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ASSESSMENT OF THE PRODUCTIVE CAPACITY OF AGRICULTURAL LANDS FOR THEIR SUSTAINABLE USE

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Abstract

The purpose of the paper was to assess the production capacity of the lands in Periam, Timiș County, in wheat, barley, corn, and sunflower. We chose 17 more important and better determining indicators and, based on them, we established, for each crop, the credit ratings, after which we classified the soils in the studied area into fertility classes. In accordance with the methodology for developing pedological studies, the degree of suitability was determined for each of the four crops: 91.73% of the area of this locality is represented by agricultural land, of which arable land represents 79.22%. and 0.41% is forested land. Following the evaluation of arable land (4,663 ha), it was found that 45.38% fall into the first class, 33.63% in Class II, 20.10% in Class III, and 0.89% in Class IV, with an average grade of 75. This makes these lands highly productive. As a general conclusion, each farmer should periodically evaluate the fertility of the farm soils, make a balance of the nutrient requirements for each crop by considering the plants' requirements according to the vegetation phase, the technology applied, the local soil land climate conditions based on realistic forecasts. In this way, a series of costs with fertilizers and soil work are reduced, the excess is eliminated, and the deficiency of nutrients is corrected, the recommended doses are fractionated and applied differently depending on the needs of the plant, the humidity, the reaction and the texture of the soil. Following the results obtained, it appears that these lands have a high production capacity.

Key words: *assessment of agricultural land, sustainable use, soil, Periam*

INTRODUCTION

The assessment of agricultural land is one of the most important activities, participating in increasing production and planning a sustainable agricultural system, able to adapt to all pedological and climatic conditions in the area, considering the continuous increase in population and the continuous need for food. The four crops chosen are essential and represent a basic food source for humans and animals [3, 4, 5, 15]. The production of these staple crops influences local and national food security [16].

After Țărău et al. (2002), the evaluation of agricultural land is an essential activity centred on land management, being one of the areas of major importance, increasingly appreciated in the recent period both nationally and globally, in the conditions of the transition to a functional market economy [2, 7, 9,].

Thus, the scope of this field is considerably widened, social-economic fields of sustainability also being considered [1, 8, 17], along with two new categories represented by technological aspects (FAO, 1970) and by aspects related to the conservation of resources land and environment (FAO, 1993).

In the field of land evaluation, remarkable research was carried out in our country by great Romanian soil science specialists [6, 7, 11, 12].

Adequate land evaluation is a method that identifies the factors that limit the cultivation of certain plants in a certain area or on certain types of soil [1, 2, 14]. This type of land evaluation includes a qualitative and a quantitative evaluation [16, 17]. Following the qualitative assessment, a series of information related to climate, hydrology, geology, vegetation, and soil properties are considered [13, 18]; in the quantitative assessment, the results obtained are much more detailed and they generally refer to the estimated yield [10, 9]. The FAO land assessment framework [7, 8] and physical land assessment methods [13] have been widely used for assessing land suitability.

In this context, the goal of this research is to assess the productive capacity of the lands in Periam, Timiş County, Romania, for wheat, barley, maize, and sunflower crops, to establish credit ratings and to classify them into fertility classes for each type of soil from the seven types identified.

MATERIALS AND METHODS

Site description

The studied area is in the western part of Romania, in Timiş County (Map 1).

From a geographical point of view, the research territory is part of the Torontal Plain, a component of the Western Plain. Among the main processes encountered there are meanders and floods with alluvium and drifts because of the reduced slope and subsistence process. The plain of the locality is crossed by the Aranca and Galaţca rivers, which are old courses of the Mureş River [3].

Due to its geographical loation, the climate of Periam commune belongs to the moderate continental type with ocean and Mediterranean influences, the Sânnicolau-Mare topoclimate characterized by a steppe climate. From an agricultural point of view, this climate is favourable for plants that need higher temperatures; the number of days corresponding to the vegetation period (temperatures above 5ºC) is 180-200 days. The average amount of precipitation is 550 mm annually, and the number of rainy days is less than 110 days/year. Also, the amount of precipitation during the summer is 27%, and dry periods are more frequent than in the rest of the plain. [1, 15, 19]. The number of days with snow cover is below 30.

From a hydrographic point of view, the Aranca and Galaţca rivers are used as irrigation canals. Analysing the situation from a geological point of view, there are permeable formations that can contain aquifer layers [9, 18]. Following the studies carried out, two types of aquifer horizons were highlighted: a phreatic aquifer layer and an aquifer layer under pressure. Between these layers, thick impermeable formations (clays and marls of various types) are interspersed. Groundwater is found at different depths [11, 19].

Map 1. Map of Romania, Timiş county AND Timiş rivers
Source: https://ro.wikipedia.org/wiki/Comuna_Periam,_Timi%C8%99 [20].

The research was carried out in the outskirts of Periam, where 35 soil profiles were excavated.

To reach the proposed objectives, soil analyses were carried out, and the following physical and chemical properties were determined:

- Soil texture, by the Cernikova method (the principle underlying this pipetting method is the sedimentation of the particles in a liquid at different speeds depending on the diameter according to Stokes' law);
- Soil density (cm^3) was measured in the laboratory (using a pycnometer and distilled water);
- Soil apparent density (cm^3) was measured on the ground (in natural settlement), using cylinders;
- Total porosity (%), by calculus;
- Aeration porosity (%), by calculus using the values of some hydro physical and physical indices;
- Determining the humus content of the soil (%) by titrimetric methods, respectively the Tiurin method. The principle of this method consists in the oxidation of C in the humus, using a solution of chromic anhydride (or

potassium bichromate) in the presence of sulfuric acid;
- The reaction of the soil was determined potentiometrically (with the help of an electrode that was inserted into a solution with a ratio of 1:2.5);
- Total nitrogen was determined by the Kjeldhal method;
- Mobile phosphorus was determined by the Egner-Rhiem-Domingo method (using a UV-VIS spectrophotometer);
- Assailable potassium was determined using an atomic absorption spectrophotometer;
- Total cationic exchange capacity, by the Bower method;
- Degree of saturation in bases (V%), by calculus.

Calculus of credit scores

To assess the agricultural land in Periam, from the totality of the environmental conditions, 17 more important and better-established indicators were chosen. [10, 11].

Based on them and on the value scales, rating coefficients were extracted from the tables, annexes 3-1 to 3-18 (according to the methodology for the development of soil studies, part II), which express the degree of suitability of an indicator for the four crops and for the category of agricultural use.

The results obtained depending on the type of soil and on the crop (wheat, barley, corn, sunflower) are extensively presented, both in tabular and graphical form, considering the physical and chemical soil properties, climatic conditions, groundwater, or other factors that limit their fertility. For each indicator, depending on its scale of use or crop, tables were compiled with the values of the respective coefficients.

Classification of agricultural land into quality classes

Currently in Romania, the assessment of the quality of agricultural land is done according to Law no. 16/1994, which considers the existing credit rating works in the I.C.P.A. or O.J.S.P.A. archives. According to this methodology, the production potential of the land is classified – depending on the soil, relief, climate, groundwater, natural rating for arable land – into 5 quality classes.

The methodology for assigning agricultural land to the quality class is unique, and the competent bodies are the Research Institute for Soil Science and Agrochemistry and the County Offices for Soil Science and Agrochemical Studies. According to the credit rating methodology existing in our country, the most productive land can reach a maximum of 100 ratings in Romania's natural conditions, except for irrigated land in the warm areas of the country, which can accumulate up to 150-160 credit ratings (after potentiation for irrigation).

RESULTS AND DISCUSSIONS

The new context caused by both the war in Ukraine and the economic situation in our country, needs considering a periodic inventory of agricultural land, taking measures leading to higher yields, cultivating varieties and hybrids to adapt as best as possible to the pedoclimatic conditions in this area, reducing the expenses necessary for the establishment and maintenance of crops through the identification and real evaluation of each type of soil based physico-chemical analyses. All this will help us make the best choice regarding the assortment of crops, cultivated areas, and rotation and fertilization plans according to the estimation of the level of the planned harvests.

The first preliminary studies carried out in this area by a part of the team took place in 2018, and the data presented in this paper will be supplemented in terms of the evaluation of agricultural land for the arable category, considering the soil and climate conditions from 2020-2022, of the calculus of credit ratings, and of the classification into quality classes for the four basic crops (wheat, barley, maize, and sunflower) [19].

The evaluation of agricultural lands is a complex operation that is carried out periodically (once every 4-5 years) involving the establishment and characterization of the natural conditions, of the technologies used for each crop according to the suitability of the soils for certain crops and ways of use.

From a geomorphological point of view, the studied area is part of the plain area whose altitude is 90 m and which is formed on parental materials represented mostly by loess and clays, which, depending on the height, includes two steps: one formed from higher lands, and a lower one, permanently subjected to flooding, which led to the formation of different soils (Table 1).

Table 1. Soil types and areas covered (ha and %)

Soil type	Area	
	ha	%
Psamosoil	47	0.80
Alluviosoil	265	4.50
Chernozem	3,905	66.34
Eutricambosoil	805	13.67
Vertosoil	12	0.20
Gleysoil	132	2.24
Stagnosoil	39	0.65
Soil associations	681	11.60
TOTAL	5,886	100

Source: Own calculation.

The largest areas are occupied by chernozems, with 3,905 ha, respectively over 66%, followed by eutricambosoils with 13.67%. In the higher areas, eutricambosoils and vertosoils appear, and in the lower areas, alluviosoils, gleysoils and stagnosoils, along with soil associations, including solonetz.

Chernozem. It is the most important soil, both by the large areas it occupies within the studied territory, and by its fertility. Physical and chemical properties are favourable for the cultivation of all four crops: wheat, barley, maize, and sunflower.

The texture of the chernozem is loamy-sandy throughout the profile.

Soil reaction (pH) is weakly alkaline with values in the Am horizon of 7.34, in the A/C horizon the value increases to 7.65, and at the basis of the profile, the pH is 8.04.

Calcium carbonate ($CaCO3$) is extremely small, with values in the Am horizon of 0.56, in the A/C horizon with values of 2.43, and in the Cca horizon with values of 4.66%.

Humus content is medium with values between 2.07 and 1.02%.

Humus reserve has the value of 318.19 t/ha.

The content of phosphorus is low, in the Am horizon the value of 15.6 decreasing towards the A/C horizon to 13.2, and in the Cca horizon to the value of 12.4 ppm.

Potassium content is medium to low, with the following values: in the Am horizon 122, in the A/C horizon 74, and in the Cca horizon, 56 ppm.

The degree of saturation in bases (V%) has the value of 100 over the entire profile, making it a eubasic soil.

For each indicator, depending on its scale of use or culture, tables were compiled with the values of the respective coefficients (Tables 2 and 3).

Table 2. Suitability of soils for wheat and barley

Soil type	Wheat		Barley	
	Credi t rating	Fertility class	Credit rating	Fertility class
Psamosoil	54	III	50	III
Alluviosoil	84	I	82	I
Chernozem	96	I	94	I
Eutricambosoil	56	III	48	III
Vertosoil	42	III	46	III
Gleysoil	38	IV	40	IV
Stagnosoil	24	IV	28	IV

Source: Own calculation.

From the analysis of credit ratings for the crops of grassy cereals (winter wheat and winter barley), a sharp differentiation of the soil units can be observed from the point of view of the conditions that create them for the crop plants. The highest scores are obtained by chernozem, with 96 ratings for the wheat crop and 94 ratings for the barley crop, followed by alluviosoil, with 84 ratings for wheat and 82 ratings for barley respectively, which places them in the best class (fertility class I).

Table 3. Suitability of soils for maize and sunflower

Soil type	Maize		Sunflower	
	Credit rating	Fertility class	Credit rating	Fertility class
Psamosoil	52	III	62	II
Alluviosoil	86	I	90	I
Chernozem	90	I	90	I
Eutricambosoil	56	III	52	III
Vertosoil	38	IV	36	IV
Gleysoil	52	III	48	III
Stagnosoil	28	IV	24	IV

Source: Own calculation.

At the opposite pole, with only 24, respectively 28 ratings, was the stagnosol,

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which fell into the IV fertility class, next to the gleysoil in terms of the two crops.

As for maize, the highest credit ratings (90) are obtained by chernozem, followed by alluviosoil, the two types of soil being included in the 1st fertility class, while vertosoil and stagnosoil were included in the 4th fertility class with only 38 and 28, respectively, ratings for maize.

The sunflower crop, scored close to or even higher than maize, adapts better to soils that benefit from a lot of heat and that are well-structured and aerated soils. The highest score of 90 ratings was obtained by alluviosoil and chernozem, which ranks them 1st in terms of suitability for sunflower, followed by psamosoil with 62 ratings, class II, respectively, while vertosoil and stagnosoil obtained the lowest score, of 36 and 24 ratings, the two types of soil being, thus, classified in the IVth fertility class for both sunflower and maize.

The fertility level of the soils in the town of Periam and their classification into quality classes was also highlighted by the average yields obtained for the four crops (wheat, barley, corn and sunflower) (Table 4 and Fig. 1).

Table 4. Average yields (in kg/ha) of the main crops in Periam commune, depending on soil type

Soil type	Fertility class	Average productions (kg/ha)			
		Wheat	Barley	Maize	Sunflower
Chernozem	I	7,500	8,200	8,000	2,505
Alluviosoil	I	7,300	7,900	7,800	2,360
Psamosoil	III	6,550	6,640	5,950	2,150
Eutricambosoil	III	6,600	6,480	6,550	2,100

Source: Own calculation.

The soil types included in fertility class I were the chernozoms and alluviosols, which obtained the following credit ratings (N.B.): The chernozom, between 86 points for corn and 96 points for wheat and the Alluviosol, between 82 points for barley and 90 points for sunflowers. On these soils, the productions obtained (Table 4) show that chernozem is the most fertile soil in the studied area, a fact reflected by the average productions obtained during the studied period (2020-2022) and which fell between: 7,500 kg/ha in wheat, 8,200 kg/ha in barley, 8,000 kg/ha in maize and 2,505 kg/ha in sunflower, closely followed by Aluviosol with 7,300 kg/ha in wheat, 7,900 kg/ha in barley, 7,800 kg/ha in maize and 2,360 kg/ha in sunflower.

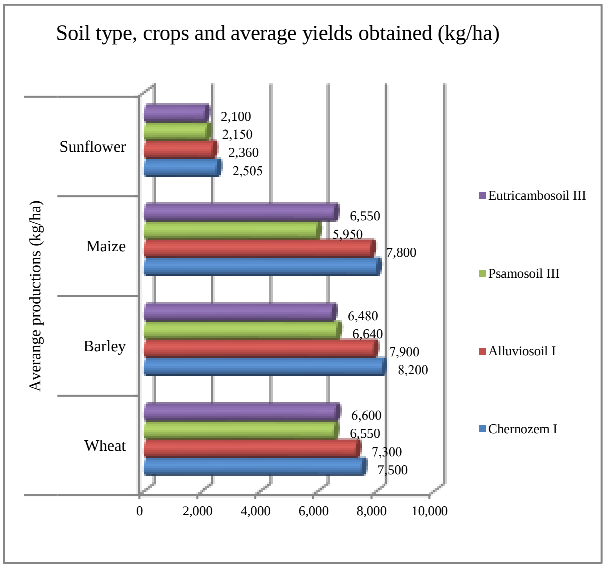

Fig. 1. Soil type, crops and average yields obtained (kg/ha) in Periam
Source: Own calculation.

Psamosols and Eutricambosols were the soils that obtained between 48 and 56 points, being classified in the III-a quality class and whose productions were between 6,550-6,600 kg/ha for wheat, 6,480-6,640 kg/ha in barley, 5,950-6,550 kg/ha in corn and respectively 2,100-2,150 kg/ha la floarea soarelui.

CONCLUSIONS

Within the studied territory, the four crops have the largest share, the cultivated areas being significant, which makes their expansion also take place on soils that have lower fertility and which, by applying soil improving measures, can give yields higher in terms of their production and quality.

From a geomorphological point of view, the studied territory has the form of a loess plain, with slightly irregular shapes, with wide flat horizons, which, due to subsidence, have taken the form of isolated and very shallow depressions.

Geographically, the low plain of Torontal is part of the group of divagation or subsistence plains.

Among the forms and processes often encountered there are strong meanders, floods with alluvium, and ramifications. All this comes from the slope, which is very low, and from the subsistence process. The plain of the locality is crossed by Aranca and Galaţca, which are old courses of the Mureş River.

The idea of fertility normally implies the best biological, physical and chemical properties of the soil, the abundance or existence in high amounts of all the nutrients necessary for plants, together with enough water.

The soils encountered within the studied territory are of the chernozem, psamosol and alluviosol types, i.e., soils with good drainage. Considering all their favourable physical, chemical, and biological properties, these soils have a high natural fertility, which makes them suitable for the four studied crops (wheat, barley, corn, and sunflower). Among them, the largest area (3,905 ha) is covered by chernozems, followed by alluvia on 265 ha. These soil types fall into the 1st fertility class for the four crops.

Gleysoils and stagnosoils appear in depressed areas due to the high level of phreatic waters rich in potassium, or due to the flat relief which, during rainy periods, leads to water stagnation in the first part of the soil profile, which places them in the 3rd class of fertility for wheat and barley and in the 4th fertility class for maize and sunflower, respectively. Gleysols occupy an area of 132 ha and stagnosoils, 39 ha.

Eutricambosoil and vertosoil are 3rd class fertility soils for all four crops studied. The area occupied by vertosoils is very small, 12 ha, while eutricambosoils occupy 805 ha.

Considering the area occupied by these soils, their physical, chemical, and biological properties, as well as their suitability for the four studied crops, the conclusion is that the research territory falls into the category of fertile areas in the western part of Romania and in Timiș County. However, there are some limitations regarding summer temperatures and the lack or uneven distribution of precipitation during the growing season, which limits their fertility and productive potential in certain periods or to certain crops.

To increase the natural fertility of these soils, it is recommended to take the following measures:

- Organic and mineral fertilization, especially on planosol, vertosoils and eutricambosoils;
- Application of lime amendments on vertosoils, gleysoils, and stagnosoils;
- Irrigation during dry periods, especially on chernozems, vertosoils, and planosol;
- Removal of excess moisture (phreatic and stagnant) in the case of gleysoils and stagnosoils;
- Reduction of the degree of subsidence in vertosoils and chernozems, and salinity.

As a general conclusion, each farmer should periodically evaluate the fertility of the farm soils, make a balance of the nutrient requirements for each crop by considering the plants' requirements according to the vegetation phase, the technology applied, the local soi land climate conditions based on realistic forecasts. In this way, a series of costs with fertilizers and soil work are reduced, the excess is eliminated, and the deficiency of nutrients is corrected, the recommended doses are fractionated and applied differently depending on the needs of the plant, on soil texture, reaction, and humidity.

For economic reasons, a correct management of fertilizer application is required. Special attention should be paid to nitrogen-based fertilization, because this element can be lost in the form of nitrates with the water from precipitation or, if applied in large doses, will cause soil acidification.

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