Available online at
http://journals.usamvcluj.ro/index.php/promediu

ProEnvironment

ProEnvironment 6 (2013) 136 - 143

Original Article

Soil Degradation and Conservative Technologies: Two Incompatible Realities for Republic of Moldova

LEAH Tamara*

Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo"
Ialoveni st. no.100, Chişinău, Republic of Moldova, MD-2070

Received 10 March 2013; received and revised form 29 March 2013; accepted 7 April 2013
Available online 1 June 2013

Abstract

The paper presents the main causes of land degradation reducing fertility and agricultural production capacity of soils. The quality of the soil cover of the Republic of Moldova on the most agricultural land is poor, and on the part of land-critical. Expanding areas affected by erosion, landslides, dehumification, destructuration, compaction, alkalization, salinity, swampy processes and droughts. In terms of soil degradation the implementation of conservative technologies have more disadvantages than advantages. Given the fact that in the Republic of Moldova is excluded the cardinal remediation of soil quality (0.4 hectares of arable land per capita) is required to develop and test methods for correcting soil characteristics without interrupting the agricultural production process. Soil minimum tillage system for soil conservation is necessary to implement gradually, concomitantly with classical traditional tillage system and implementation of technologies combating soil degradation.

Keywords: soil degradation, soil protection, no-till, conservation agriculture.

1. Introduction

According to experts, the technology "no-till" has several advantages compared to traditional agriculture. Conservation agriculture results in increasing agricultural production through better use of material resources reduce excessive land degradation and integrated management of land, water and biological resources. Mechanical work is replaced with technologies to improve soil properties and balancing the nutrients. Soil fertility is controlled by managing crop residue of soil cover, crop rotation and weed control.

In addition, conservation agriculture ensures reduced fuel consumption by 2 - 3 times by lowering the number of entries in the field of aggregates [1, 8].

Worldwide, the conservative system was introduced five decades ago and is used on the surface of 125 ml ha. Technology is successfully practiced in the USA, Germany, Romania, Ukraine and southern areas of the Russian Federation. Surprisingly, the USA is not the country with the highest percentage of area occupied by no-till, but Paraguay. This is due to the proper understanding of stewardship concerning vegetal residues problem in crop rotation, in particular, using the crops as green manure that is herbicide and leave on the soil surface for the next crop. In South America, for the last 15 years the cultivation area by no-till increased 50 times. In the USA, this practice is widespread, especially in Corn Cord [1, 6].

* Corresponding author.
Tel.: 37322-28-48-59; Fax: 37322-28-48-55
e-mail: tamaraleah09@gmail.com

In the Republic of Moldova the technology "no-till" or farming without plowing was introduced 10 years ago. Conservation agriculture is practiced by 18 farmers and only on the 5% of arable land or on the area of 50 thousand hectares, mainly in the north part of the country. To encourage farmers to use the no-till technology in the different parts of the country was initiated the creation of demonstration plots which will be implemented the technology and attraction donors investment. Currently, is working on the development on the national concept of conservation agriculture. Some of the farmers understood the need to implement the new system of agriculture and realized successful. To familiarize farmers with conservation farming system in the last two years, the Ministry of Agriculture has organized several seminars with the participation of scientists from Ukraine, Germany, and Moldova. The main problem encountered implementation of conservative technologies is the agricultural land degradation [2, 4].

2. Material and Method

Soil degradation. The strategic objectives of the agriculture in Moldova are required volume of agricultural production to meet population needs and export products; protection, conservation and enhancement of soil fertility in delivering agricultural production. To achieve these objectives it is necessary to develop and implement measures and technologies to stop the agricultural land degradation and disappearance of chernozems.

The quality of the soil cover of the Republic of Moldova on the most agricultural land is poor, on the other part of land is critical. Expanding areas are affected by erosion, landslides, dehumification, destructuring, compaction, alkalization, salinity, swampy and droughts.

In the 1970 the average credit rating of agricultural land was equal to 70 points. Currently the creditworthiness note of land is 63 points.

Price of the 1 point/ha per year of creditworthiness note is 47 lei. Annual losses as a result of decreasing the soil creditworthiness note, calculated by losses of agricultural production is 330 lei per ha and 830 ml lei for all agricultural land area - 2518 ml ha (table 1).

The main causes of soil degradation reducing the fertility and production capacity are: Incorrect organizing farmland caused by excessive fragmentation of land.

Excessive share of arable land (about 64% of the total area), lead to increasing the drought and desertification processes of land. Domination of hoeing crops in land structure, which causes erosion on the land surface.

Reducing the areas with perennial grasses 4 - 5 times, that leads to decrease of natural processes to restore soil fertility. Lack of optimal co-report between sectors: plant production - horticulture - livestock, which lead to decreasing in quantities of organic fertilizer into the soil (10 kg ha^{-1}) and create a profoundly negative balance of humus.

Insufficient and improper use of chemical fertilizers, which lead to decreasing of soil fertility and reducing agricultural output 2 times. Non-compliance of tillage system applied on the chernozem with fine texture that leads to the destructuring and excessive compaction of arable layer. Failure to follow crop rotation and anti-erosion agricultural equipment.

Evaluation of the soil quality in dynamic highlighting and characterization of soil degradation processes is a very important and difficult task that can not be solved by "visual" observations carried out in the field or by a simple determination of certain features.

Table 1. Distribution of arable land on the evaluation classes and quality

Classes of evaluation	Note of evaluation, points	Soil fertility	Surface	
			thousand ha	%
I	81-100	Very good	576.5	31.4
II	61-80	Good	680.3	37.1
III	41-60	Medium	383.3	20.9
IV	21-40	Low	195.7	10.6
V	1-20	Very low	-	-

This monitoring activity is done by specialized complex studies based on a variety of indicators and specific properties that allow the identification and characterization of various forms of degradation. Numeric values and their ranges allow assessing the level of intensity of these processes and establishing measures to restore the soil fertility [2, 7].

Anthropogenic activities carried out in conventional agriculture in complex with natural causes: physical, chemical and biological degradation, which must be taken into account when implementing the conservative technologies.

3. Results and Discussions

I. Physical Degradation. In the mechanized agriculture, classical tillage had the greatest impact and, although they are used in order to achieve positive change of characteristics, regimes and physical processes in the soil to allow plants to highlight their genetic potential, their excessive or incorrect application lead to the negative effects. Of the most severe natural processes of soil degradation in intensive conventional agriculture in Moldova are: *water erosion, destructuring and secondary compaction.*

Water erosion This process is considered one of the most complex form of soil degradation in Moldova in relation to the degree of manifestation, particularly on the arable land that are located on the 80% of slopes (fig. 1). In the triggering and intensification of erosion processes, the human activity has played an important role, especially in determining how land use, crop structure on the arable land, cultivation technology system (fig. 2).

Figure 1. Eroded land of Moldova

Figure 2. Correct organization of the territory

Water erosion is accentuated by the natural factors action as the climate: high intensity of torrential, presence of clay and compact soils with low water permeability or destructured soils. Surface erosion on the cultivated soils are intensified by incorrect soil tillage, unorganized and intensive grazing, excessive deforestation, which enhances and accelerates the erosion processes.

According to soil surveys, the surface of soil eroded increased over 40 years with 284 thousand ha (594 thousand ha in 1970 and 878 thousand ha in 2010), increasing annually by 7.1 thousand hectares. Eroded soil fertility decreases following: weakly eroded – 20%, moderately eroded – 20 - 40%, strongly eroded – 40 - 60%; very highly eroded – 60 - 80%. Along with surface water erosion, in the Moldova is widespread and deep water erosion. Gullies on agricultural land area increased from 8.8 thousand hectares in 2000 to 13.6 thousand ha in 2010. Unreasonable management in agriculture in recent years generates their surface increasing [4, 5].

The most urgent problems which arise to ambient degradation process are developing and implementing strategies to minimize erosion and their prevention on the long-term and increasing specialized knowledge of farmers. Erosion control is necessary to act locally by specialized projects concerning hydrological and river basins through terracing agriculture by plugging or blocking the gullies, especially by applying an appropriate system of agriculture and passing into land conservation of excessively eroded soils.

For farmers, where erosion processes are not serious, the easiest prevention measures of this process are: keeping the vegetation cover, soil tillage contours, organic fertilizer, avoidance overgrazing. Afforestation of eroded lands is one of the most viable solutions and successful, but can be applied only with state support. The agro-ameliorative, anti-erosion, specific technologies, including current works carried on the contours, grassed strips or buffer, vegetable mulch in quantities of 5 - 10 t ha^{-1}, appropriate selection of cultures to reduce leakage on the slopes and thus loss of fertile soil and applied fertilizer, and prevent clogging and polluting processes in downstream of both soil and surface water. Some of these measures are relatively simple and can be applied to farmers who use a larger area of land, but require an adequate systematization and consolidation of land dispersed plots.

Prevention of soil erosion processes in areas where practices the conventional farming is recommended current agro-technical tillage applicable by owners on the small areas such as: Use of organic fertilizers in moderate doses;

Introducing of the ameliorative crops in rotation, such as perennial grasses (*Lolium perenne*); Soil tillage only in optimal range of soil moisture status and their performance in contours; Protecting the soil surface with mulch; Exclusion of the overgrazing.

Destructuring is the reduction or loss of structural stability of soil aggregates to water and agricultural machinery, is one of the worst process of soil degradation.

Destruction influences the hydrological characteristics, soil permeability to water and air, stability and configuration of porous space. Destruction of soil is determined by natural limiting factors: size composition unbalanced, reduced amount of humus, continental climate, and anthropogenic factors belonging mostly to conventional agriculture.

The most primary cause of soil degradation by destructuring process in conventional agriculture is considered the practice of intensive soil tillage systems, often made in the improper humidity conditions, requiring then a large number of superficial works for seedbed preparation to carry out sowing.

Other important causes of deterioration of structural aggregates are reducing use of organic fertilizers, removal or burning of crop residues, short rotation in that dominate corn monoculture or wheat-corn rotation, absence of protective cultures, reducing biological activity, incorrect using of water through irrigation. The natural structure of virgin soil profile is shown in (fig. 3).

a). **b).**

Figure 3. Profile of chernozem typical (a), and natural structure of arable layer (b)

In order to prevent these negative processes must be respected a few basic rules:

• Soil tillage, harvesting and transport operations should not be performed on the humidity soils, but according to the specifics of workability and trafficability of the soil type;

• Application of organic fertilizers and use of ameliorative plants in long-term crop rotation should become mandatory component of agricultural technology system;

• Agricultural machinery traffic is prohibited on moisture soil, leaving deep scars that favor surface erosion processes;

Anthropogenic or secondary compaction. The secondary compaction is considered a specific physical degradation process with many negative effects on other components of the environment, particularly in the conventional agriculture, highly mechanized, and the presence of incorrect technology. Compaction occurs in the long term and manifestation throughout the depth of soil layer annually worked, but has a greater intensity in the layer just under the annual tillage (fig. 4).

Deformation anthropogenic increasing of soil layer with maximal distribution of the roots is a consequence of heavy agricultural equipment using, which exerts a pressure of 3-5 kg cm^{-2} and more, instead of 0.4 - 0.5 kg cm^{-2} – the acceptable value for most soils. Excessive compaction of soil is observed in 60 - 65% of arable land before harvest and 98% - after harvest.

Depending on the system of used agricultural machinery, the compaction points to a depth of 40 - 50 cm. Hydrostabile aggregates content (10 - 0.25 mm) decreased from 61 to 40%. Organic fertilizers increased the content of valuable agronomic components normal humidity from 69 to 79% and the hydro stabile - from 52 to 67% [6, 7].

This process of physical degradation of soil by compaction can become in time even worse than the erosion, because occurs inside, being an "invisible" process, unlike other processes, concerning physical degradation, such as erosion, crusting or water puddle , which is manifested on the surface, making it easy to see.

Excessive soil compaction manifesting negative consequences on other processes that influence each other, such as: reducing water infiltration and therefore increase the risk of excess water in the soil profile and on its surface, increasing soil leakage resulting the transfer of potential pollutants including pesticides and fertilizers into surface waters; reducing the volume of soil explored by root mass; restricting access of air into the soil and affect biological activity; increased demand for loosening soil and energy consumption; soil profile stratification through the emergence of compact layers at different depths, determines the accumulation on the soil surface the phosphorus fertilizers with reduce solubility; affect the quality and quantity of biomass, with negative repercussions on income and costs.

a). **b).**

Figure 4. Typical chernozem clayey-silty arable with compact horizon (a), soil structural element from compacted layer, situated under recent arable layer (b)

This process of physical degradation of soil by compaction can become in time even worse than the erosion, because occurs inside, being an "invisible" process, unlike other processes, concerning physical degradation, such as erosion, crusting or water puddle , which is manifested on the surface, making it easy to see.

Excessive soil compaction manifesting negative consequences on other processes that influence each other, such as: reducing water infiltration and therefore increase the risk of excess water in the soil profile and on its surface, increasing soil leakage resulting the transfer of potential pollutants including pesticides and fertilizers into surface waters; reducing the volume of soil explored by root mass; restricting access of air into the soil and affect biological activity; increased demand for loosening soil and energy consumption; soil profile stratification through the emergence of compact layers at different depths, determines the accumulation on the soil surface the phosphorus fertilizers with reduce solubility; affect the quality and quantity of biomass, with negative repercussions on income and costs.

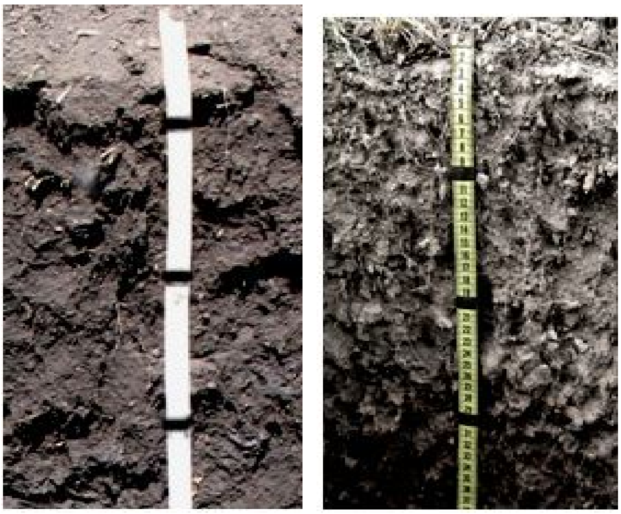
Anthropogenic compaction (settlement) or secondary through such effects, immediate and residual, has taken in recent time, the attention of the scientific community, farmers and machine operators, becoming the best-known form of soil physical degradation in conventional farming systems, intensive mechanized, which is widespread in industrial developed areas. Continue intensification of mechanization in the most industrialized countries of North West of Europe and the USA has concerned the scientific community and practitioners about the possible of anthropogenic compaction penetration in depth, reaching 50 - 60 cm [8, 9].

Soil affected by anthropogenic compaction, as well as for genetic natural compaction, can be partially ameliorated through various improvement technologies, raising deep mechanical works, used according to the depth by which this process occurs. In order to improve the soil compaction at the Experimental stations of "Nicolae Dimo" Institute of Pedology, Agrochemistry and Soil Protection was developed technologies to remediate the quality status of chernozems [3].

In order to restore degraded characteristics, natural structure and humus content of soils over 5 years is used the technologies with mixture of perennial grasses (ryegrass + alfalfa) used as feed. Within 5 years have returned to the soil about 24.2 t ha^{-1} of organic residues, absolutely dry mass (about 6 t ha^{-1} annually) containing 1.8% of nitrogen. Organic matter content increased in the 0 - 12 cm by 0.45%. The advantage of the proposed technology to remedy the degraded characteristics of arable layer of chernozems, that is not expensive and provide fodder farming each year, equivalent to at least 4 t ha^{-1} of grain units (figs. 5 and 6).

Figure 5. The field with mixture of perennial grasses (*Ryegrass* + *Alfalfa*)

Research on restoring degraded chernozem fertility and properties using vetch as green manure have showed that they partially restored natural qualities of the soil natural structure.



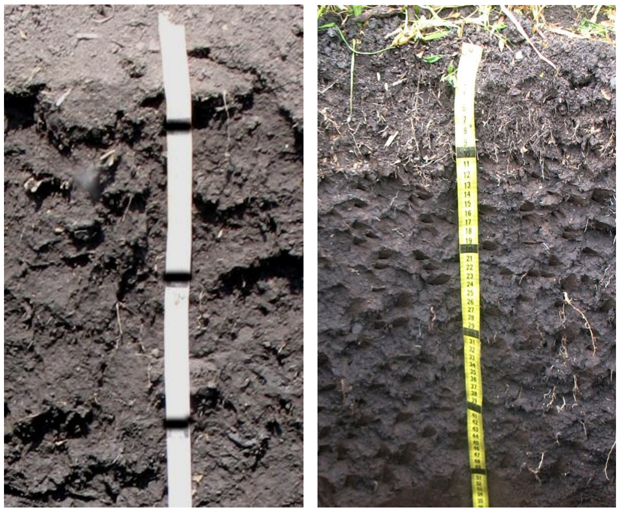
a). **b).**

Figure 6. Arable layer of leached chernozem before (a) and after (b) 4 years of phytoamelioration with perennial grasses mixture

As a result of soil incorporation of 28 t ha^{-1} of green mass of vetches (6.1 t ha^{-1} of absolutely dry mass containing 4.2% nitrogen) content of organic matter in the 0-12 cm soil layer increased by 0.19% [3]. This procedure returned about 250 - 300 kg of soil organic nitrogen, 60% of which is symbiotic sourcing (in the atmosphere).

For winter wheat harvest was obtained a growth of 1.3 t ha^{-1} (figs.7, 8).

Figure 7. Restoring degraded chernozem fertility and properties using vetch as green manure, the strip of vetch (April), b) winter wheat after vetch (May)



a). **b).**

Figure 8. Arable layer of chernozem (a) before and b)after phytoamelioration with vetch as green manure

In order to prevent soil degradation by compaction processes farmers must apply the following measures: reducing the load on the axle of agricultural machinery and equipment is required to be established maximum allowable limits according to soil specific and moisture depending on its condition. Often on the soil surface moving the heavy vehicles load exceeding 50 Mg; decreasing traffic intensity at the soil surface, reducing inputs on the soil; making all interventions according to the conditions of trafficability and workability of the soil; using in the crop rotation the large power plants for soil penetration *(Lolium multiflorum);* the already compacted soils is need in fertilizer application in high doses to compensate the negative balance of humus, nutrients and other effects.

All those measures are needed to improve the status of soil settlement, its ability to infiltration and aeration, increase available water reserves, the distribution of soil nutrients, conditions of the depth penetration of the root mass of crops etc. It is recommended to all farmers for proper no use the heavy farm machinery, specialized technical assistance, especially when used on clayey and loamy soils, on argillaceous soils with poor internal drainage and high risk of degradation by compaction. Given that the agricultural machinery are not used appropriately there are occurs rapidly anthropic compaction in large deep with all negative consequences on different soil processes and regimes, on biomass production and development, etc.

II. Chemical degradation. In the conventional agriculture, organic matter mineralization processes are accelerated through intensive soil tillage and scarcity of vegetal waste and other organic material incorporated into the soil. Therefore, the content of organic carbon in arable soils decreased significantly, and the quality has declined, affecting all other features and processes. Decreased content and qualitative degradation of organic matter has on the long-term numerous negative consequences, the soils become more vulnerable in relation to processes regarding: destructuring, erosion, acidification, salinization, nutrient imbalances, drought etc.

In the Moldova's agriculture with limited land resources the nutrient balance in soil is negative; there are also imbalances between different nutrients and as a result of the extremely low quantities of fertilizer applied into the soils. Agrochemical research indicates a serious impact of chemical degradation on the 80% of agricultural land. Essential decrease of humus content in soils of Moldova in the last 20 - 30 years is due to the negative balance of organic substance, other processes, particularly those of erosion. To cardinal improve the situation is required reduction of hoeing crop surfaces up to 40% of the sown area and increase the share of perennial grasses surfaces up to 20%. Such changes in crop structure, along with the application of organic fertilizers, crop rotations will allow a positive balance of humus in the soil. Also to stop processes of soil dehumification and insurance plants with nutrients, it is necessary to apply average per year by 10-12 t ha^{-1} of organic fertilizers, on the eroded soil by 14 - 15 t ha^{-1}. On the all agricultural land is now necessary to introduce into the soil by 17 - 18 million annually tonnes of organic fertilizers [1, 4, 7].

To prevent the agrochemical soil degradation should be based on studies, stating doses, times of application of agrochemicals, in relation to the requirements of the crops and soil nutrient supply, types of fertilizers and monitor environmental consequences.

III. Biological degradation. Biological degradation is the result of factors that lead to physical and chemical processes of soil deterioration: lack of nutrients, large quantities of fertilizer, loosening or excessive soil disturbance by diverse soil tillage. Management of structural status of the soil is the main way to control of the biological processes. Induced changes in soil tillage methods quantitatively and qualitatively affect living populations by reducing their number, by changing diversity and their activity. In the 48 years of arable use the soil lost 40 - 70% of initial enzyme activity, significantly decreased the number of fungus and bacteria that assimilate mineral forms of nitrogen in gray soils and chernozems. With the decrease of humus content was established specific weight increase in soil microbial carbon: from 1.21% up to 1.64% in gray soils, from 1.10% up to 2.35% in leached chernozems [5].

In the conservative systems with direct sowing allows the accumulation of vegetal waste on the soil surface, providing nutrition to microbial population and better protect the soil cover against erosion processes, modifying favorable environmental characteristics of the surface and upper soil layers and, thus, creating a micro-habitat for all soil organisms. As a result of the amount of root abundance in the arable layer and crop residues on the soil surface the number of *fam. Lumbricidaie* average increased from 2.5 - 3.0 times, the total biomass - by 1.6 times. In the 5 years of application of grasses as green manure into the soil the amount of dry microbial biomass was 494 - 830 kg ha^{-1} or an average of 133 kg ha^{-1} annually [3, 5]. Populations of microorganisms within 10 cm of the soil are lower in conventional tillage systems compared to those where direct seeding is practiced. This was due to both increased organic matter content and improves its quality and improvement of soil physical characteristics on condition of settlement, different ways of forming, redistribution, morphology of macropores, increasing water content.

4. Conclusions

The soil conservation tillage system is necessary to implement in the Republic of Moldova gradually, concomitantly with classical tillage system and implementation of technologies to combat soil degradation.

The introduction soil minimum tillage system on the degraded soil with fine texture - clayey-loamy, loamy-clayey, clayey and high clay content (greater than 30.0%), lead to formation after streaked a surface with large and compacted structural soil fragments.

Under the no-till seeding layer with fine textured soils (heavy) initially unstructured is formed a compact layer poorly permeable for water and roots, with low water reserves available for plants, and thickness of physiologically useful layer is reduced to 10 - 12 cm.

In the case the implementation of no-till system without a radical improvement of the physical and chemical quality of degraded former arable layer of heavy soil (fine textured), the interior compaction phenomenon will be more pronounced.

Due to insufficient penetration of roots in the compacted clay layer of destructured soil will be dominate the processes of mineralization of humus and humus loss in continue.

In the no-till system, the herbicides replace mechanical soil tillage; their procurement costs will be much higher than for traditional agriculture.

Uncontrolled use of large amounts of herbicides can lead to pollution of soil and agricultural production. In this context it is useful to know spectrum of characteristics of each crop weeds, their stages of growth, efficient use of herbicides periods and rules for their use.

References

[1] Boincean B., 2011, Lucrarea solului – tendinţe şi perspective, Academos. No. 3(22), 61 - 67

[2] Cerbari V., Coordinator, 2010, Monitoringul calităţii solurilor Republicii Moldova (baza de date, concluzii, prognoze, recomandări), Chişinău, Editura Pontos, 17 - 39

[3] Cerbari V., 2011, Programul de dezvoltare a tehnologiilor conservative în agricultură. Agricultura Moldovei, No. 4 – 5, 7 - 9

[4] Cerbari V., V. Scorpan, 2012, Remedierea stării de calitate şi capacităţii de producţie a cernoziomurilor obişnuite din sudul Moldovei sub influenţa unor măsuri fitotehnice. Mediul Ambient, 1 (61), 38 - 43

[5] Leah T., 2012, Status of Soil Fertility of the Republic of Moldova in Conditions of Intensification of Degradation Processes. Bulletin UASVM Cluj, Agriculture, 69 (1), 30 - 38

[6] Senicovscaia I., C. Marinescu, S. Andries, 2012, Instrucţiuni metodice privind evaluarea şi sporirea rezistenţei biotei solurilor în condiţiile intensificării proceselor de degradare. Chişinău, Editura"Pontos" SRL, Tipografia Reclama SA, 13 - 56

[7] Унгурян В.Г., А.М Холмецкий, 1990, Проблемы окультуренности и воспроизводства плодородия почв Молдавии. Кишинев, Штиинца, 95 - 117

[8] http://www.agrisolvwaste.com/no_till

[9] http://www.gazetadeagricultura.info/eco-bio/614-agricultura-ecologica