RECOMMENDATIONS FOR THE IMPROVEMENT OF THE CONSERVATION TECHNOLOGY OF SPRING CEREALS IN THE TRANSYLVANIAN PLATEAU

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Abstract. In the hilly area of the Transylvanian Plateau, due to the non-application of specific cultivation technologies, the failure to comply with the requirements to combat limiting phenomena and factors, in particular soil erosion, coupled on the other hand with the lack of means of production, the non-existence of technologically adequate agricultural machinery systems, but also insufficient in terms of quantity, modest levels of production have been obtained in recent years. The evolution of soils in the Transylvanian Plateau is influenced by a combination of natural and anthropogenic factors. The natural factors are climate - in particular precipitation, wind, drought and relief. The soil is vulnerable to the climate because heavy rainfall washes away the soil, causing it to lose its fertile qualities; anything washed away by rainfall affects lakes, settlements and communication routes. The list of anthropogenic factors is longer and includes: inappropriate agricultural technologies, urban aggression and the social component, which includes an ageing population, lack of interest in the countryside among young people, low prices for agricultural products, lack of infrastructure and deforestation. The specific conditions of the Transylvanian Plateau make it necessary for spring cereals to opt for varieties that are well adapted to the specific climate, characterized by relatively short and cool summers and cold springs. Varieties with resistance to foliar diseases and drought conditions are recommended as they can reduce yield losses. Varieties that ensure harvest before the onset of summer drought are preferred. Direct seeding allows spring cereals to be sown without disturbing the topsoil. This reduces soil compaction and helps maintain moisture. Conservation tillage is a viable solution for growing spring cereals with a positive impact on the soil and the environment. It can contribute significantly to a more sustainable farming system, conserving natural resources and reducing long-term production costs. Adapting farmers to these methods can bring considerable long-term economic and environmental benefits.

Keywords: *Transylvanian Plateau, soil, technology, conservation agriculture, spring cereals.*

INTRODUCTION

Adapting soil tillage and crop plants to areas where conventional, intensive agriculture caused over the years, the decrease of soil fertility and its degradation is of enormous agronomic and economic importance (Chețan et al., 2021; Calistru et al., 2024). Cereals represent the basis of the agri-food industry that supplies food to the global population (Oprea et al., 2023). A vital part for supporting life on Earth is soil, a limited and non-renewable resource. It serves as the cornerstone of agricultural production, supplying vital nutrients, storing water, and giving support for plant growth. In addition, soil supports a variety of creatures, promotes biodiversity, and isessential for controlling the cycles of nutrients and water (Nilabh et al., 2023).

Nowadays, people have come to understand that agriculture should not only be high yielding, but also sustainable (Reynolds and Borlaug, 2006). Deforestation coupled with anthropogenic pressure on soil ecosystem and climate change has led to dramatic changes in the sustainability of the soil. Researchers are highly focussed towards climate resilient agriculture, regenerative agriculture, natural farming, resource conservation technology, use of latest tools and techniques for soil quality assessment etc for soil health improvementand sustainable agriculture (Kumar et al., 2022).

To improve soil quality, fertility, and general soil conservation, these methods entail the adoption of specific strategies including conservation tillage, crop rotation, cover crops, mulching, contour farming, terracing, and windbreaks (FAO, 2020; Nilabh et al., 2023). Average production per surface unit depends on many factors, the main ones being: cereal type, variety, soil type, fertility and water reserve capacity, availability of irrigations or not, applied technologies and climate favorability (Popescu et al., 2022). Regenerative agriculture is an approach to farming pursued globally for sustaining agricultural production and improving ecosystem services and environmental benefits. An initial systematic review revealed a wide range of definitions for regenerative agriculture, although it is generally understood as a framework consisting of principles, practices, or outcomes aimed at improving soil health, biodiversity, climate resilience, and ecosystem function (Sadeeka et al., 2023). In order to produce agri-food products in a sustainable way, a new and pro-environmental farmer attitude to soil is of key importance. In a situation of significant degradation of agricultural land as a result of the spread of intensive farming, there has been growing interest in regenerative agriculture (Dudek and Rosa, 2023).

Intensive tillage, non-diversified crop rotations and reduction in the return of organic residues to soil imply decreasing levels of soil organic carbon (Schjonning, 2023). Straw, particularly cereal straw, is a valuable by-product of crop production, which can be used for various purposes, e.g. as livestock feed and bedding or for making fuels, however it should primarily be retained on farmland in order to prevent soil organic matter losses and thus to maintain or improve soil quality (Smagacz et al., 2023).

The aim of this paper is to evaluate the existing resources in the Transylvanian Plateau and to specify some conservative technological measures for the spring cereal crops in the development of a conservative agriculture. This analysis is required both by the situation in the field, i.e. the acceleration of soil degradation phenomena, the accentuation of climate change in this area, and by the evolution of the principles and objectives pursued in regenerative agriculture.

MATERIALS AND METHODS

Assessment of the Transylvanian Plateau resources needed for regenerative agriculture involves analysis of soil, climate, social and economic factors.

The soil assessment focused on identifying the physical and chemical characteristics essential for agriculture, such as texture, structure, fertility and erosion. This can help to identify areas with higher agricultural potential and to adapt soil management.

Climate is a key factor for agriculture and its analysis focuses on the assessment of temperature, precipitation and other climatic parameters. This assessment is

important to determine how well the soil can receive water and sustain the crop during periods of drought.

Social resources are important in determining a community's capacity to sustain agriculture. Analyzing the population's access to agricultural knowledge and training is crucial to assess their readiness to apply modern agricultural technologies.

Economic assessment allows determining the viability of agricultural activities by analyzing economic resources at local and regional levels.

By combining these methods and means of assessment, it is possible to develop a complex picture of agricultural potential in the Transylvanian Plateau. This assessment helps farmers and authorities to understand how they can optimize the use of natural resources, anticipate risks and implement sustainable management measures.

RESULTS AND DISCUSSIONS

The evolution trend of the agricultural areas in the researched area is presented by exemplification at the Cluj county level (Table 1). From this point of view, of the structure of the agricultural surface, it should be noted that the particularities of the hilly area of Cluj county and the support of the trends of land use categories change, by increasing the areas occupied by forests, pastures and meadows at the expense of arable land on poorly fertile soils and high slopes, may improve their conservation.

Table 1. The dynamics of agricultural areas between 1989-1997-2018 in Cluj county

Land use	1989	1997	2018	Trend (±)
	ha			
Agricultural area, of which:	424377	416127	432835	+
Arable	202163	180906	182570	-
Pasture	146399	149298	152206	+
Forage	66119	78184	93276	+
Vineyard	1155	1131	247	-
Orchard	8541	6608	4536	-

Soils. The presence of the Carpathian mountainous ring and the almost concentric relief of the Transylvanian Depression determine the development of a succession of zonal soil types in a horizontal zonality as a direct influence of the lithology and indirect influence of the relief, through the modification of climate and vegetation.

Diversity of pedogenetic factors - highly fragmented relief, forest and grass vegetation grafted on a lithologic background predominantly acidic in the northwest and predominantly basic in the southeast. Taking into account a wide variety of pedological-climatic conditions, soils differ greatly in morphological, physical and chemical characteristics, as well as in fertility and productive potential. The frequent use of wrong or inappropriate crop technologies not only affects the quantity and quality of agricultural production, but also risks soil reserves.

Soil cover is highly variable, with soil formation being closely related to relief, climate, parent rock, the influence of groundwater, periodic overflows and, last but not least, anthropogenic influence (Table 2).

Table 2. Some characteristics of the dominant soils of the Transylvanian Plateau

Soil type	Slope, %	Horizon thickness A, cm	Texture in A_p	Texture in sub-arable	Humus in A_p, %	pH in A_p
Cernoziom	5-20	40-50	LL/LA	LA	4-5	6.2-7
Rendzina	10-25	20-30	LA	LA	4-6	7-8.3
Faeoziom	5-20	30-40	LA	AL	4-5	7-7.8
Preluvosol	2-20	20-30	LL/LA	LA/AL	2-3	6-7
Luvosol	2-10	10-20	LN/LL	LA/AL	1-2	4.8-6
Luvosol albic	2-5	10-20	LN	LA/AL	1-2	4-5.2
Districambosol	5-20	20-30	LL	LL	3-6	4.5-5
Gleiosol	<2	15-40	LL/LA	LL/LA	3-7	5-8
Stagnosol	2-8	25-30	LA	LA/AL	3-6	6-6.8
Solonceac	<5	15-25	LL	LL/LA	1-2	8.3-9
Aluviosol	<2	15-30	LL/LN	LN/LA	1-3	6-8
Eutricambosol	2-7	10-40	LL/LA	LL/LA	2-6	6-8
Regosol/Erodosol	10-20	5-25	LL/LA	LL/LA	1-2	6-7

Note: LL - dust; LA - dust - clays; AL - clays - dust; LN - dust - sand.

In the eastern and southeastern part of the area, on fine-textured rocks with high CaCO3 content, soils specific to the Transylvanian Plain silvosteppe were formed, mainly represented by cernisols. The Cernisols are represented by cernoziomuri, faeoziomuri, rendzine, kastanoziomuri, etc. Moving towards the center of the hilly area of the Someșan Plateau, it can be seen that the lithologic and orographic factors still control the territorial distribution of soils. The dominant soils in this area are the preluvosols, luvosols and hydrisols.

Climate. The Silvosteppe of the Transylvanian Plain is characterized by the following: average temperature of 9-11°C, thermal resource higher than 5°C, ranging between 3200-3400°C, annual precipitation between 450-600 mm, of which 63-65% falls during the growing season. Sudden temperature fluctuations are frequent, snow is snowdusted and frosts in December-January are moderate.

Solutions for the conservation and sustainable use of arable land in this area start from some general socio-economic aspects and others specific to the farms in this area, mentioning at least the following:

Large areas of land affected by erosion occur in the hilly areas of Transylvania. In these areas very large areas have been deforested, much more than in any other European country at the same latitude as us (450 m, ±50 m). By implementing new technologies, the impact of erosion should be greatly reduced. It is characteristic of the hilly area that the natural factors influencing the agricultural production process, in particular soil, climate, relief, exposure, etc., vary even within the same farm, and the alternative solution is to choose the optimal variant. An average of 4 ha of agricultural land owned by an agricultural holding is estimated for this area, the economic situation of which can be improved by reducing production costs and substantial consolidation of areas.

Unfortunately, at the present stage, the actual endowment with tractors and agricultural machinery is totally insufficient and ageing, and they are not sufficient to carry out tillage in optimal time. The tillage and trafficability limits for most soils in the hilly area are relatively narrow, between 10-20 good plowing days/year, thus

optimal in terms of physical maturity for tillage. The tillage alternatives should ensure that tillage times are minimized. Today's rural population is very large, accounting for 44% according to some statistics, and 3.5 million of the working-age population are "employed" in agriculture. The analysis of the structure of production costs at the level of 2023-2024 shows the share of tillage in the total cost for grain maize and winter wheat cultivated under conventional tillage. They account for 30% of the total costs incurred for tillage and maintenance of a crop, with minimal plant treatments and fertilization. Reducing these costs under tillage alternatives can make land use more efficient.

In order to apply a regenerative agriculture, capable of halting soil degradation and restoring soil, a number of aspects have to be taken into account, such as land suitability, land use structure, efficiency of cultivation and tillage technologies, and even the application of soil improvement measures. The particularities for the hilly area of the Transylvanian Transylvanian Uplands we consider to be the following:

Supporting trends towards changing land use categories, by increasing the areas occupied by forests, grasslands and meadows at the expense of unproductive, heavily eroded or even arable land on poorly fertile soils and steep slopes, can improve their conservation. The slope of arable land conditions the rational use of soils and imposes technological and mechanization restrictions. Nationally, about 30% of the total arable land is located on slopes and exposed to erosion, in the Transylvanian Plateau this represents about 70%.

Research carried out in this area on the suitability and efficiency of different tillage alternatives, conservative tillage systems, shows the positive influence of their application. On the basis of a balanced organo-mineral fertilization with an increase of at least 30-50% of the plant residues remaining on the land, with effective weed, disease and pest control, the new systems periodically replace ploughing with the plough, with tillage without turning the furrow using paraplow, chisel, or surface tillage with disc, rotary harrow and even direct sowing. This has restored the structure, increased humus content and reduced erosion, while reducing diesel consumption and obtaining economically efficient yields.

The main purpose of tillage is to achieve a number of immediate positive effects resulting from the tillage objectives themselves: basic tillage, seedbed preparation and maintenance of the fields. Often, however, the effects of tillage can have an immediate negative effect or a lasting (positive or negative) lingering effect. Reducing field traffic and carrying out tillage at the optimum time are important conditions for the efficiency of the tillage system applied. Based on the intrinsic characteristics of soils in this area, inappropriate tillage induces negative eco-agricultural and agromanagerial consequences at the level of the agro-ecosystem.

The great diversity of soils in the hilly area of the Someșan Plateau, their characteristics and ecological conditions require the differentiation of tillage and highlight many limiting factors in this area. The optimization of the relationships between technological interventions, crop development and the hydro-physical, chemical and biological properties of the soil thus starts from the differentiation of the agricultural works carried out. Technological differentiation is imposed by the marked variability of vegetation factors and plant requirements in relation to these factors, variability that can occur at the level of the area, plot or even the depth of the soil profile.

The changes towards which farmers in hilly areas must be oriented are based on forecasting future trends in this area, starting with educating them in the choice of cultivation methods. Under these conditions, technology recommendations for spring cereals are given below. Season I, urgency I includes spring barley, oats, spring wheat, etc. whose minimum germination temperature is between 1-4°C (Table 3). The recommended calendar for the Transylvanian Depression is March 1-20. For some of the plants in this group, very early sowing is also motivated by the large amount of water required for germination and the low temperatures needed to trigger the fruiting phenophases. Crop plant spacing should be related to seedbed quality and soil water supply (Table 4).

Table 3. Sowing time and urgency for spring cereals

Crop	Soil temperature at sowing depth, ^{0}C
Season I, Emergency I	
Spring barley	1-2
Oats	1-4
Spring wheat	1-2

To maximize their productive potential, crop plants need adequate amounts of water, light, carbon dioxide and mineral nutrients. Soil is the main source of mineral nutrients and water for plants. Its ability to provide the nutrients needed by plants varies according to its fertility level. The removal of nutrients from the soil through their absorption into the plant, leaching or other processes related to the natural dynamics of soils, leads to a decrease in the content of mobile forms of nutrients and a gradual decline in the production capacity of soils For these reasons, it is an objective necessity to compensate for this by applying mineral (Table 5) and organic fertilizers (Borlan 1994).

Table 4. The sowing rate also depends on field conditions

Crop	Seedbed preparation and soil water supply of germinating grains/m^2	
	Good	Medium
Spring barley	380-425	425-500
Oats	440-500	500-550
Spring wheat	500-550	550-600

Table 5. Optimal economic fertilizer doses (DOE - N, P_2O_5, K_2O) depending on the expected yield (Rs) and soil agrochemical indices (IN, P-$_{AL}$, K-$_{AL}$)

Crop	Rs kg/ha	DOE –N, in kg/ha for values IN from:				DOE – P_2O_5, in kg/ha for values P-$_{AL}$ (ppm):				DOE-K_2O, in kg/ha for values K-$_{AL}$ (ppm):		
		1.5	2.5	3.5	4.5	10	20	35	70	80	140	220
Wheat	4000	124	109	99	94	101	70	42	18	73	37	10
	5000	142	127	117	112	121	90	63	38	95	59	32
	6000	156	142	132	126	139	108	80	56	113	77	50
	7000	169	154	144	139	152	121	94	69	129	93	66
	8000	184	165	155	149	164	133	105	81	142	106	79

Spring barley	2000	78	68	59	51	48	20	-	-	28	-	-
	3000	95	85	76	68	82	54	29	16	63	32	13
	4000	106	96	87	79	110	83	58	38	90	59	40
	5000	114	104	95	86	134	107	82	62	111	80	62
Oats	3000	93	78	68	63	55	22	-	-	45	12	-
	4000	112	97	87	82	79	46	17	-	68	34	11
	5000	127	113	102	97	99	66	37	15	85	52	28

CONCLUSIONS

The sustainable use of the soils of the Transylvanian Plateau implies the application of conservative, regenerative agricultural technologies, which preserve or even improve the soil properties.

Preventing degradation processes in cultivated land necessarily involves preserving a good structure by avoiding repeated passes over the land and using machinery systems suitable for carrying out several operations in a single pass. Other measures are also required, which can be summarized as follows: crop rotation and appropriate tillage; maintaining a sufficient humus ratio; preventing soil acidification through cultivation; avoiding the 'bare' soil during heavy rainfall; using organic fertilizers (manure, green manure).

Nowadays it is unanimously accepted as one of the most negative consequences of the conventional farming system, surface (secondary) compaction and stratification of the soil profile. The causes of soil compaction are manifold, and the methods of correcting it derive from them, namely: tillage at the appropriate soil moisture content; reduction of the number of passes on the soil surface; reduction of the pressure of agricultural machinery per unit area; fallow with a large number of non-prevailing crops; variation of tillage depth; restrictive use of disk harrows; improvement of soil drainage; increase of soil organic matter.

The Transylvanian Plateau has a moderate continental climate, with cold winters and relatively warm summers, but mean annual temperature and precipitation are often variable. This can affect the optimal sowing time and development of spring cereals, which need consistent moisture during germination and growth. However, spring temperatures and rainfall received throughout the year may be suitable for cereals such as spring wheat, spring barley, and oats.

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