REGIONAL CONSERVATIVE TILLAGE SYSTEM OF CHERNOZEMS BETWEEN PRUT AND DNIESTER

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Abstract

The basic components of chernozems conservative tillage technology between Prut and Dniester are stipulated in the State Program "Conservative tillage system of soils" developed by Ministry of Agriculture and Food Industry of Moldova. Development and implementation was conditioned by accelerated degradation of soil resources in the region. Conceptual framework theoretical and applied in the regional conservative tillage system of chernozems (RCTSC) is provided by procedural approach of soil fertility in the concept of landscape evolution of chernozems genesis. Chernozems genesis is perceived as result of landscape development determined by complexation and intensification of soil-plant relationship. In accordance with these basic components of RCTSC the most important are landscape adaptation of agroecosystem, biologization and their ecological restoration focused on restoring composition and volume of substances through biogeochemical cycle's renaturation in the elementary pedogentic processes in the formation of chenozems type. A component part of RCTSC is practice of integrated system for plant protection in a crop rotation with minimum 5 crops including one ameliorative. RCTSC implementation involves elaboration of a technology fiche that provides a transitional period lasting 3-5 years during which are practiced biologization and optimization processes for agrogen layer.

Key words: conservative tillage technology, regional conservative tillage system of chernozems, chernozems genesis, landscape adaptation, agroecosystem

Problem evaluation: Regional conservative tillage system of soils is recognized as basis of conservative agriculture defined in the context of sustainable agriculture. Currently it knows accelerated extend being adapted to different soil types and to different bioclimatic conditions. At the global level conservative agriculture is practiced on 72 million hectares. The wider use it is found in Latin America (about 47.5 % from the world), USA (36.7) and Australia (12.5 %). In the other three regions (Europe, Asia and Africa) despite results obtained during scientific research and production conditions throughout a long period soil conservation tillage system have been adapted on limited areas.

In Moldova climatic conditions allow utilization and bioclimatic conditions require it application. More than 75 % of arable land represent thick chernozem which contain more than 3 % humus and particle size is predominantly medium (loamy) and fine medium (loam-clay and clay-loamy). Even though application of soil conservative tillage at national level received lack of attention.

Some conservative technology elements (replacement of plowing through disc harrow loosening, soil deep loosening with paraplow without furrow return, intermediate crops practice and hidden crops) were addressed in the region still '70-80 years last century. Researches in this area were initiated in the same period in several research institutions (Research Institute for Field Crops "Selection", Institute of Vegetable and Irrigated Agriculture and State Agricultural University of Moldova) being registered a comprehensives experimental material in favor of promotion and implementation of these works.

From 1992 research were initiated in Scientific Laboratory Pedogenesis Processes (Moldova State University). These researches focused on role of conservative tillage in the protection, conservation and extended reproduction of chernozems fertility between Prut and Dniester. Research which started in 2003-2004 where based on conceptual-theoretical and methodological basis promoted until that stage. Conservative tillage of soils was conducted on more than 20 thousand hectares located in the northern and central part of Moldova. Successes registered during activities implementations in production conditions accelerated implementation of conservative tillage system of soils. Currently their practice is extended

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on more than 70 thousands hectares. Throughout a short period have been outlined main conservative models of used agricultural technologies which comprised No-Till (12 thousand hectares) and reduced tillage (Mini-Till) that included superficial loosening while maintaining crops remains (about 30-35 %) on the surface and rotational system. Latest involves alternations of No-Till time to time with superficial loosening (8-10 cm) in the loamy and loamy-clays soils or deep loosening without furrow return in soils with clays-loamy particle size composition. Attention given to conservation tillage system implied requirement to develop and to approve State Program "Conservative tillage system of soils". Applied part of this program is supported in the framework of soil resource management in the region. According to the recent calculation more than 80 % surface of agricultural land in the region are affected by two or three even more degradation processes. In the forefront are compaction and disintegration processes. These are associated with crusting and sealing of porous space. Therefore abruptly have been reduced permeability, conductivity and water capacity. Pedological investigations conducted during 2011-2013 on an area 15600 hectares in 300 hydrophysic points revealed that in 90% of the cases water permeability and hydraulic conductivity varies between unsatisfactory to satisfactory. Specified processes are synchronized with dehumification processes. Dehumification is conditioned by small quantities of organic debris placed in pedogenesis and intensity and efficiency reduction during formation processes and humus accumulation due to hydrotechnical and airhydric degradation regimes in the whole physical degradation process of soils. Under fragmented lands an important role returns to erosion. Last is performed on over 740.000 hectares and is associated with physical degradation products. In these condition is reduced effectiveness of crop rotation and fertilization. According to recent calculations weight of yield structure constitutes from 10 to 30 % for wheat and sugar beet and less than 10 % for maize, sunflower. Other 70-90 % returns to natural fertility of soils. In these circumstances conservative tillage system of chernozems is called to reduce degree of soil physical degradation, to reduce superficial runoff and to favor water storage in soil which contribute to the recovery of hydrothermal and airhydric regimes. At the same time whatever is conservative tillage model that will contribute to enhancement of quantity of organic debris framed in pedogenesis. In this respect conservative tillage system is indicated for renaturation process of chernozem pedogenesis.

MATERIAL AND METHOD

Conceptual-theoretical and methodological framework: Conceptual-theoretical and applied framework of Regional Conservative Tillage System of Chernozems (RCTSC) is assured by procedural approach of soil fertility in concept framework evolutive-landscape of chernozem genesis from space between Prut and Dniester. In its chernozems genesis is perceived as result of landscape evolution determined by complexation and intensification of soil-plant relationships. In this respect basic components of RCTSC are: landscape adaptation of agroecosystems, avoidance of soil physical degradation and improvement of pedogenetical regimes (hydrothermal and airhydric) through reduction of mechanical pressures on soils, biologization and ecologization of agroecosystems oriented on restoration composition and volume of biogeochemical cycles substances and elementary pedogenetic processes renaturation within soil formation of chernozem type. A component part of RCTSC is practice of integrated system for plant protection in a crop rotation with minimum five crops including one ameliorative. RCTSC implementation supposes elaboration of technology fiche which provides transitional period for lasting 3-5 years (if applicable) during that are practiced biologization procedure and agrogen layer optimization.

RESULTS AND DISCUSSIONS

Implementation of RCTSC processes demonstrate from identification of pretability/ favorability level of soils to practiced conservative technologies in the region (Jigau, 2011). Factors which influence the choice of conservation tillage systems are grouped into two major categories: biophysical and biogeomorphological. Biogeomorphological factors are relief (shape, slope, exposition, and slope length), culture and cultural methods, row spacing and fertilization. According to enumerate factors has been developed research methodology of landscape adaptation of agroecosystem to landscape concrete condition (tab 1). Based on described and listed in table 1 we concluded that introduction in agriculture of conservative tillage of chernozems technologies require adequate knowledge both as soil cover, its various physical and chemical characteristics and other criteria and conditions. On the other side it is necessary to know crop plant capabilities to exploit potential of each agricultural biophysical landscape in part.

Table 1

Landscape adaptive hierarchical levels in agroecosystems management

Hierarchical level	Factors involved	Landscape function	Intrinsic factors	Parameters evaluated
o oo	Biological characteristic of plant Physical proprieties which determine utilization of plant biological potential	Soil – support for plants Soil – development environment of root system Soil – water supplier, air, heat, nutrition	Particle size composition Bull density Cohesion and penetration resistance	Particle size composition Bull density Penetration resistance
1 10	Idem + solar + solar radiation Physical proprieties which favor valorization radiation potential	Soil – surface which receives solar radiation, transformer and heat supplier	Thermal absorption capacity Specific heat Thermal conductivity	Content and humus composition Particle size composition Total porosity and differential
2 20	Idem + water resources (rainfall, irrigation) Physical features which determine water resources exploitation	Soil - surface participating in the water cycle Soil – accumulator of water reserves and supplier	Water permeability Hydraulic conductivity Water capacity (molecular, in field, capillary, total)	Particle size composition Total porosity Differential porosity
3 30	Idem + substances transformation and biogeochemical formation cycles Physical proprieties which determine direction and intensity of transformational processes and condition establishment of biogeochemical cycle of substances	Soil – decomposition environment and transformation of organic debris Soil – interaction space of large geological cycle and small substances biological cycle	Hydrothermal regime Airhydric regime Oxidation-reduction regime	Differential porosity
4 40 401 402 4021 4022 403	Idem + practiced technologies Physical properties which determine technologies: Irrigation Fertilizer Organic fertilization Mineral fertilization Tillage system	Soil – migration space and substances accumulation Soil – management environment and transformation of fertilizers and amendments Soil – modeling body in agricultural works	Pore space (volume, dimension and continuity)	Particle size composition Bulk density Structure Aggregates stability

Table 2

Evaluation criteria of land pretability to technologies for soil conservative tillage

Criteria	No-Till		Mini-till		Strip-Tiil
	Classic	Rotational	Classic	Rotational	
Particle size composition: - physical clay content (<0,01mm) - fine clay content (<0,001mm) - coarse silt content (0,05-0,01mm)	30-60 20-30 40-60	60-75 >30 <40	30-60 20-30 40-60	60-75 >30 <40	60-75 >40 <40
Slope, %	<3	2-5	2-5	5-8	8-10
Compaction degree, arable layer and subarable layer	1,1-1,20	1,20-1,40	1,15-1,35	>1,35	>1,35
Compaction degree, subsoils	<0	<0	<0	<0	<0
Siltization level (%)	absent	absent	absent	low-moderate	low-moderate
Moisture excess	absent	absent	absent	absent	absent
Crusting capacity	absent	absent	absent	low	moderate
Aggregate stability, %	>50	>50	>50	>40	>30
Na content in adsobtion complex, % from excange capacity	absent	absent	absent	Absent -low	low-moderate
Humus content, %	>4	>4	>3	>3	anyone
Glayzation degree, %	absent	absent	absent	absent	absent
Water permeability of profile	increased	moderate - increased	moderate - increased	satisfăcătoare-moderată	satisfactory
Hydraulic conductivity	increased	moderate - increased	moderate - increased	satisfactory – moderate	satisfactory
Total porosity, % layer 0-100 cm	>55	50-55	50-55	45-50	45-50
Field capacity for water, % g/g	30-35	25-30	30-35	25-30	≈25

In order to identify soil pretability in tillage systems is recommended criteria presented in table 2. These criteria and indicators as their numerical values limitative or restrictive may suffer some amendments due to soil evolution and methodologies improvement for assessing land pretability to soil conservation tillage. Along with factors mentioned success in implementation of conservative agriculture systems is influenced by a series of economic and socio-economic factors particularly important such as agricultural farm size, farm type, infrastructure and gross profit, institutional support, property type and training level of agricultural workers.

In accordance with criteria presented in table 2 in our research chernozem from region were classified in three types of structural-functional models (tab 3, 4, 5).

Table 3

Agrophysical parameters of structural functional models of chernozems in spaces between Prut and Dniester

Fertility factors	Normative for fertility levels			Soil fertility reproduction measures
	low	moderate	increase	
Particle size composition: - physical clay content (<0,01mm) - fine clay content (<0,001mm)	15-30 12-18	30-45 20-30	45-60 30-40	It cannot be optimized It can only be diminished by action that respect sowing terms and practice of resource reproductive technologies
Micro-aggregates composition: - Micro-aggregates composition content (> 0.01 mm.), % - Nepeptisation clay content (< 0.001 mm.)	65-70 3-4	70-82 2-3	> 82 1-2	Ensure stability of geochemical environment Ensure reproductive processes of humus reserves Ensure stability of CAS composition
Structural-aggregates composition: - Aggregates content > 0,25 mm, % - Aggregate stability	60-70 < 42	70-80 42-55	> 80 > 55	Application of resource reproductive technologies Crop rotation of weeding cereal and weeding cereal with herbs Practice of intermediate crops

Table 4

Hydrophysic parameters of structural functional models of chernozems in spaces between Prut and Dniester

Fertility factors	Normative for fertility levels			Soil fertility reproduction measures
	low	moderate	increase	
Mean permeability for 6 hours, mm/h	< 25	25-35	35-45	Practice of resource reproductive technologies Increase humus reserves in the soil through organic debris incorporation and including grass in rotation Crop rotation of weeding cereal and weeding cereal with herbs Practice of intermediate crops
Field capacity for water, % g/g	< 25	25-30	30-35	
Total porosity,%	< 50	50-55	55-65	
Capacity for air, % g/g	12-15	15-20	20-25	
Conductors pores of moisture, % from total prosity	< 40	40-55	55-65	
Water content inaccessible, % g/g	> 13	11-13	9-11	
Productive water reserve, mm. layer 0-100 cm	< 180	180-200	> 200	

Table 5

Physic-chemical parameters of structural functional models of chernozems in spaces between Prut and Dniester

Fertility factors	Normative for fertility levels			Soil fertility reproduction measures
	low	moderate	increase	
Humus content in horizon Am, %	< 4	4-6	> 6	Resource reproductive technologies Including herbs in rotation Utilization of maximum efficiency of plant biomass Practice of intermediate crops Optimal conditions for decomposition and humification of organic remains Assurance of condition which reduce to a minimum mineralization processes of organic matter including humus
Humus layer thickness, cm.	< 60	60-90	> 80	
Humus reserves t. / ha. layer 0 -100 cm.	< 350	350-500	> 500	
Ratio C : N	> 13:1	10-13 : 1	10 : 1	
pH	> 7,8	7,2-7,8	6,8-7,2	
Ratio Ca : Mg in root layer	< 10 : 1	10-13 : 1	13-14 : 1	
Adsorbed calcium content, % of cation exchange capacity	< 70	70-80	> 80	
Degree of base saturation, %	< 80	81-95	~ 100	

In the context of presented models, chernozems management in conservative technologies condition emphasis is placed on the organic component of soils. Through the impact on soil fertility organic component involves two groups of substances:

1. Stable humic substances with impact on basic characteristics of soils
2. Labile humic substances (nutritive humus) which participate in assurance to all necessary for plant

Stable fraction implies:

- Action on the basis of soil characteristics (physical, physic-chemical, chemical and hydrophysical)
- Slow mobilization of nutrients
- Nutrient acquisition
- Ensure an optimal level of aggregate structure
- Increased capacity for water
- Increase of thermal absorption capacity and specific heat
- Increase of water permeability and buffering capacity
- Inactivation of harmful substances

Labile fraction involves strictly limited quantities and ecologically conditioned for each soil type separately. For chernozems these constitutes from 0.3 to 0.1 %. Ratio C: N constitutes 10: 1 and corresponds to nitrogen content from 0.02 to 0.06 %. In the case of below indicated values soil productivity is reduced and in case of values higher than those indicated are occurring losses of nitrogen and carbon.

Specified values cannot be assured through mineral fertilization system no matter how effectively would be it. Starting from evolutive - landscape approach of chernozem genesis in spaces between Prut and Dniester we consider as assurance model of specified optimum values have to be taken mechanisms which are realized in steppe ecosystems.

At this chapter we remind that in the structure of steppe ecosystem vegetation up to 25 % return to annually beans. Annual nitrogen quantities framed in regional chenozems pedogenesis is correlated to some biophile elements content and is sufficient to ensure optimal ratio C:N and labile humus substances content for deepening in time of vertical pedogenesis process by ensuring progressive accumulative character of humus layer in chenozems. In this respect we consider that the presence in beans composition of steppe associations and sialitic-carbonate weathering crust are main premises which guarantee the pedogenesis chenozems in the region.

Therefore in condition when parental rocks are not changed and relative stability of geological scale, time, climate and relief become a primary condition for chenozems type conservation in regional pedogenesis is necessary perennial grasses inclusion in crop rotation structure including beans on 30 % technical crops surface.

CONCLUSIONS

Implementation of Regional Conservative Tillage System of Chernozems (RCTSC) involves:

- Oriented measures for humus accelerated accumulation in soils up to optimal level and ensure optimal content of mobile organic compounds in their composition
- Increase share of crop beans and multiannual herbs in crop rotation up to 30 % of technical crops surface for agroecosystem biologization

- Tillage technologies implementation capable to limit mineralization processes of humus
- Avoidance of physical degradation of soils

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