Conservative agriculture in the context of sustainable development - a review

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Abstract. Sustainable development is that type of development that meets the needs of the present, without compromising the needs of future generations. The objectives of sustainable agriculture are to optimize production and conserve basic natural resources. As a result, there must be a major interest for innovative technologies, for sustainable land use systems that prevent or minimize soil degradation. Modern, intensive agriculture exerts significant demands on the soil which can have negative consequences manifested through degradation processes and even destruction of production capacity. Conservative agriculture consists in the application of modern agricultural technologies while protecting and improving soil quality. When choosing a particular system of soil works, the conditions of soil, plants and climate that can influence or can be influenced by the respective system must be taken into account. Plant cultivation technologies can induce in the soil long-lasting effects that affect the physic-mechanical properties of the soil, modifying them. The current concerns for developing sustainable agricultural systems are justified by the worsening extension of soil degradation, even by desertification. That is why it is necessary to introduce technologies that will ensure the possibility of sustainable development. This is a review paper that represents a comparative study between conservative and conventional agriculture and presents research on this topic.

Key Words: sustainable development, conservative agriculture, system of works, soil degradation, agricultural technologies.

Introduction. Food security is one of the key challenges worldwide in this century. Agriculture plays a strategic role in all countries of the world, as it is the main sector responsible for the food security of the population, at the same time having a special contribution to the overall process of sustainable economic development and environmental protection (Bologa 2013). Sustainable agriculture is, first and foremost, an economically viable agriculture that meets the requirements of the demand for healthy and high quality food, it is an agriculture that guarantees the protection and improvement of natural resources in the long term and passes them unchanged to future generations. Sustainable land management is crucial for minimizing soil degradation and rehabilitating degraded areas (http://mem.md).

The intensification of conventional agriculture over a long period of time contributes to accelerating the soil degradation process, increasing the risk of desertification in vulnerable areas. A special problem is that which takes place in areas with dry climate, where through intensive soil work and removal of vegetal debris increases the process of losing water content from the soil. The intensive conventional technologies have determined the increase of the anthropic pressure exerted on the ground by intensifying the mechanization and the use of the agricultural machinery more and more difficult and faster. As agricultural technology systems intensified their activity, the negative effects on soil processes became more severe (Cerbari 2011).

The soil's resilience is one of the most important and complex characteristics of the soil which implies its ability to react as an elastic body if it is subjected to a force or action, returning to its original form (http://www.capmu.md) The soil resilience depends on a number of factors and processes. The soil being a mineral-organic and dynamic entity has the capacity to recover its vital processes degraded by certain anthropic activities, if they were not drastic and if the period of time after the termination of their action was not very long. Under certain conditions, the soil may also suffer irreversible processes through degradation, if the pressure exerted on it is very severe and the vital processes are completely destroyed (Kassam et al 2009).

In these conditions, the sustainable use of the soil, implies the reduction until the negative impact of the degradation process is eliminated, increasing the capacity of resilience and its quality being restored (Bologa 2013). At present, there is a special interest for the system of conservative agriculture that allows a more efficient

management of the vegetal remains, ensures in the long term the sustainable use of the land preventing and minimizing the degradation of the soil by restoring both the production capacity and resilience (Moraru & Rusu 2013). Thus, conservative agriculture excludes conventional tillage by plowing with the total overthrow of the furrow, requiring that the surface of the soil throughout the year be covered and thus protected, by a living carpet or vegetable mulch. The surface of the soil covered with vegetal debris, remaining from the pre-cultivation, must be at least 30%. The conservative agricultural system is that technological system that saves resources (energy, materials, human, financial) and reduces or even eliminates the aggressive factors that determine any form of soil degradation or other components of the environment. Conservative agriculture is a combination of a wide range of cultivation practices / technologies that aim to ensure minimal soil disturbance, adequate soil cover, crop rotation, so as to reduce physical and chemical soil degradation (Cainarean & Jigău 2015). A combination of practices, such as surface plowing or plowing exclusion, mulching, intercropping, crop rotation, is the basis of conservative agriculture. Conservative agriculture has great potential to break the vicious cycle of poverty due to low productivity and food insecurity, caused by land degradation that makes society more vulnerable (Sustainet 2010).

Agriculture has a major contribution to the sustainable development of the economy and society through the economic and social opportunities it provides. Agriculture is not just the sector that provides food for mankind or the support for biomass production, but the very basis of life. The European Union places a strong emphasis on obtaining organic agricultural products. "Organic farming", a term assigned by the European Union to Romania, is similar to the terms "organic farming" or "organic farming" used in other Member States (https://www.agro.basf.ro). This type of farming system is a natural process of growing plants and producing food. The practices specific to organic farming are: banning the use of pesticides and chemical fertilizers, banning the use of food additives and genetically modified organisms, capitalizing on existing resources for soil fertilization (manure and fodder produced on the farm), crop rotation, rational execution of agricultural works. As a result, the purpose of this paper is to present the importance of developing a conservative agriculture in order to obtain appropriate agricultural products, both quantitatively and qualitatively. The need to obtain sufficient food for the entire population of the globe requires the most rational use of soil and finding solutions in the process of tillage that do not cause disturbances to it and the environment in general.

Conservative agriculture and conventional agriculture. Conservative agriculture uses natural ecological processes to conserve moisture, increase fertility and improve soil structure. This reduces soil erosion and the presence of diseases and pests (https://agroexpert.md). Principles of conservative agriculture are depicted in Figure 1.

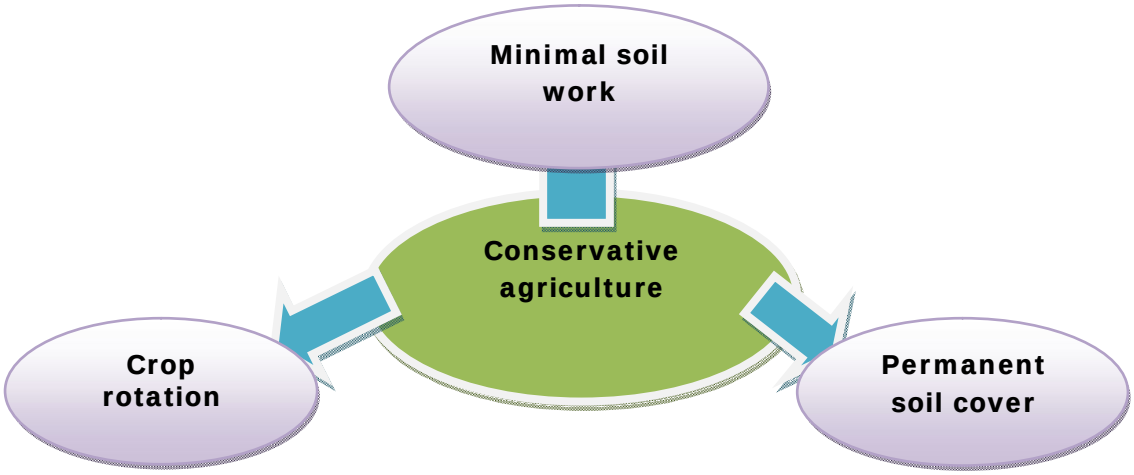

Figure 1. Principles of conservative agriculture (Source: http://network.app4inno.eu).

The three principles of conservative agriculture represent the methods of comparative analysis with conventional, traditional agriculture that is achieved through the following types of agricultural works: The primary or main tillage of the soil which is carried out annually by vigorously loosening the soil by plowing with the total or partial turning of the furrow; The secondary tillage that is done after plowing and consists in the crushing and fragmentation of the structural macro-aggregates of the soil; The work of deep loosening of the soil at certain periods of time, in order to improve the compacted soil layers at great depths due to natural and / or anthropogenic factors (https://www.icpa.ro).

The minimum soil work can be achieved through a reduced system of works or by direct sowing. The zero-tillage system is considered ideal, but it may also involve controlled processing in which no more than 20-25% of the soil surface is tilled:

- reduces the destruction of soil structure;
- does not expose the soil to wind and water erosion;
- improves the rate of infiltration of water into the soil;
- less disturbs the organisms living in the soil;
- saves time, energy and expenses because less land is processed;
- reduces soil compaction because the root system of the crop remains undisturbed.

Permanent soil cover ensures the preservation of an organic layer on the soil surface by retaining debris from previous crops. Often the figure of 30% minimum coverage is indicated, but the ideal level is local specific:

- contributes to reducing water leaks and infiltrating water into the soil;
- does not allow the crust to form on the surface of the soil;
- organic waste improves organic matter content and nutrient status from the soil;
- provides a beneficial environment for soil organisms, such as worms and millipedes, which are important for biological loosening;
- moderates soil temperature.

Crop rotation contributes to reducing weed, disease and pest infestation. There where the surfaces are too small for rotation, intercropping can be used.

- ensures the restoration of soil fertility;
- allows crops to use nutrients from the soil more efficiently;
- helps control weeds, diseases and pests by interrupting their life cycle.

The conservative system of soil works has the following advantages, as depicted in Figure 2.

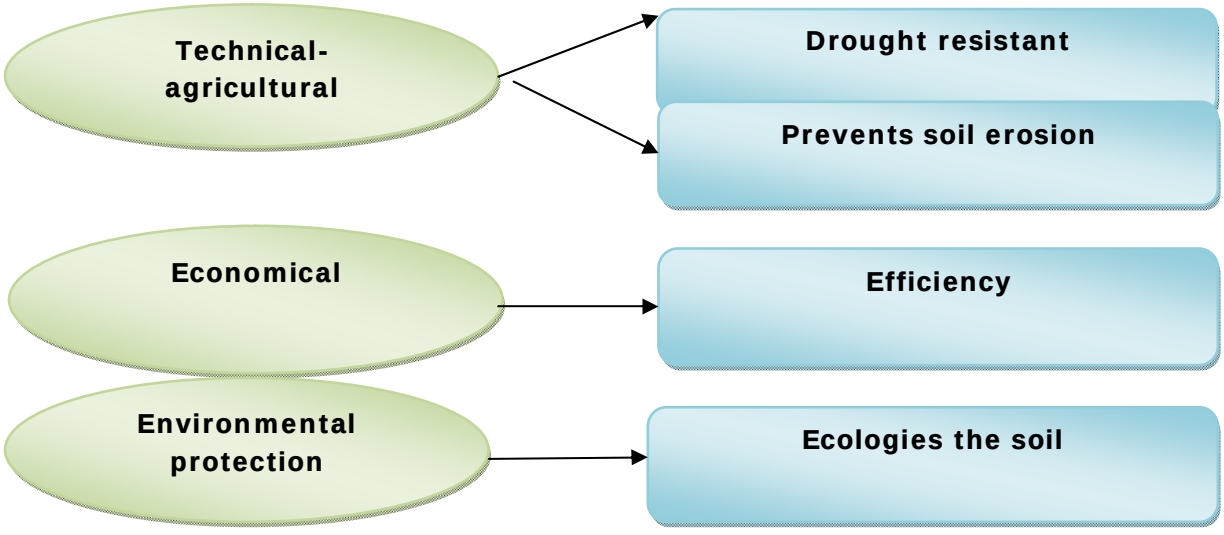

Figure 2. The advantages of the conservative system of soil works.

Methods and data analysis. Romania is considered to be the country with the lowest capacity to adapt to climate change. Therefore, the cultivation of drought resistant varieties or even a modification of the optimum sowing periods is envisaged so that the plants benefit from the optimum water supply during the vegetation period (Bonciu & Soare 2013). Limiting the effects of drought due to climate change can be achieved through agro-technical measures of rainfall accumulation, conservation and efficient use of water. In the current agricultural system, 50-60% of the water quantities came from precipitation during a year are lost by direct evaporation (http://adapt.clima.md). The water reserve in the soil at various depths from sowing to harvest depending on the technical equipment used for tillage is depicted in Figure 3.

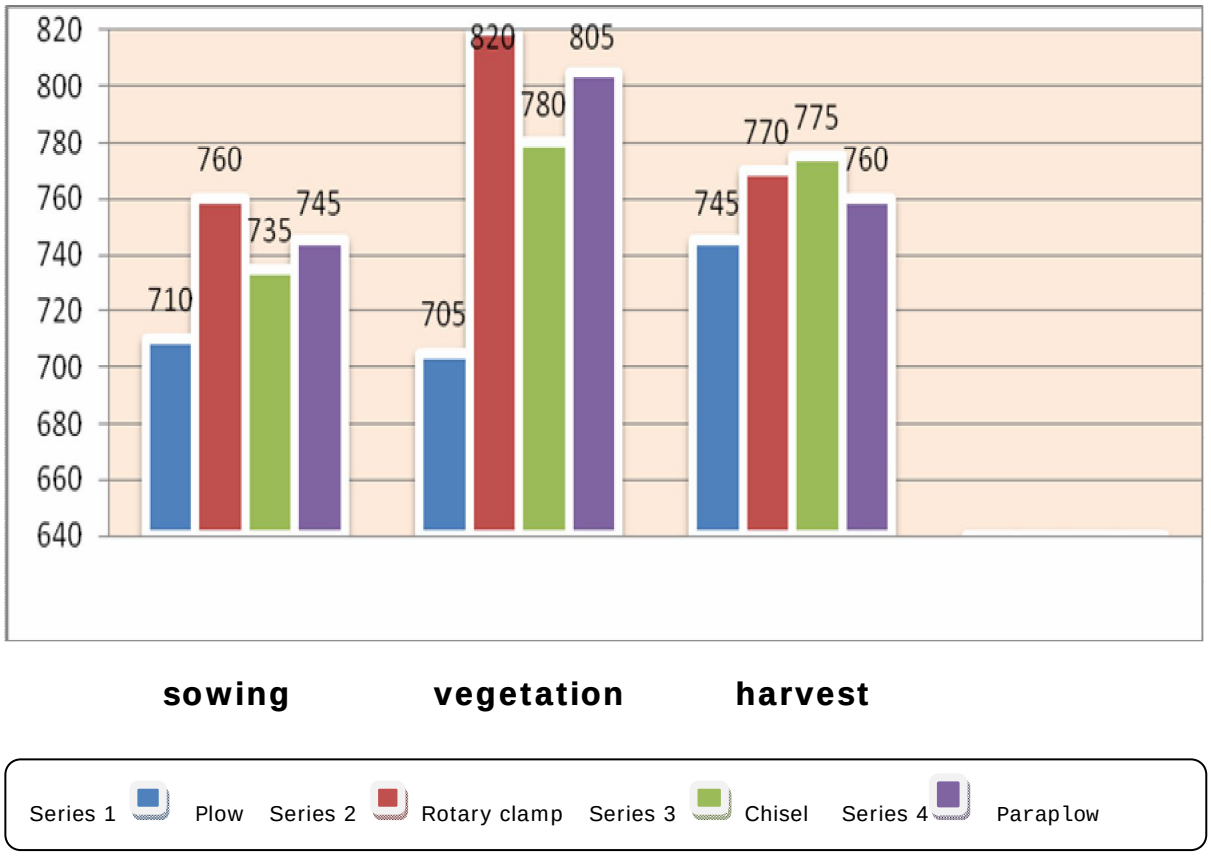

Figure 3. Water supply in m^3/ha at depths between 0 and 50 cm (Source: http://network.app4inno.eu)

Preservation of soil organic matter when implementing conservative technologies. In order to prevent the phenomenon of soil water loss, agro technical water conservation measures are required through an agricultural system based on soil protection and its work so that the vegetal remains remain on the soil surface. The organic matter in the soil represents a complex mixture of different substances as origin and chemical structure. For the most part, the organic matter from the soil mass comes from plant debris, to which is added the organic matter of animal origin and that resulting from the body of microorganisms (https://agroexpert.md). The amounts of organic debris in the soil, which are subject to decomposition processes, vary greatly depending on the type of vegetation zones, depending on the volume of biomass that is produced within some ecosystems. Thus, each type of natural biocoenosis accumulates different amounts of organic matter. The type of technical equipment used for tillage is of great importance in maintaining plant debris at the soil surface (Cojocaru & Cerbari 2015). Thus, the percentage of plant residues maintained in the soil at various depths depending on the technical equipment used is presented in Figure 4.

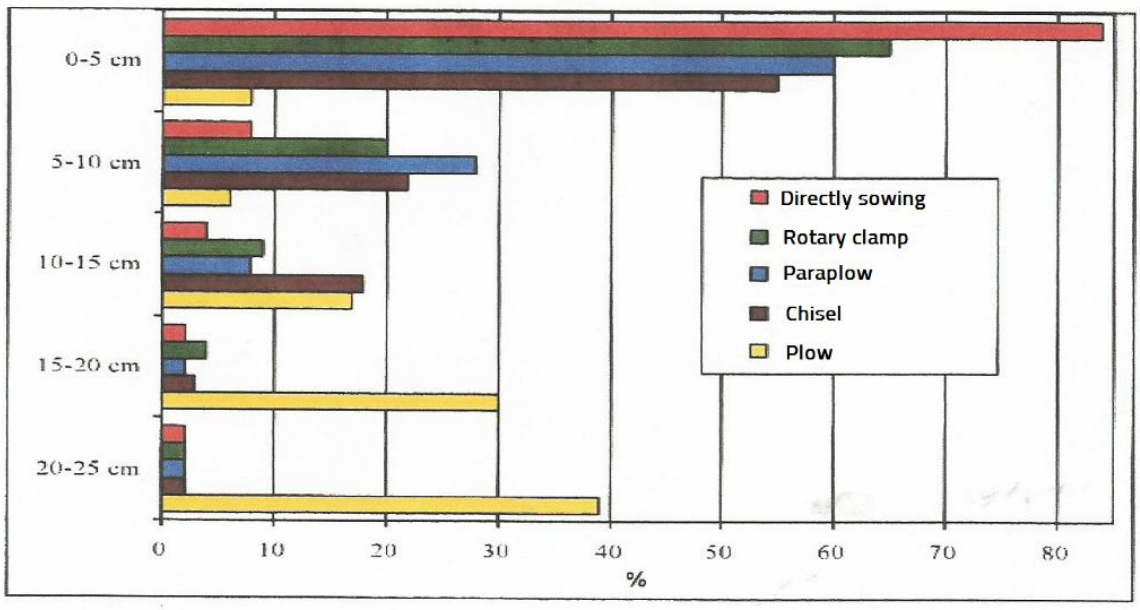

Figure 4. The influence of the soil tillage system on the percentage of vegetal debris and their distribution at different depths (Source: http://network.app4inno.eu).

Intensive agriculture and plowing works have led to the destruction of the stuck up horizon, which played a major role in the formation of humus. The type of work system also influences the formation or maintenance of humus in the soil. The percentage loss of humus from the soil is significant in the case of conventional agriculture compared to conservative agriculture as shown in Figure 5.

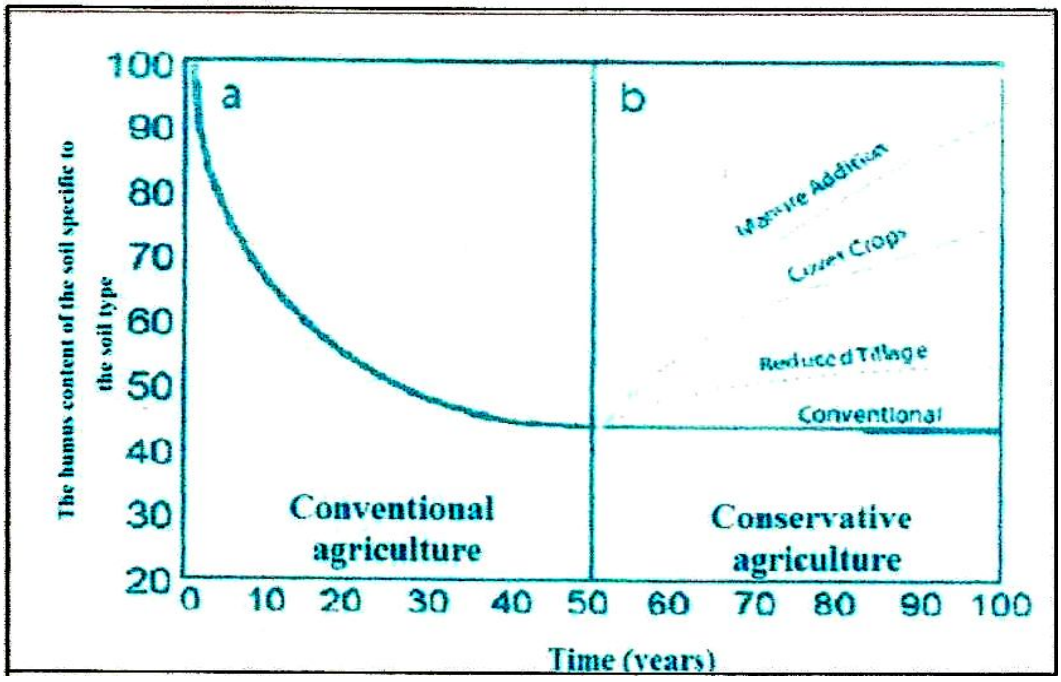

Figure 5. Loss in% of soil humus (Source: http://network.app4inno.eu).

Research has shown that the systematic practice of conservative agricultural systems lead to the restoration of the genetic framework for the recovery of humus. The evolution of soil humus indices is synchronized with the evolution of settlement indices (apparent density, total porosity) and soil regimes expressed by water reserves and differential soil porosity. Soil organic matter is a complex mixture of different substances as origin and chemical structure. For the most part, the organic matter from the soil mass comes from

plant debris, to which are added the organic matter of animal origin and that resulting from the body of microorganisms (Cojocaru & Cerbari 2015). The amounts of organic debris in the soil, which are subject to decomposition processes, vary greatly depending on the type of vegetation areas. The quantities of organic residues in the soil are variable according to the volume of biomass that is realized within some ecosystems (http://mem.md). The process of humus formation over time in conservative agricultural technologies is presented in Table 1.

Table 1

The stages of evolution of the system of organic substances in the soil with in of conservative agricultural technologies (http://mem.md)

The initial stage	*The transition stage*	*The formation stage*	*Stabilization stage*
Restoration of structural aggregates	Increasing the apparent density of the soil	Large amount of vegetable debris	Accelerated accumulation of plant debris
Low content of organic substance	Increase the content of organic waste	Increased coefficient of carbon content	Continuous variability of nitrogen and carbonate
Small amount of organic waste	Increase the content of organic substances	Increasing the capacity of cation exchange	Very high coefficient of carbon content
Restoration of soil microbiota biomass	Increased phosphorus content	Increased moisture content	Increased moisture content
Increased nitrogen content	Nitrogen immobilization. Mineralization.	Nitrogen immobilization. Reduction of mineralization. Intensifying the biological circuit of substances, optimizing and increasing its volume	Great circuit of nutrition substances. Reduction of nitrogen and phosphorus consumption.
Time (years)			
0 - 5	5 - 10	10 - 20	> 20

Discussion. In the field, the appreciation of the humus content, its type and nature, its distribution on the profile, the intensity of the color, the degree of decomposition or mixing with the mineral part of the soil is made visually. In this context, humus is a more or less stable fraction of organic matter in the soil. It consists of specific substances made by microbial synthesis or having a residual origin. The types of humus are differentiated according to the degree of moistening and the intensity with which it is mixed and linked to the mineral part of the soil (Cojocaru & Cerbari 2015). The evaluation of the types of humus allows drawing conclusions regarding the correspondence of the agricultural system practiced to the soil conditions. In case of non-compliance, the work system will be replaced with another, which corresponds to the respective conditions.

Conclusions. From the analysis of the conservative system of soil works, the following conclusions can be drawn:

- contributes to the creation and storage of organic matter in the soil, stops soil degradation, increases fertility, increases productivity and contributes to ensuring food security;
- reduces the state of compactness in the layer immediately following the superficial one, so the tendency of disappearance of the "plow's sole" and of the respective negative effects;
- ensures the speed of infiltration of water in the soil with positive consequences for improving the water, chemical and biological regime in the soil;

- the vegetal debris remaining at the surface of the soil or incorporated at 10-15 cm depth (where the biological activity is maximum) contributes to the conservation of humidity, growth of the fauna and flora of the soil;

- energy consumption and lower costs, although there is a significant increase in costs for the effective control of weeds, diseases and pests.

With all its advantages, the application of the conservative system also has some apparent risks:

- it cannot be applied on poorly drained or strongly compacted drainage soils;

- requires additional investments for a machine system adapted to the technological process;

- additional expenses for herbicides are needed for weed control;

- control of diseases and pests, use of mineral and organic fertilizers is difficult, as they cannot be incorporated into the soil;

- the management of conservative works systems requires special knowledge and a greater responsibility than in the case of the conventional system.

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