LIMITATIVE FACTORS FOR EXPANDING SOIL TILLAGE SYSTEMS IN THE HILLY AREAS OF THE TRANSYLVANIAN DEPRESSION

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Abstract. Soil conservation systems cover a broad spectrum of agricultural methods mainly aiming at irreversible soil loosening and recovering plant debris in order to reduce erosion. This paper aims to clarify the criteria, conditions and limitative factors for extending conservative tillage systems in the agricultural holdings in Transylvania. Knowledge of pedoclimatic and socio-economic peculiarities of agricultural areas is a prerequisite for recommending optimal soil conservation systems. The changes towards which farmers in hilly areas should be oriented are all based on the trends of the implementation and expansion of soil conservation systems, starting from their education in choosing the cultivation methods.

Keywords: conservation systems, soil functions.

INTRODUCTION

Currently, more and more interest is being granted to factors which degrade agricultural areas and it is acknowledged that some of the main causes are considered the soil cultivation methods used. Maintaining a stable structure of soils, often limited by water erosion, decrease in humus content, surface compaction and depth, washing out calcium salts and clay leaching. Soil compaction is caused by heavy machinery traffic and it is manifested through soil structure degradation in the surface layer as well as in the arable sublayer.

Applying any type of agricultural technological system, including different technological sequences (basic soil tillage, irrigation, fertilization, seeding, maintenance work, transport etc.), aims to at least maintain and conserve the soil fertility condition. Both its positive and negative consequences, were subject of much internationally and national research, so that nowadays we have accumulated sufficient information which allows the transition from conventional systems to new technological systems of soil conservation (Rusu, 2001; Gus, 1995; Hoble et al., 2010; Weindorf et al., 2011).

Developing a certain variant is conditioned by the effects on soil fertility conservation and farmers' belief that their economic and social stability in the long term depends on choosing the optimal alternative.

This paper aims to clarify the criteria, conditions and limitative factors for extending conservative tillage systems in the agricultural holdings in Transylvania. Knowledge of pedoclimatic and socio-economic peculiarities of agricultural areas is a prerequisite for recommending optimal soil conservation systems.

MATERIAL AND METHODS

The Transylvanian Plateau also includes from the physical-geographical viewpoint the following three main units: the Transylvania Plain, Someş Plateau and the Apuseni Mountain area. The geomorphological, lithological, bioclimatic and pedological differentiation creates a great variability of vegetation factors in these areas (Nemeş et al., 1963; Crişan, 1995; Rusu, 1998; Guş et al., 1999).

The Transylvania Plain, located in the south-eastern part of Cluj, is characterized by absolute altitudes between 250-500 m, with "orderless" gentle hills, often separated by narrow valleys with excessive moisture with hogbacks on southern exhibitions, with softer slopes and slope processes on the Nordic exhibitions. The average annual temperature is 9-11°C, and average annual rainfall of 450-550 mm. Partially woody vegetation, dominated by herbaceous hayfield vegetation on clay parent material rich in calcium carbonate, with specific steppe annual rainfall deficit of between -50 to - 100 mm, in interaction with other factors of soil formation, have favoured strong fallowing and bioaccumulation domination. Thus, mollisols have taken shape in this area: chernozem, cambic chernozem, argillic chernozem, rendzinas, or pseudo-rendzinas or soils with A mollic horizon: clino-hydromorphic black soil, marshy soil etc.

As far as the Somes Plateau is concerned, the relief is more energetic and active, with intense slope processes triggered in time. Southern slopes are short, steep segmented, with ravines and torrents. Northern slopes are longer, colder and wavy. Hipsographically, we situate between 450-800 m levels, the relief energy averaging 150-250 m. The average annual temperature is 7-8^{0}C and average annual rainfall of 550-650 mm. The specific conditions in the forest areas with rainfall surplus of +50 to +100 mm annually and parent materials poorer in basic elements led to the predominance of weak-moderate acid bioaccumulation and leaching with clay-alluvial class soil formation: argillic brown soil, luvic brown soil, albic luvisol etc. There are also frequent pseudo-gleyed soils or pseudo-gleyed soil subtypes in different degrees.

The premontane area of the Apuseni Mountains, although in places presents a gentler relief, distinguishes itself both climatically and environmentally. The average annual temperature is 6-7^{0}C, and average annual rainfall of 700-800 mm, reaching to 1000 mm in mountainous areas. The pedological shell of this area is dominated by brown acid soils (Geography of Romania, 1987).

The Somes and Aries passages with afferent meadows should be added to these three units, which confer optimal mechanization, dominating the alluvial soils, colluvisoils, gley and marshy soils.

RESULTS AND DISCUSSIONS

In the hilly area, because of the lack of implementation of specific cultivation technologies, by ignoring requirements of phenomena and limiting factors combat, particularly soil erosion and drought, coupled on the other hand with the lack of production method, non-existence of systems of agricultural machinery technologically adequate, but also insufficient quantitively, in recent years, yield levels typical to subsistence agriculture have been obtained.

Conservation solutions and sustainable use of arable land in this area range from several general socio-economic aspects and other specific to agricultural farms in the area, stating at least the following:

1. Large areas of land affected by erosion can be found in the hilly areas of Transylvania (6.8% afforestation degree in the Transylvania Plain), areas where large areas have been deforested, much more than in any European country located on the same latitude with us ($45^0 \pm 5^0$). By implementing new technologies, the erosion impact must be greatly diminished.

2. Specific of the hilly area is that natural factors that influence the agricultural production process and in particular soil, climate, topography etc. (table 1) varies even within the same farm, the alternative solution being choosing the optimal variant.

Table 1

The main features of climatic areas from Transylvanian Depression

Area denomination	Altitude, m	Specific relief	A.a.t. ^{0}C	A.a.r. mm	P_{max}/ 24h, mm	Complementary objectives for soil tillage
Someş and Arieş river meadow	250-375	meadows, embankments	8.2-8.4	552-613	65-96	- water conservation in soil - avoiding structure degradation
Transylvania Plain	300-500	hills, deep valleys	8.0-9.0	538-666	65-88	- erosion prevention - water conservation in soil - avoiding soil compaction
Someşan Plateau	300-525	hills, narrow valleys	7.0-8.0	632-700	70-110	- idem areas 1 and 2 - removal of temporary excessive moisture - avoid the formation of hardpan
Mountainous	500-100	strongly tilted slopes	4.0-6.0	800-1000	72-97	- favouring mineralization and erosion prevention

A.a.t. - average annual temperature; A.a.r. - average annual rainfall; P_{max}/24 h - maximum rainfall in 24 hours.

3. Reduced size of arable surfaces owned by a farm in which the economic condition may improve by reducing the costs of production and substantial surface amalgamation.

4. Equipping with tractors and farm machinery is inadequate and aging, these being insufficient to provide soil tillage in optimum time. Tillage and traffic limits for most soils in hilly area are relatively limited, between 10-20 days appropriate for ploughing per year, consequently optimal under the physical maturity aspect for soil tillage. Soil tillage alternatives must ensure the reduction of the of soil tillage execution duration.

5. The current rural population is very numerous, according to some statistics it represents 47-49%, and in terms of working age population, a total of 3.5 million inhabitants are "kept busy" in agriculture. The income earned by those working in agriculture, however, is extremely low, estimated at 20-50% as compared to other economic sectors, whereas farmers work over 60 hours a week compared to 40 hours in most other economic sectors. Reducing the number of hours-person / hectare is another goal that must be attained by alternative soil tillage techniques.

6. Analysis of the structure of production costs in most cultures show directions and possibilities for efficiency. Economic efficiency of a culture is closely linked to how they are executed and soil tillage quality. Soil tillage constitutes the technological component which, through rationalization, leads to a substantial reduction in fuel consumption, because soil preparation requires 35-65% of the total energy consumed in a culture technology. Reducing these expenses under the soil tillage alternatives can engender more effective land use.

In order to apply a differentiated agrotechnics capable of halting land degradation and soil restoration, one must keep in mind a series of issues regarding the suitability of lands, their usage structure, streamlining the cultivation and soil tillage technologies and implementing pedo-ameliorative measures on soil. The Transylvanian hillside peculiarities are, in our opinion, the following:

(i). Supporting the change trends in the land usage category by increasing the areas occupied by woods, pastures and forested hayfields at the expense of unproductive, heavily eroded areas or even of arable land on less fertile soils and steep gradients, can improve their conservation.

(ii). The arable land slope condition rational soil usage and calls upon restrict technology and mechanization. Nationally, out of the total arable land, approx. 30% are lands situated on slopes and subject to the phenomenon of erosion, in Cluj County they represent around 80%.

(iii). Research conducted in this area concerning the suitability and effectiveness of the various alternative soil tillage systems, of conservative soil tillage, conclude in a positive influence of their implementation. Based on a balanced organic-mineral fertilization, with an increased percentage of plant debris remaining on the field at 30-50%, with an effective control of weeds, pests and diseases, the new systems periodically replace ploughing, with aeration without turning the furrow, using paraplow, chisel or surface processing with rotary harrow, disc and even direct sowing. One can thus assess the structure rebuilt, the increase in humus content and erosion reduction, combined with reducing diesel fuel consumption and getting effective economic production.

(iv). Soil tillage primarily aims at a series of immediate effects with positive role arising from the very objectives of soil tillage: basic tillage, seedbed preparation and land maintenance. Often, however, the effects of soil tillage can have immediate negative impact or with long lasting, residual effect (positive or negative). Reducing traffic on field and soil tillage performance at the optimal time are important conditions for optimising the implemented soil tillage system. Starting from the inherent characteristics of soils in this area, improper tillage induces eco-agricultural consequences (erosion, biological, chemical and physical degradation) and negative agro-managerial consequences (tillage difficulty, supportability reduction, loss of fertility) at the agricultural agro-ecosystem level.

(v). Great soil diversity in the hilly area of the Transylvania Depression, their characteristics and ecological conditions require differentiation of soil tillage and highlights numerous factors with limitative acting in this area. Optimizing the relationship between technological interventions, the development of crop and hydro-physical, chemical and biological properties of soil thus start to distinguish such agricultural tillage performed. Technological differentiation is required by the sustained variability of the vegetation factors and plant requirements compared to these factors, which variability can occur at the level of the area, parcel, or even at the depth of soil profile.

Expansion conditions in farms in the hilly areas of Transylvania are considered the following:

a. Soil suitability. The investigations carried out in the Transylvanian conditions reveal that some conservative researched systems are considered effective in certain pedo-climatic conditions, while in others their effectiveness is not valid. In choosing a conservative system variant one must take into account the technical soil properties, largely dependent on the texture, moisture, structure, drainage, humus content, type of cations absorbed in the complex etc., slope and terrain exposition, macro and microclimate conditions. It is stated that the classic soil tillage has a better efficiency on a poorly drained soil. Reducing the soil tillage number on poorly drained soils leads to delayed sowing, and the plants show symptoms of lack of nutrients. On poorly drained soils, as compared to the classic system, similar yields can be obtained through minimum system with chisel, paraplow or ridges.

An important condition for the success of conservative systems relies on the soil stable structure, sufficient rainfall, proper aeration and sufficiently high soil temperature. A stable structure most easily form on clay loam soils with high content of biologically active humus, but also on clay soils and sandy clay soils with high content of humus.

Heavy soils with high content of argil and low in organic residues, defective internal drainage, reduced biological activity, weakly developed structure and compactable, are improper for minimum processing, regular tillage of deep aeration being required.In the case of direct sowing on such soils, there is a danger that the seed would remain uncovered, due to insufficient fine soil for coverage.

Sandy soils poor in humus and, with a reduced biological activity and labile structure, easily form on their surface a layer of mud; they need large amounts of organic residues, fertilizers, and organic amendments, annually incorporated into the ground. In such soils the ploughing presents some advantages when compared to conservative systems.

(b). ***Excessive moisture.*** Soils with a high level of groundwater (1 m), subject to flooding or those that have higher apparent density near to soil surface, with waterproof horizon for water and roots, require carrying out ameliorative tillage, the first requiring a lowering of the groundwater levels whereas compact soils require deep aeration. Conservative systems may be implemented on these soils if a reduced production by 15-20% is taken into account.

(c). Land restrictions. There are soils that cannot be tilled by turning the furrow: salted soils, in order not to bring to the surface material with high content of salts; marshy soils, at which ploughing could bring from the subarable layer marcasite (iron disulphide), resulting from the decomposition of organic matter under anaerobiosis conditions and which, through oxidation generate sulphuric acid and iron sulphate, harmful compounds for culture plants; podsols, at which deep ploughing brings to surface iron and manganese salts under bivalent form with harmful action on plants; thin arable layer soils and with many rocks, where machines wear out quickly, regular collection of stones being necessary; these soils are recommended to be cultivated through conservative systems.

(d). Prevention and control of soil erosion. On sloping land, tillage productivity system should be subordinated to the concept of soil conservation, a criteria which requires the implementation of minimum tillage. They contribute to rebuilding soil structure, increase soil permeability for water and decrease erosion process.

(e). Adapting elements of technology and in particular the integrated management of plant protection and crop fertilization system. Thus, the strategy for weeds, pests and disease control should be changed from a curative way of applying the treatment, towards preventive treatments using effective products. Incorporation of phosphorus in the soil is scanty, its poor migration being known by its application on soil surface. It is thus recommended its regular insertion under crop rotation, thus rotating the soil tillage system as well.

CONCLUSIONS

The changes towards which farmers in hilly areas should be oriented are all based on the trends of the implementation and expansion of soil conservation systems, starting from their education in choosing the cultivation methods.

The peculiarities in the hilly slopes of the Transylvanian Depression, related to relief, climate, soil and its characteristics, condition and require that soil tillage should ensure:

- conditions of growth for the plants in the culture;
- soil capacity to store large amounts of water and thus avoid deep and surface runoff;
- reduction of tillage number in order to avoid water evaporation, structure degradation and soil erosion;

- aeration through turning or not the furrow, limited at the bio-accumulative horizon and aeration without turning of the Bt horizon;
- to avoid leaving the land bare and loose during critical periods in terms of erosion from rainwater and snowmelt.

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