very suitable, 37% suitable, 14% less suitable and 7% non suitable. These categories are in the paper characterized in details and specified from the view of geographic, soil, climatic, production, economic and energetic parameters, respectively.*

***Key words:*** *winter wheat; winter wheat growing soil suitability, agricultural landscape categorization*

## INTRODUCTION

Wheat belongs among the oldest traditional agricultural crop-plants. According to the well-preserved records predecessor of present wheat was grown in the 8th to 10th millenium BC in Asia Minor and Southwest Asia. It has been grown since the 5th century AD in our region. Summer wheat, winter sort is the widest spread agricultural crop-plant in

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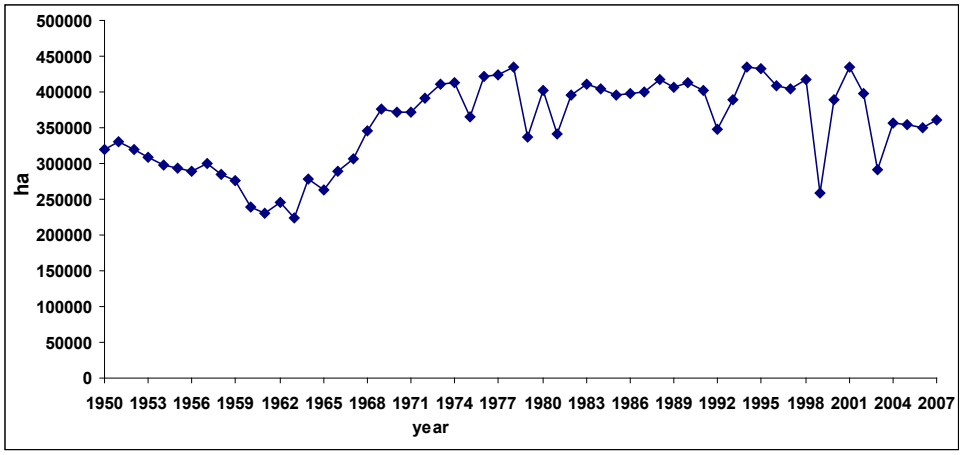
Slovakia at present. It is grown at the acreage of 365 000 hectares in the average of the last years. It is grown practically in all regions from lowlands to mountain areas. The success of its growing depends, similarly to other crops, mainly on climatic and soil conditions of the countryside. These factors influence in the critical way productive and economic presumptions of this crop. It is sown at 30 thousand hectares in Levice and Nové Zámky district, at over 20 thosand hectares in Komárno and Dunajská Streda district, and over10 thousand hectares in Nitra, Trnava, Košice, Galanta, Trebišov, Michalovce and Rimavská Sobota districts. The smallest areas of this crop are in Kysucké Nové Mesto district (less than 100 hectares).

During last 55 years the biggest amount of wheat was grown in 1994 (435 thousand hectares) and the least amount in 1963 (224 thousand hectares).

**Fig. 1** *Development of winter wheat area sown in Slovak Republic (1950-2007)*

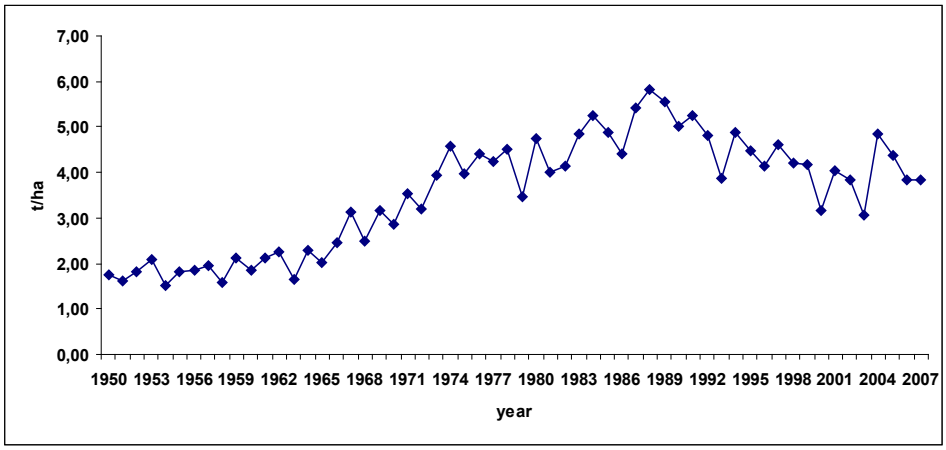



Source: Statistical Office of the Slovak Republic

Attained winter wheat yields are at the level of 4.03 tons per hectare in averages during the last ten years. The highest yields (over 5 tons per hectare) are in Piešťany, Topoľčany and Partizánske districts. Average over 4.5 tons per hectare is noticed in Nitra, Trnava, Bánovce nad Bebravou, Dunajská Streda and Šaľa districts. Long-termed low yields (in average under 2 tons per hectare) are in Medzilaborce and Svidník districts.

During last 55 years the highest winter wheat was in 1988 (5.81 tons per hectare) and the lowest in 1954 (1.51 tons per hectare).

**Fig. 2** *Development of winter wheat hectare yields in Slovak Republic (1950-2007)*




Source: Statistical Office of the Slovak Republic

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

**MATERIALS AND METHODS**

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

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

The dependence of studied indicators on soil production potential in analyzed farms (expressed by average point value in 100-point scale) was tested by non-linear polynomial regression analysis. Subsequently, potentially possible yield of winter wheat, its share in cropping system as well as potential economical parameters (yields, costs, profit, or loss) were calculated using the regression equations for each of the BPEU and added to database. Soil rate of suitability for winter wheat growing was differentiated and qualified using the Geographic Information System ARC INFO, based on vector bonity maps (scale

1:5000) and area distribution of 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 Pedo-Ecological Unit (BPEU) 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 winter wheat yields, their economic parameters (receipts, yields and costs) and real cropping system structure of arable land,
- energetic equivalents for winter wheat 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 arable 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**

Productive potential of our soils for winter wheat growing is used only at 75.6% nowadays. There are significant reserves in the correct placement of this crop according to the most suitable conditions for its growing. It is logical that winter wheat growing successfulness is influenced by many other factors, which varies in space and time. To detach suitable zones there is a problem to respect for e.g. recent soil reaction (pH). It is well known, that the optimal soil reaction for wheat is 6.6–7.2. It is not recommended to grow wheat withtout lime treatment when pH reaction is lower than 5.5. Genetically acid soils are intergrated among the less suitable categories for wheat growing.

The similar approach is used for typing light soils. Wheat demands concerning soil-climatic factors result from its superficial root system (most part of roots occurs in the depth to 0.25 m). Regarding to the moisture needs, light, easy dried soils are not suitable for its growing.

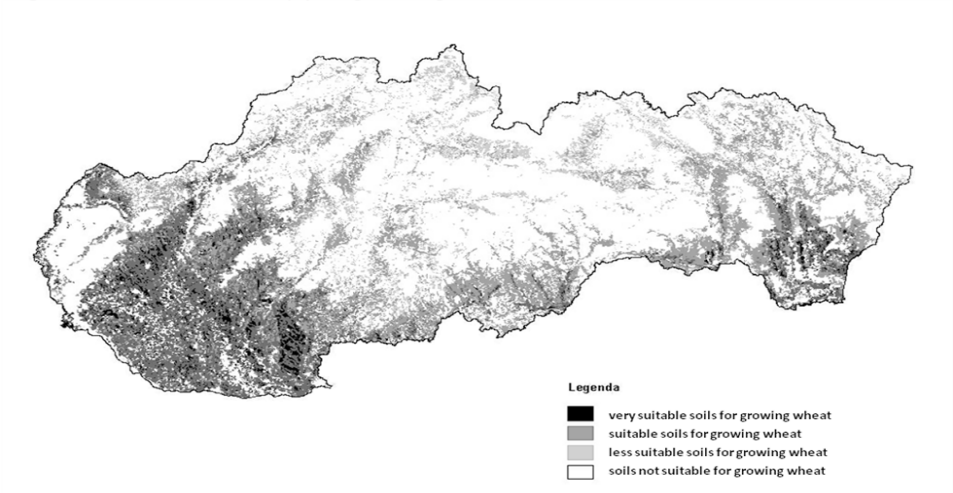
Analyzing the individual soil parameters in regard to wheat productive ability it can be followed that in mild slopes (to 7°) cropable potential is reduced in comparison to plain lands in 9.2% and in middle slopes even in 13.5%. There is an assumption that

middle eroded soils yields are decreased in 16.4%, strongly eroded soils in 20.4% and very strongly eroded soils even in 26.8%. There is a significant decrease of wheat production due to deteriorating climatic conditions. For example, in a very cold moist climatic region the wheat crop potential is lower in 32.0% in comparison to a very warm and very dry region. If the soil quality would be expressed using 100-point scale (100 points the most –productive Mollic Fluvisols), it can be stated that zero value of wheat growing profitability is at the soil value 18.53 points.

The economical effectivity analysis of wheat growing according to the soil representants shows at present that it is possible to produce 165 € profit from one hectare of this crop in Chernozems, in Mollic Fluvisols 145 €, in Fluvisol**s** and Calcic Luvisols it is 117 € , Albic Luvisols 78 €, Distric Planosols 55 €, Cambisols 48 €..

On the basis of available pedological facts and databasis four regions suitable for wheat growing were determinated by the inductive method. Spacial dislocation of this regions is presented in the following picture.

**Fig. 3** *Farm suitability for growing winter wheat*




Source: author

## RURAL COUNTRY CHARACTERISTICS WITH REGARDS TO WINTER WHEAT GROWING SUITABILITY

### Region of very suitable soils

This region covers about 28.7% of all agricultural soils.It represents about 42% of potentially arable soils. There are soils in Podunajská lowland, Chvojnická highlands and Východoslovenská plain. According to the soil types there are chernozems, mollic fluvisols, brown earth, and fluvisols, which are medium heavy, deep and without soil skeleton. They can be found in warm to the very warm, dry to the very dry climatic region with continental type of weather.

Highly productive to productive arable soils were included into this region (soil point value 63-100 points),which winter wheat production potential is higher than 5.03 tons

per hectare and presumption of wheat seeding on the arable soil presents 21.7–32.3%. According to the typological-production soil categorization there are first four productive soils categories (O1–O4). It is possible to reach profit over 93 € per hectare and profitability rate higher than 25% by growing wheat. Bioenergy which is produced by photosynthesis and occurs in wheat grain reaches value equal to 80–96 GJ per hectare.

**Region of suitable soils**

This region covers about 25.4% of agricultural soils in Slovakia. It represents about 37% of potentially arable soils. Geografically it is presented by Chvojnická highlands, Myjavská highlands, north-eastern part of Podunajskej highlands, Juhoslovenská fold, Hornonitrianska fold, Košická fold, Východoslovenská highlands and Ondavská uplands. Dominant soil types there are fluvisols, brown earth, cambisols, pseudogleys and medium heavy regosols. Soil point value occurs in the range 33-62 points. There are mostly soils medium heavy to the heavy, without soil skeleton to the slightly skeletal, deep, situated in the plains to the slight slopes. This area is represented by the climatic regions 00 to the 07 (very warm and very dry to the mild warm and mild humid), the region 05 with quite warm and dry weather is the largest.

Winter wheat production potential presents 4.04–5.00 tons per hectare, and concerning the seeding structure in the arable soil it presents 10.6–31.6%. According to the Slovak typological-production soil categorization there are included very productive arable soils to the little productive fields (O3 to OT3). It is possible to reach profit 63-93 € per hectare and profitability rate 20- 25% by growing wheat. Bioenergy which is produced by photosynthesis and occurs in wheat grain reaches value equal to 65 - 80 GJ per hectare.

**Region of less suitable soils**

This region covers about 9.2% of agricultural soils and 14% of potentially arable soils in Slovakia.There are marginal parts of Turčianska fold, Ždiar fold, Žilina fold, Podbeskydská highlands, Oravská fold, Liptovská fold, Popradská fold, Hornádska fold and Spišsko-Šarišské intermontane. Cambisols predominate there as soil representant and mostly stagnicambisols. There is a significant occurence of pseudogleys and rendzina. Soil point value occurs in the range 18-32 points There are soils medium heavy to the heavy, mostly medium deep, medium in the less and more steep slopes. Absolutelly dominant are the climatic regions 07 up to 10 (mild warm and mild humid to very cold and humid), which take 87% of the category.

Winter wheat yields per hectare reach 3.44–4.00 ton per hectare. According to the Slovak typological-production soil categorization there are included medium productive arable soils to little productive fields (O5 to OT3), where supposed profit is to 63 € per hectare and profitability rate is to 20% by growing wheat. Bioenergy which is produced by photosynthesis and occurs in wheat grain reaches value equal to 55 - 65 GJ per hectare.

**Region of non suitable soils**

Soils which are non suitable for winter wheat growing take about 36.7% of agricultural soils and 7% potentially arable soils in Slovakia. They occur mostly in the northern and middle part of Slovakia. Regarding pedological point of view there is a great variety of soil types, light, extremely heavy, acid, sloppy with unfavourable physical and chemical

characteristics. Cambizems, rendzina, fluvisols and gleys are predominant soil types here. In term of granularity, medium heavy, strongly skeletal, shallow soils occuring in steep and very steep hills are predominant. Similarly to the previous region, climatic regions 07 to 10 are absolutelly dominant.

Winter wheat yields per hectare does not reach 3.44 tons per hectare in the long term, so it should not occur in seeding structure. These soils are mostly suitablefor permanent grass overgrow (typological-production soil categorization OT and T). Point value of the soil usually does not reach 18 points. Regarding economic point of view winter wheat growing is lossy there.

**CONCLUSIONS**

In the paper presented soil categorization for winter wheat growing suitability brings more detailed analysis of the territory pedo-climatic conditions (based on BPEJ basic mapping unit) and it associates economical and energetic aspects of the crop growing. Substantial is that the system enables possible detailed area identification of given category for any region of Slovakia by GIS help. It is obvious that in 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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## POTENCIÁL AGRÁRNEJ KRAJINY SLOVENSKA NA PESTOVANIE PŠENICE LETNEJ FORMY OZIMNEJ

*(Triticum aestivum* L.*)*

*Zhrnutie*

Pri kategorizácii poľnohospodárskej krajiny podľa vhodnosti pre pestovanie pšenice letnej f. ozimnej sa zohľadňovali korelačné vzťahy medzi vlastnosťami stanovišťa (pôd, klímy) a biologickými i agrotechnickými požiadavkami tejto plodiny. Požiadavky pšenice boli zapracované pomocou softwarových filtrov tak, že daná vlastnosť stanovišťa buď pestovanie pšenice vylučovala, resp. ju obmedzovala, čo sa odrazilo na výške predpokladanej produkcie. Táto bola následne interpolovaná do štyroch oblasti vhodnosti pôdy pre pestovanie pšenice - 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 pšenice. Prostredníctvom geografického informačného systému o rozšírení BPEJ na Slovensku potom bolo možné vytvoriť aj mapu priestorového rozšírenia kategórii vhodnosti pôd pre pestovanie pšenice.

Z výsledkov vyplýva, že na Slovensku je 29 % poľnohospodárskych pôd pre pestovanie pšenice veľmi vhodných, 25 % vhodných, 9 % málo vhodných a 37 % nevhodných. Z potenciálne orateľných pôd zaberá oblasť pre pestovanie pšenice veľmi vhodná 42 %, vhodná 37 %, málo vhodná 14 % a nevhodná 7 %. Tieto oblasti sú v príspevku charakterizované z hľadiska pôdno-klimatických i produkčno-ekonomických parametrov.

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