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**CONSERVATION AGRICULTURE SYSTEM IN THE NORTHERN PART
OF MOLDOVA**

SPECIALITY: 411.01 - AGROTEHCHNICS

Summary of PhD Thesis in Agricultural Sciences

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List of Abbreviations

SOM – soil organic matter

CA – conservative agriculture

No-till – No tillage

RIFC – Research Institute of Field Crops

SOC – soil organic carbon

CONCEPTUAL FRAMEWORK OF THE RESEARCH

Relevance and importance of the research topic. Soil tillage has always been a central element in the development of agriculture worldwide. Since humans first began cultivating land to produce crops, nomadism was replaced by a sedentary lifestyle. Over time, rudimentary wooden tools were replaced by heavy machinery, which profoundly altered soil structure and biodiversity. This evolution often overlooked the fact that soil is a complex and dynamic ecosystem, essential for sustaining life. Thus, the advent of agriculture marked not only a major step in the evolution of human society but also the beginning of significant contemporary economic, ecological, and social challenges [2, 12, 20].

Soil tillage does not contribute to maintaining soil health; on the contrary, it accelerates soil degradation, contributes to water and air pollution, and increases erosion. The long-standing perception that soil resources are infinite has led to devastating consequences, including severe land degradation in many regions of the world. As a result, millions of tons of soil are lost every year due to erosion on a global scale [1,11,12].

Research conducted at the Selectia Research Institute of Field Crops highlights a concerning situation regarding soil degradation in the Republic of Moldova. The findings show that Typical Chernozem soils have undergone significant losses of soil organic matter as a result of intensive tillage, particularly plowing with a moldboard plow. This degradation is directly linked to agricultural practices, underscoring the negative impact of conventional soil tillage on soil health [1].

Therefore, the researchers conclusions emphasize the need for a systemic approach to agricultural practices, one that not only safeguards soil fertility but also ensures the provision of the ecosystem and social services [16].

Based on the above, it follows that the soil tillage methods used within the agricultural system in Moldova need to be re-evaluated, with the aim of optimizing or even eliminating tillage practices under the conditions of the northern region of the Republic of Moldova.

State of the research of the topic. Currently, in the Republic of Moldova, research on conservation agriculture systems with the inclusion of all its basic principles: minimal soil disturbance; crop diversification and permanent soil cover is lacking. At the international level, however, there are numerous studies on CA systems conducted under different conditions and diverse geographical areas. Among the pioneers of research in CA are Sir Albert Howard, who promoted agricultural practices aimed at maintaining soil health and fertility in his renowned book „*An Agricultural Testament*” (1940); Edward Faulkner, an American farmer and author, who,

through his well-known book „*Plowman's Folly*” (1943), criticized conventional agriculture and encouraged the use of conservative technologies, based at that time on minimum tillage and no-till; Don Reicosky, who made significant contributions to CA starting from the last decades of the 20th century, is actively promoting the CA system to the present day [18].

Professor Rattan Lal is rightly considered the father of conservation agriculture, who demonstrated in practice the benefits and harms of different soil tillage methods [13,14,17].

Research by Andriucă V. et al. highlights that the implementation of the No-till system on clay-illuvial and loam-clay chernozem soils significantly improves soil quality, water use efficiency, and crop productivity. This agricultural approach represents a valuable strategy for promoting sustainable agriculture, particularly under drought conditions [26].

A study conducted by Olesea Cojocaru, Gheorghe Panfil and Petru Panfil demonstrates that conservation agriculture systems, particularly No-till and Mini-till, offer effective solutions to current agricultural challenges. These systems contribute to improving both productivity and sustainability under difficult environmental conditions through several mechanisms: reducing soil erosion, enhancing soil structure, conserving soil moisture, lowering production costs and improving nutrient cycling, among others [27]. Results obtained by G. Baltag show significant changes in the structure of unit costs of the analyzed crops, depending on nutrient levels [28].

Research carried out at the Selectia Research Institute of Field Crops in Balti includes long-term field experiments investigating various sustainable agricultural systems. Within the framework of the PhD thesis, studies were conducted on conservative soil tillage systems for winter cereal crops within crop rotations, with results published in several national and international scientific articles by the author of the thesis and members of the research team [3,5,6,7,21,22].

The Republic of Moldova, however, requires systematic and interdisciplinary research on conservation agriculture (CA) to facilitate the adaptation of the CA system to local conditions. The lack of knowledge in implementing CA practices could create serious challenges for its promotion and adoption by farmers. Therefore, in 2023, at the Selectia Research Institute of Field Crops, a dedicated CA trial was established, applying CA principles to all crops within the rotation.

The aim of the research is to investigate the possibility of eliminating soil tillage in the cultivation of winter cereal crops (winter wheat and winter barley) within crop rotations, using No-tillage, in order to reduce production costs and enhance adaptation to climate change.

To achieve the proposed aim, the following objectives were set:

- study the climatic conditions during the study years 2019–2021;

- study the yields of winter cereal crops depending on the predecessors when using No-till and soil tillage with a disc harrow;
- determine the available water stocks in the soil and calculate water-use efficiency for the formation of one ton of winter wheat sown directly (No-till) after corn for grains, depending on the crop rotation;
- compare the available water reserve in the soil and water-use efficiency by winter wheat grown after different predecessors and different annual climate conditions;
- study the yield of winter barley in the organic agriculture experiment, depending on crop rotation and fertilisation in the absence of chemical means for disease, pest and weed control;
- study the influence of different rates of corn residues on the yield of winter barley when using No-till;
- analyze the possibility of water accumulation in the soil during winter wheat cultivation using direct sowing (No-till);
- determine the soil bulk density in winter barley cultivation in the studied experiments.

Scientific hypothesis. Agrotechnical practices based on soil tillage have proven to be economically inefficient due to increasing fuel prices, while simultaneously exerting a considerable negative impact on the environment and human health. Soil tillage influences global warming both directly and indirectly. Direct effects include fuel combustion during field operations, the intensive mineralization of soil organic matter following plowing, and the absence of soil cover with vegetation for extended periods, which increases the risk of erosion. Indirect effect is the need to increase the application rates of mineral fertilizers and pesticides as a consequence of soil fertility loss. The production of mineral fertilisers, particularly nitrogen-based ones, results in enormous CO₂ emissions [3].

The CA system can address these challenges by reducing mechanical soil disturbance, diversifying crop rotations, and maintaining soil cover with live or dead mulch. In other words, conservation agriculture seeks to mimic natural ecosystems within agricultural systems while simultaneously reducing production costs.

Scientific research methods. The research was conducted in accordance with the methodology used at Selectia RIFC, following the work program approved at the Scientific Council meeting. To achieve the aim and objectives of the research, the following analyses were carried out according to the established plan:

- soil bulk density – using the cylinder method;

- total soil porosity – by calculation;
- available water reserve – using the gravimetric method;
- nitrate content determination – using an ionometer [23];
- P and K content – according to Ciricov [23];
- organic matter content and reserve – according to I.V. Tiurin, 1937 [23];
- statistical analysis of results – according to B.A. Dospehov, 1985 [24];
- crop harvesting was performed mechanically, by combine.

Approval of scientific results. The scientific results obtained from the research conducted under the PhD Program were presented and approved annually at the meetings of the Department of Crop Science of the Faculty of Agronomy within the State Agrarian University of Moldova; at the International Scientific Symposium „*Plant Protection – Achievements and Perspectives*”, held in October 2–3, 2023; and during the annual reporting at the Scientific Council meetings of Selectia RIFC.

SYNTHESIS OF CHAPTERS

CHAPTER 1. CONSERVATION AGRICULTURE AS AN ALTERNATIVE TO CONVENTIONAL AGRICULTURE

The first part of Chapter 1 describes the consequences of conventional agricultural practices on agroecosystems. It also presents some of the crucial challenges currently faced by agriculture, as well as those expected in the future. In this context, the CA system is presented as an alternative to conventional agriculture.

Subchapter 1.2 highlights the influence of the CA system on crop productivity, while simultaneously mentioning its benefits for soil and the environment. Some results from the implementation of CA practices are also presented in this subchapter.

Subchapter 1.3 mainly focuses on the impact of CA on soil fertility, defining the concepts of soil health (quality) and fertility. It also describes the capacity of soil to provide ecosystem and social services, including carbon sequestration as a measure to mitigate global warming.

In Subchapter 1.4 special attention is given to the influence of the CA system on the degree of weed infestation in crops. At the same time, problems that may arise during the transition from conventional agriculture to conservation agriculture are highlighted. The need for a clear understanding of the system and weed management strategies is also emphasized in order to avoid their negative impact. Several examples of the influence of the agricultural system on weed infestation are presented.

The last subchapter describes the influence of the conservation agriculture system on global warming. The role of soil in providing ecosystem and social services, which also has climate regulation capacity through carbon sequestration, is emphasized. The main greenhouse gases responsible for intensifying global warming are highlighted.

CHAPTER 2. RESEARCH CONDITIONS AND METHODS

2.1. Meteorological conditions

Meteorological data were analyzed based on observations from the Selectia RIFC meteorological station for the agricultural years 2018–2019, 2019–2020, and 2020–2021, focusing on precipitation amounts and air temperature. The last two years were characterized by contrasting climatic conditions: 2019–2020 was a very dry year, while 2020–2021 had abundant precipitation, thus providing the opportunity to evaluate results under different agroclimatic contexts (Fig. 2.1).

The mean air temperature showed positive deviations in all study years (Fig. 2.2). The largest deviation, +2.7 °C compared to the long-term average, was recorded in 2019–2020. In 2018–2019 and 2020–2021, the increases were 1.7 °C and 1.2 °C, respectively.

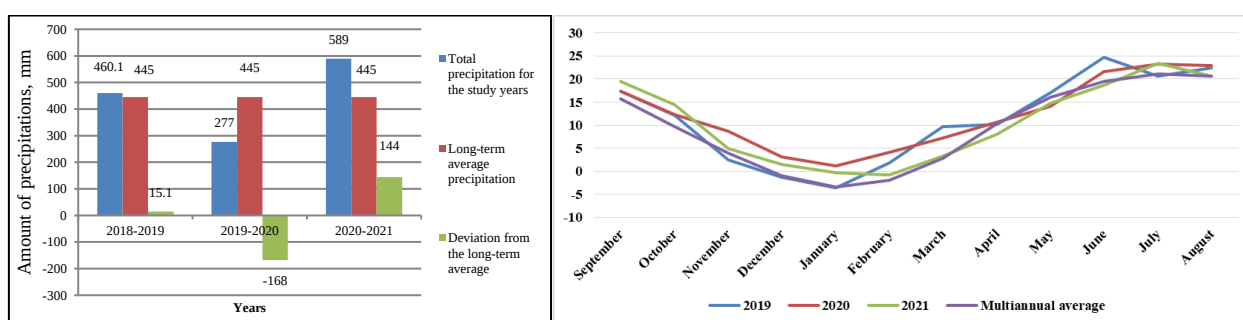


Fig. 2.1. Dynamics of precipitation and air temperature during the agricultural years 2018–2021, based on data from the meteorological station of the Selectia RIFC, Balti

2.2. Research methods and conditions

The research was carried out within the long-term field experiments of the Selectia Research Institute of Field Crops, established in 1961 (crop rotation and permanent cropping experiment) and in 1989 (experiment on ecological agriculture). The soil of the experimental field are represented by typical loam-clay chernozem. According to soil analysis data from 1993, the arable layer (0–20 cm) is characterized by the following agrochemical indicators: organic matter content (Tiurin method) 4.8–5.0%; pH in water 7.3; total nitrogen, phosphorus, and potassium content 0.21–0.25%, 0.09–0.11%, and 1.22–1.28%, respectively [29]. The research included two experiments conducted simultaneously using direct sowing (zero tillage), located on nearby but distinct fields under identical pedoclimatic conditions, each with its own set of experimental variants.

In the first experiment, the yield of winter barley and winter wheat cultivated in crop rotations through direct sowing (zero tillage) after corn for grain, and under minimum tillage with a disc harrow after peas for grain and spring vetch as preceding crops, was studied. The experiment was set on two fertilisation backgrounds: unfertilised and fertilised with organo-mineral fertilizers.

It was carried out in three replications, according to the principles of experimental statistics. The area of an experimental plot was 283 m². It should be noted that zero tillage (No-tillage) was studied under fertilised and unfertilised backgrounds within a long-term crop rotation field (crop rotation 1, 3, 4, 5, 6 – fertilised; crop rotation 7 – unfertilised), starting from 2015. In crop rotations 2 and 8, a disc harrow operation was performed after harvesting the predecessors in order to control weeds before seed formation. Sowing in all studied variants was carried out during the same period using a Moore Unidrill seeder, with a seeding rate of 5 million of germinant seeds for winter wheat and 4.5 million for winter barley. Fields under conventional soil tillage were sown by using SN-16 seeder, with the same seeding rates.

The second experiment aimed to study the yield of winter barley, variety “Scînteia”, was sown directly (No-till) after corn for grain, under ecological farming without the use of chemical means for controlling diseases, pests, and weeds. The experiment included three blocks with three fertilisation backgrounds: unfertilised, fertilised with farmyard manure (40 t/ha under sugar beet; 30 t/ha under spring vetch), and fertilised with organo-mineral fertilisers. The plots were divided into two halves: mineral fertilisers with nitrogen (NPK) and without nitrogen (PK). Three crop rotations were studied - with and without a mixture of perennial legume and grasses species. The structure of the first two crop rotations included a mixture of perennial forages composed of alfalfa for green mass (legume) and ryegrass (grass), while crop rotation 3 consisted of a mixture of annual forages, namely spring vetch (legume) and oat (grass), cultivated for green mass.

In crop rotations 1 and 3, crop residues were not applied, unlike in crop rotation 2, where the influence of different amounts of residues left on the soil surface after harvesting wheat, barley, and corn for grain was analyzed. In addition to crop yield, several indicators were evaluated: available soil water reserve, NPK content, organic matter content, bulk density, soil respiration, etc. Water accumulation and consumption were determined depending on predecessor, crop rotation, fertilisation, and tillage system. To assess the impact of agricultural systems on organic matter and agrophysical properties, data from permanent black fallow and meadow were used.

CHAPTER 3. YIELD OF WINTER CEREALS AFTER CORN FOR GRAINS AND EARLY PRECEDING CROPS IN DIFFERENT LONG-TERM CROP ROTATIONS

3.1. Yield of winter wheat, variety “Vestitor”, in the long-term field experiment on crop rotations and permanent cropping

During the three-year research, it was found that winter wheat has responded more strongly to crop rotation and preceding crop than to fertilisation. Therefore, the preceding crop had a decisive impact on the formation of yield levels (Table 3.1).

Table 3.1. Yield of winter wheat, variety “Vestitor”, in crop rotations with different predecessors, and fertilisation under No-till and disc harrow tillage, average for the years 2019–2021

Crop rotation	Predecessors	Fertilisation background	Average yield for 3 years		
			t/ha	Extra yield from fertilisation, t/ha and %	
				t/ha	%
7	Corn for grains*	Unfertilised	3.02	-	-
3	Corn for grains*	Farmyard manure +NPK	3.08	+0.06	2.0
2	Peas for grains**	Farmyard manure +NPK	4.10		
4	Corn for grains*	Farmyard manure +NPK	3.05		
5	Corn for grains *	Farmyard manure +NPK	3.20		
8	Mixture of spring vetch + oats for green fodder**	Farmyard manure +NPK	3.43		
Dl ₀₅			0.12		

Note: * zero tillage

** disc harrow (single pass after harvesting predecessors)

The maximum yield was achieved on the variant after peas for grains (crop rotation N2), reaching 4.10 t/ha. A higher winter wheat yield was also recorded when sown after the mixture of spring vetch and oats for green fodder (crop rotation N8), reaching 3.43 t/ha. When winter wheat was sown after corn for grains on unfertilised background, the yield was 3.02 t/ha. The yield increase from fertilisation after the same preceding crop was insignificant – 0.06 t/ha.

3.2. Yield of winter barley, variety “Scânteia”, in the long-term field experiment on crop rotations and permanent cropping

The average yield of winter barley over three years indicates a pronounced response of winter barley to fertilisation (Table 3.2). Two crop rotations with the same crop sowing structure were compared: crop rotation N7 (unfertilised background) and crop rotation N3 (fertilised

background). The yield increase from fertilisation was 0.88 t/ha or 35.3 %, representing a significant increase compared to the unfertilised background.

Table 3.2. Yield of winter barley, variety “Scânteia”, depending on predecessors, crop rotation, and fertilisation under direct sowing, average for the years 2019–2021

Crop rotation	Predecessors	Fertilisation background	Average yield for 3 years	
			t/ha	Extra yield from fertilisation, t/ha and %
7	Corn for grains*	Unfertilised	2,49	-
3	Corn for grains*	Farmyard manure +NPK	3,37	+0,88/35,3
1	Corn for grains*	Farmyard manure +NPK	3,51	
2	Peas for grains**	Farmyard manure +NPK	4,12	
4	Corn for grains*	Farmyard manure +NPK	3,27	
5	Corn for grains*	Farmyard manure +NPK	3,27	
8	Mixture of spring vetch + oats for green fodder**	Unfertilised	3,78	
DI ₀₅			0,10	

*Note: * zero tillage*

*** disc harrow (single pass after harvesting the predecessors)*

The highest yield level was obtained on the fertilised background in crop rotation N2 (after peas for grains) and N8 (after mixture of spring vetch and oats). Thus, direct sowing after a late preceding crop fails to compensate for yield losses compared to the level achieved after early preceding crops. Subsequently, we will analyze water accumulation in the soil after different preceding crops, including with the application of direct sowing. In the case of winter barley sown directly after corn for grains, no significant differences were observed among the studied rotations on a fertilised background.

3.3. Influence of different rates of plant residues on winter barley sown after corn for grains under different fertilisation backgrounds, without the use of chemical means for controlling diseases, pests and weeds

In Experiment 2 (on ecological farming), plots were established each autumn with the application of different rates of crop residues, on various fertilisation backgrounds, within a crop rotation including a mixture of perennial legume and grasses species. No chemical means were used in the experiment for controlling diseases, pests and weeds.

Based on the analysis of the obtained results, the optimal rates of crop residues left on the soil surface were identified, which contributed to achieving the maximum yield level depending

on the fertilisation background (Fig. 3.3). In the absence of fertilisation, the use of crop residues proved to be ineffective, leading to a decrease in yield with increasing amounts of residues. On the variants with both organic and organo-mineral fertilisation, the application of a single dose of residues (5.7 t/ha) proved to be more effective in most cases.

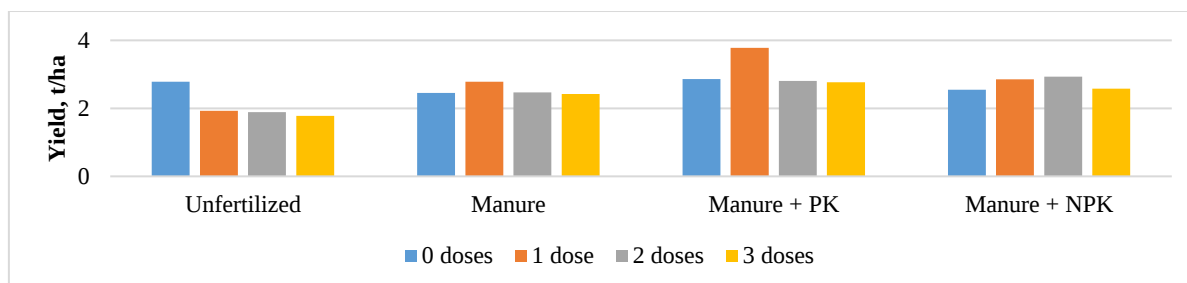


Fig. 3.3. Yield of winter barley on fertilised and different rates of crop residues, average for 3 years

The yield of winter barley sown directly after corn for grain varied significantly depending on fertilisation and, to a lesser extent, on the crop rotation (Table 3.3). The response of winter barley to the crop rotation with perennial leguminous grasses was observed in practically all fertilisation backgrounds, but it was insignificant, with a yield increase ranging between 0.08 and 0.11 t/ha. The 3-year average highlights the influence of fertilisation, particularly in the variants with manure and manure + PK. Here, grain yield ranged between 3.12 t/ha and 3.18 t/ha. Therefore, the increase compared to the unfertilised control was +0.61...+0.97 t/ha.

The additional application of nitrogen fertilisers, on top of the organic background, led to a reduction in yield compared to the PK variant and the farmyard manure treatment.

Table 3.3. Yield of winter barley depending on crop rotation and fertilisation system, average for 2019–2021, t/ha

Fertilisation background	Crop rotation	Yield, t/ha	± from crop rotation, t/ha	± from fertilisation, t/ha	± from N application, t/ha
Unfertilised	With annual grasses	2.21	-	-	-
	With perennial grasses	2.32	+0.11	-	-
Farmyard manure	With annual grasses	2.82	-	+0.61	-
	With perennial grasses	3.12	+0.30	+0.80	-
Farmyard manure + PK	With annual grasses	3.18	-	+0.97	-
	With perennial grasses	3.18	0	+0.86	-
Manure + NPK	With annual grasses	2.88	-	+0.67	-0.30
	With perennial grasses	2.96	+0.08	+0.64	-0.22

CHAPTER 4. INFLUENCE OF THE CONSERVATION TILLAGE SYSTEM ON AVAILABLE SOIL WATER RESERVES

4.1. Possibilities of soil water accumulation depending on preceding crop and tillage methods

The experimental data highlight a higher capacity for soil water accumulation from precipitation in the case of zero tillage with crop residues compared to disc harrowing. On average, over three years, soil water retention under zero tillage variants ranged between 87.1% and 100% (Table 4.1).

Table 4.1. Soil water accumulation during autumn–winter–spring under winter wheat sown directly (No-till), average for 2019–2021, mm

Average for 3 years									
Crop rotation	Soil water reserve at sowing, mm		Soil water reserve at vegetation regeneration, mm		Total amount of precipitations, mm	Water reserve accumulated in different layers, cm		Layer share 0-100 cm, %	Water accumulated from precipitations, %
	0-100	0-200	0-100	0-200		0-100	0-200		
1	62.4	155.4	137.3	274.4	136.6	86.6	119.0	62.9	87.1
2	98.4	243.2	152.9	338.3	136.6	61.9	95.1	57.4	69.6
4	66.6	153.5	162.7	320.8	136.6	114.6	167.2	57.5	100
5	65.6	147.2	152.3	279.0	136.6	104.6	131.8	65.8	96.5
In the dry year 2020									
1	45.2	131.1	96.6	189.5	76.5	51.4	58.4	88.0	76.3
2	84.4	241.7	124.3	293.5	76.5	39.9	51.8	77.0	67.7
4	67.5	155.0	126.9	221.8	76.5	59.4	66.8	88.9	87.3
5	61.0	132.7	112.0	205.7	76.5	51.0	73.0	69.9	95.4

The accumulation and conservation of soil water are of major importance for agriculture in the Republic of Moldova, taken in consideration the local meteorological conditions. In addition to the increasing frequency of droughts, an essential problem is the uneven and variable distribution of precipitation throughout the year. This highlights the need to apply technologies capable of retaining water in the soil.

4.2. Influence of fertilisation, crop rotation, and crop residues on the agrophysical properties of soil for winter barley under direct sowing

The data presented in Figure 4.1 highlight the influence of crop rotation type and fertilisation on the amount of water accumulated in the soil during different agricultural years, in the 0–100 cm and 0–200 cm layers. Under normal climatic conditions (2019), the highest amount of water was recorded in the fertilised variant with annual grasses (196.5 mm, 0–200 cm), suggesting a beneficial effect of these crops in soil moisture accumulation. In the extremely dry

year 2020, the values decreased considerably for all variants; however, the best results were obtained on the fertilised variant with perennial grasses (130.8 mm), demonstrating their superior capacity to conserve water under drought conditions. In 2021, with a more favorable distribution of precipitation, the maximum amount of water was recorded in the unfertilised variant with annual grasses (189.5 mm), while the fertilised variants accumulated less water, possibly due to the higher water consumption of well-developed plants. Overall, the results show that systems with perennial grasses are more stable in maintaining soil water reserves during dry years, whereas annual grasses, in combination with fertilisation, are more effective in accumulating water under normal or wet climatic conditions.

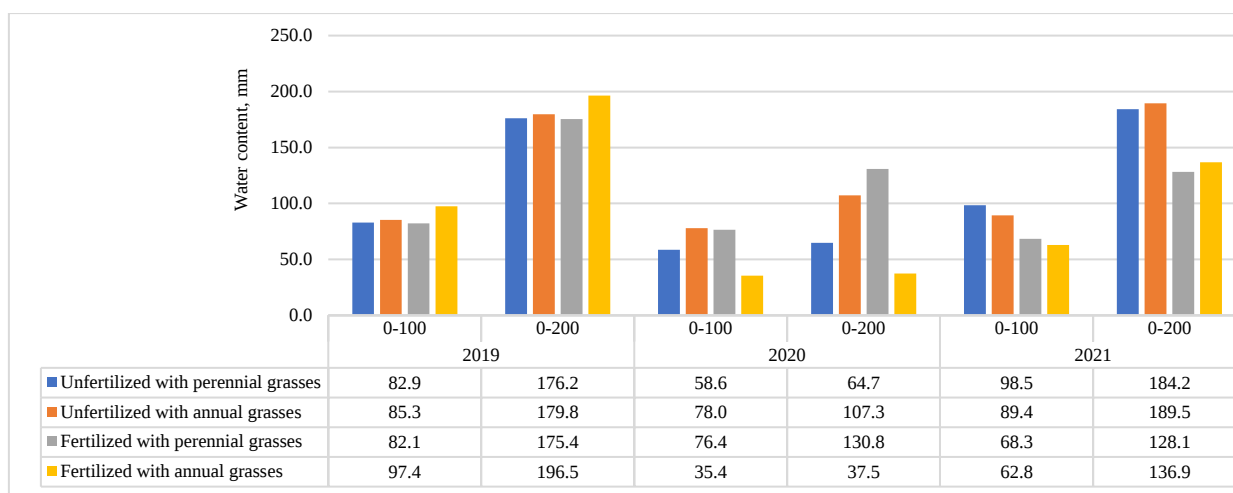


Fig. 4.1. Soil water accumulation in winter barley under direct sowing after corn for grain during the autumn–winter–spring period, average 2018–2020

CHAPTER 5. NUTRITIONAL REGIME AND AGROPHYSICAL PARAMETERS OF THE SOIL

5.1. Agrochemical indicators

According to V.R. Viliams, soil fertility is the capacity of soil to provide plants with terrestrial factors (water and nutrients) [4].

According to Amir Kassam, soil fertility can be defined as „*the capacity of the soil to sustain sustainable plant production in a way that protects and improves soil quality, water quality, biodiversity, and other environmental functions, as well as human health*”. This definition integrates both agricultural and ecological-social aspects, emphasizing the importance of healthy soil and sustainable agricultural practices for environmental protection and human health [15].

Soil organic matter represents any organic matter of plant or animal origin present in the soil that can undergo microbial decomposition. This organic matter is composed of a complex mixture of organic compounds such as carbohydrates, proteins, lipids, and nucleic acids, which enter the soil through plant roots, excretions of microorganisms and animals, and other biological processes [10].

Carbon is an essential element for soil fertility. Soil organic matter, largely composed of carbon, plays a crucial role in maintaining soil health and fertility. It serves as a food source for soil microorganisms, contributing to the formation of a viable and productive soil [9].

According to the research program, the organic carbon content in the soil was determined in the studied experiments. To convert the soil organic carbon (SOC) content into organic matter, a transformation coefficient of 1.724 was used.

Figure 5.1 shows the distribution of SOC by soil layers, determined for the variants studied in the experiment. A gradual decrease in soil organic carbon content can be observed with increasing depth. This trend is characteristic of all studied variants; however, the SOC content determined in crop rotation N5 (crop rotation with perennial leguminous grasses) proved to be higher, even in the deeper soil layers. The difference is particularly evident in the 40–60 cm layer, explained by the greater amount of roots compared to crop rotations that do not include perennial leguminous grasses in their structure.

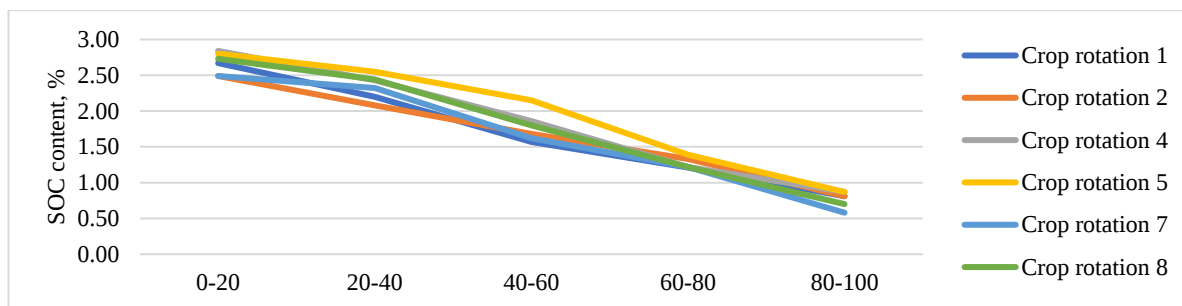


Fig. 5.1. Distribution of SOC content by soil layers depending on crop rotation and fertilisation

The analysis of the average SOC content for the 0–40 cm soil layer highlights crop rotation N 2 and N 5 (Fig. 5.2). The highest SOC content was recorded in the crop rotation with perennial leguminous grasses, reaching 2.68%, compared to the rotation that includes black fallow, where the organic carbon content was only 2.29%, even lower than in the unfertilised background (crop rotation N7). For the 0–100 cm soil layer, the same trend is maintained, with SOC content ranging between 1.68% and 1.95%, emphasizing the same variants.

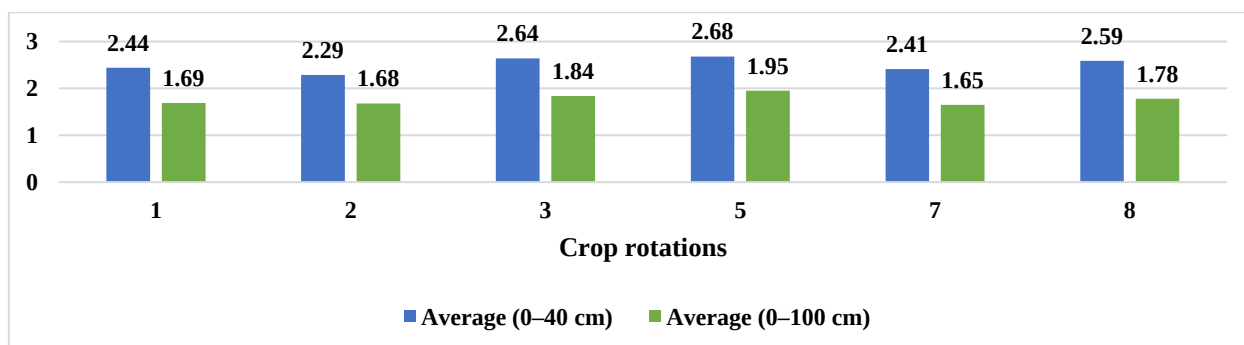


Fig. 5.2. Soil organic carbon content in the long-term crop rotations field experiment, year 2020

The results of SOC content analyses obtained in the ecological farming experiment are presented in Fig. 5.3. According to these data, a lower SOC content is observed here compared to the long-term crop rotation experiment. Thus, the SOC content for the 0–40 cm soil layer ranges between 2.16–2.61%, and between 1.51–1.76% for the entire 0–100 cm profile. At the same time, more pronounced differences are observed in the upper soil layers compared to the deeper ones.

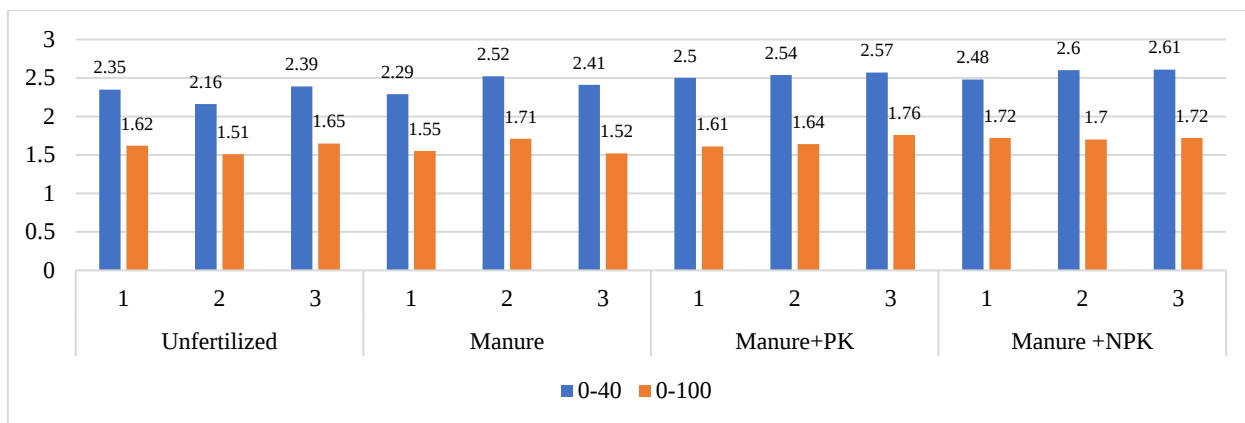


Fig. 5.3. SOC content in the long-term organic farming experiment, year 2020

Annotation:

1. Crop rotation with a mixture of perennial legume and grass species (without additional crop residues applied);
2. Crop rotation with a mixture of perennial legume and grass species (with additional crop residues applied);
3. Crop rotation with annual legume and grass species (without additional crop residues applied).

5.2. Agrophysical indicators

The agrophysical properties of soil influence the growth and development of plants. Although defined differently by various authors, these properties generally include the following indicators: water field capacity, soil structure, bulk density, soil porosity, and texture [25, 30, 8, 19].

For comparative analysis, the experiment included two extremes: permanent black fallow and permanent uncultivated land. As intermediate variants (representing a transition from black fallow to a natural ecosystem), crop rotation N2 (with black fallow) and Crop rotation N5 (with alfalfa) were analyzed. The experimental data indicate an increase in soil carbon content depending on management practices (Fig. 5.4).

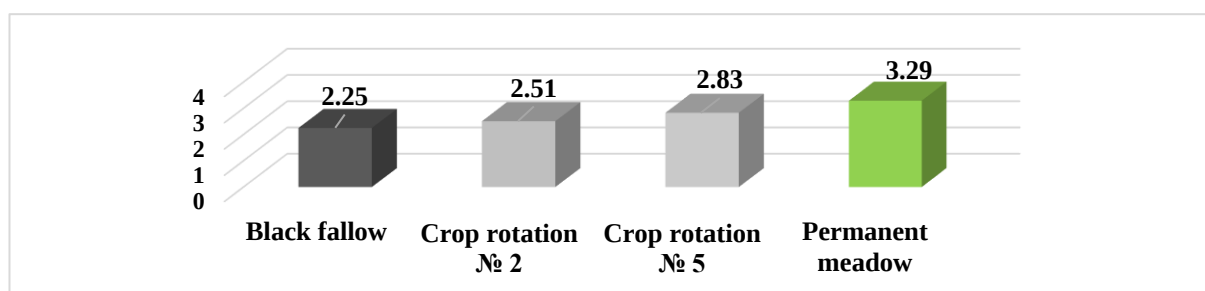


Fig. 5.4. Soil carbon content depending on the studied variants (soil layer 0–20 cm), 2020, Selectia RIFC, %

The lowest soil carbon content was determined in the variant with black fallow under permanent cultivation, amounting to 2.25% in the 0–20 cm layer. In crop rotations, an increase in carbon content is observed, especially when cultivating alfalfa for green mass within the rotation. Here, the carbon content reached 2.83%, being closer to the natural ecosystem (permanent meadow). However, maintaining the soil permanently covered, along with a greater species diversity and the absence of mechanical disturbance, favored the accumulation of the highest amount of carbon in the soil – 3.29%.

The carbon stock in the 0–100 cm soil layer varies depending on the studied variants, ranging between 196.2 and 280.8 t/ha. It increases with the amount of organic matter left in the soil during plant cultivation, particularly from perennial legume grasses (Fig. 5.5). This trend is similar to that observed for soil carbon content.

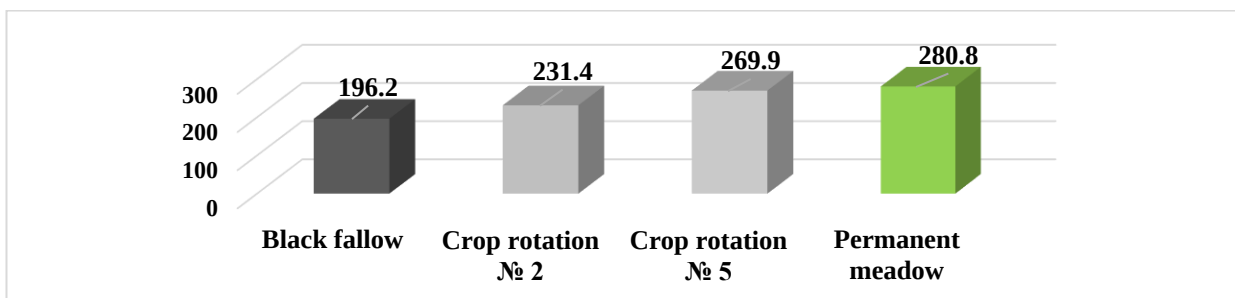


Fig. 5.5. SOC stock in the 0–100 cm soil layer depending on the studied variants, t/ha, 2020, Selectia RIFC, %

Experimental data on the bulk density of the soil demonstrate the relationship between soil organic matter (SOM) content and the soil's agro-physical properties (Fig. 5.6). An opposite trend is observed here, namely a decrease from the black fallow to the meadow. The bulk density of the soil ranged between 1.12 and 1.35 g/cm³. Therefore, the higher the organic matter content, the lower the bulk density of the soil.

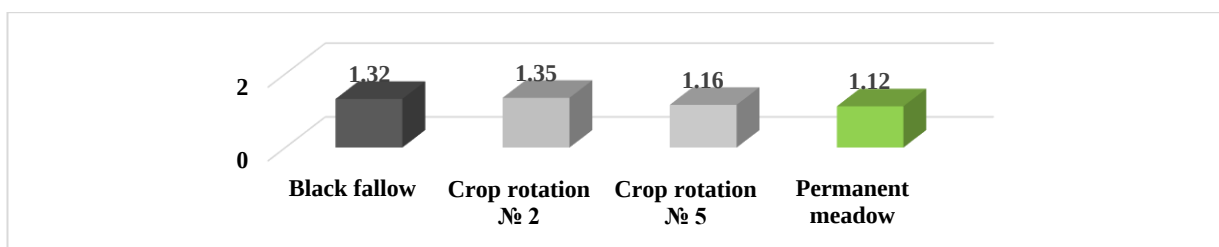


Fig. 5.6. Bulk density of the soil depending on the studied variants, g/cm³, summer 2020, Selectia RIFC

The total soil porosity also varies depending on the SOM content (Fig. 5.7). Thus, for the studied variants it ranged between 46.0 and 55.2%, showing similar values in the case of permanent black fallow and black fallow in crop rotation (46.0–47.2%). Total porosity increased

considerably in the crop rotation with perennial leguminous grasses (53.6%) and in permanent meadow (55.2%).

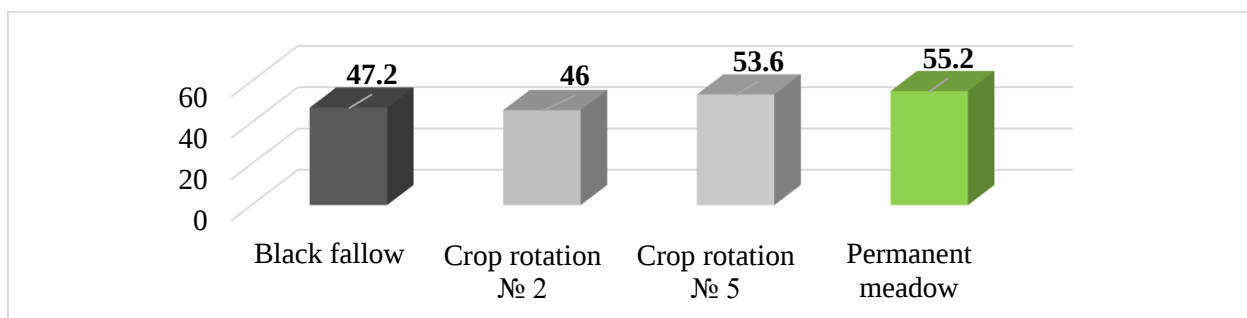


Fig. 5.7. Total soil porosity depending on the studied variants, year 2020, Selectia RIFC, %

Field capacity plays a particularly important role in the soil's ability to accumulate water (Fig. 5.8). To a large extent, this determines the soil's capacity to adapt to droughts, which have become increasingly frequent in recent years.

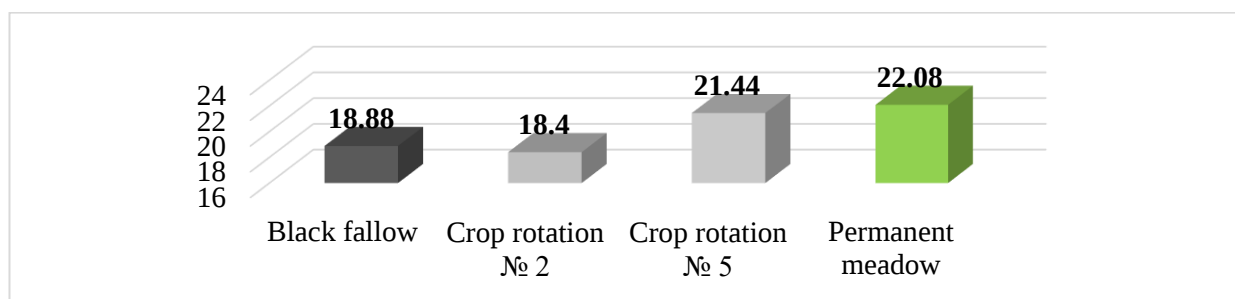


Fig. 5.8. Field capacity of the soil under the studied variants, summer 2020, Selectia RIFC, %

The results of our research confirm the relationship between the soil properties described above and water field capacity. Thus, in variants with lower organic matter content, field capacity is lower, and vice versa. Therefore, we can state that in order to enhance adaptability to droughts, which are often caused by the uneven distribution of precipitation throughout the agricultural year, it is strictly necessary to increase the soil's capacity to store water from atmospheric inputs. This is possible only by increasing the content of soil organic matter, with a simultaneous reduction of soil mechanical disturbance.

CONCLUSIONS AND RECOMMENDATIONS

Following the conducted research, the following conclusions can be formulated:

1. The soils of the Republic of Moldova are exposed to an alarming danger of degradation due to their irrational management, characterized by intensive agricultural practices focused mainly on production and short-term economic profit.
2. The adaptation of agroecosystems to climate change caused by global warming can be achieved by imitating natural ecosystems, using conservation technologies that exclude soil tillage and keep its surface permanently covered. These practices help reduce the negative impact of biotic and abiotic factors on crops.
3. Excluding soil tillage (zero tillage) in the cultivation of winter wheat after maize for grain contributes to higher efficiency of water accumulation in the soil. On average, over three years, the water retention capacity from precipitation ranged between 87.1% and 100%, and in the dry year 2020, between 76.3% and 95.4%. By comparison, under minimum tillage, the average values for three years were 69.6%, and in the dry year 2020 – 67.7%.
4. The inclusion of perennial grasses in crop rotation facilitates carbon accumulation throughout the entire soil profile. The SOC content in the 0–100 cm soil layer reached 1.95% in the crop rotation with alfalfa and 1.68% in the crop rotation with black fallow.
5. A high SOC content ensures a granular soil structure and improves water storage capacity. Consequently, improving agrophysical properties can provide better adaptation to climate change.
6. Winter barley shows a stronger response to fertilisation compared to winter wheat. In favorable years, the application of fertilisers led to a yield increase of 2.27 t/ha (135%) compared to the unfertilised variant. In the case of winter wheat, the yield increase obtained from fertilisation was 0.63 t/ha, exceeding the unfertilised variant by 34%.
7. Winter wheat responds better to crop rotation and preceding crops than to fertilisation, and the importance of the preceding crop increases significantly under drought conditions due to its influence on soil water reserves. The earlier the preceding crop is harvested, the greater the possibility of accumulating a larger amount of precipitation water in the soil before sowing (34.5–47.8 mm).
8. Fertilisation under excessive moisture conditions can cause significant yield losses due to the abundant growth of plant aerial biomass and lodging.

RECOMMENDATIONS

1. The Republic of Moldova needs to intensify fundamental and applied scientific research aimed at developing a new agricultural system based on sustainable (regenerative) soil resource management, as an essential element in the process of adapting to climate change.

2. For the adaptation of agricultural ecosystems to climate change, we recommend reducing or excluding soil mechanical disturbance, while keeping its surface permanently covered with live or dead mulch.

3. The soils of the Republic of Moldova require improvement of their agrophysical properties; therefore, the inclusion of mixtures of leguminous and perennial grasses in crop rotation is crucially important.

4. Winter cereal crops can be successfully cultivated using direct seeding, while respecting crop rotation, even after late preceding crops, and also in the absence of chemical means of controlling diseases, pests, and weeds, by respecting the entire agricultural system.

5. In the cultivation of winter wheat, regardless of the applied cultivation technology, it is important to take into account the preceding crop, especially in dry years. Under such conditions, the preceding crop plays a more important role than fertilisation.

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ADNOTARE

Cebanu Dorin „Sistemul Conservativ de Agricultură în zona de Nord a Republicii Moldova”, teză de doctor în științe agricole, Bălți, 2025

Structura tezei: introducere, 5 capitole, concluzii generale și recomandări, 117 pagini de text de bază, bibliografie din 109 surse, 42 tabele, 34 figuri. Rezultatele obținute au fost publicate în 9 lucrări științifice.

Cuvinte cheie: agricultura conservativă, fertilitatea solului, materia organică a solului, managementul durabil și rezilient a solului, cernoziom, degradarea solului, încălzire globală, sechestrarea carbonului, producția culturilor, asolament.

Scopul lucrării: constă în examinarea posibilității adoptării lucrării zero a solului la cultivarea culturilor cerealiere de toamnă, în special a grâului și orzului de toamnă, în contextul respectării unui asolament diversificat.

Obiectivele cercetării: includ studierea condițiilor climaterice, evaluarea producției culturilor cerealiere de toamnă în funcție de diferite procedee agrotehnice aplicate, determinarea consumului de apă și a rezervei de apă accesibilă din sol pe parcursul perioadei de vegetație, analiza efectelor asolamentului și a resturilor vegetale asupra producției agricole și evaluarea impactului lucrării zero a solului asupra posibilității de adaptare la secetele tipice pentru Nordul Republicii Moldova.

Noutatea și originalitatea științifică: derivă din abordarea holistică și integrată a diferitelor aspecte legate de procedeele agrotehnice, tehnologiile de cultivare prin influența lor asupra solului și a producției agricole. Lucrarea se distinge prin analiza detaliată a impactului lucrării zero a solului (No-tillage) asupra producției culturilor cerealiere de toamnă (grâu și orz de toamnă), cu o atenție deosebită asupra asolamentului și a practicilor de management a resturilor vegetale. Un alt aspect relevant constă în evaluarea posibilității acumulării apei în sol folosind diferite tehnologii de cultivare cu aplicarea lucrării zero a solului, în condițiile repartizării neuniforme a precipitațiilor atmosferice cu evidențierea avantajului sistemului conservativ de lucrare a solului în raport cu procedeele convenționale.

Rezultatul obținut care contribuie la soluționarea unei probleme științifice importante: constă în argumentarea necesității tranziției la un nou sistem de agricultură, capabil să răspundă provocărilor alarmante cu care se confruntă agricultura contemporană, inclusiv degradarea solurilor și încălzirea globală. Rezultatele cercetărilor confirmă creșterea capacității de acumulare a apei în sol la păstrarea resturilor vegetale de porumb la suprafața solului prin folosirea lucrării zero a solului, cu reducerea concomitentă a cheltuielilor de producere la culturile cerealiere de toamnă. Rezultatele obținute oferă un suport științific solid pentru necesitatea adoptării unei

strategii agricole sustenabile, capabile să protejeze resursele naturale și să minimizeze impactul negativ al activităților agricole asupra mediului înconjurător.

Semnificația teoretică: cercetările științifice efectuate contribuie la aprofundarea cunoștințelor în domeniul cultivării culturilor de câmp, folosind diferite sisteme de agricultură în diferite condiții climaterice. Analiza datelor obținute a confirmat posibilitatea refuzului de lucrarea solului în cazul respectării întregului sistem de agricultură, bazat pe asolament, folosirea resturilor vegetale, folosirea îngrășămintelor organice etc. Rezultatele obținute permit promovarea sistemului conservativ de agricultură prin respectarea unui management durabil și rezilient a solului de cernoziom.

Valoarea aplicativă: rezultatele obținute în cadrul cercetărilor realizate pe unele elemente a Sistemului Conservativ de Agricultură (SCA) reprezintă un pilon esențial în tranziția spre sistemele agricole durabile. Prin adaptarea sistemului de agricultură conservativă la condițiile specifice locale, aceste rezultate servesc drept bază solidă pentru educația și informarea fermierilor, studenților și lucrătorilor științifici în vederea adoptării unui sistem durabil de agricultură adaptat la provocările actuale ale agriculturii.

АННОТАЦИЯ

Чебану Дорин «Консервативная Система Земледелия в Северной Зоне Республики Молдова», диссертация на соискание ученой степени доктора сельскохозяйственных наук, Бельцы, 2025 г.

Структура диссертации: введение, 5 глав, общие выводы и рекомендации, 117 страниц основного текста, библиография из 109 источников, 42 таблицы, 34 рисунка. Результаты работы опубликованы в 9 научных работах.

Ключевые слова: консервативное земледелие, плодородие почвы, органическое вещество почвы, устойчивый и жизнеспособный менеджмент почв, чернозём, деградация почвы, глобальное потепление, секвестрация углерода, растениеводство.

Цель работы: изучить возможности применения технологии нулевой обработки почвы (No-till) при возделывании озимых зерновых культур, в частности озимой пшеницы и озимого ячменя, в контексте диверсифицированного севооборота на типичном черноземе Бельцкой степи.

Задачи исследования: оценка производства озимых зерновых колосовых культур в условиях разных климатических условий и различных агротехнических приемов, определение накопления и потребления воды из доступных запасов воды в почве в течение вегетационного периода, анализ влияния почвы и растительных остатков на производство сельскохозяйственных культур и оценка влияния технологии с применением нулевой обработки почвы на возможности адаптации к засухам, характерным для севера Молдовы.

Научная новизна и оригинальность: обусловлена целостным и комплексным подходом к различным аспектам агротехнических приемов, технологий возделывания сельскохозяйственных культур через их влияние на почву и сельскохозяйственное производство. Работа отличается подробным анализом влияния технологии с применением нулевой обработки почвы на производство озимых зерновых колосовых культур, включая озимую пшеницу и озимый ячмень, с учетом методов обработки почвы и управления растительными остатками.

Другим актуальным аспектом данной работы является оценка возможности накопления почвенной влаги при использовании различных технологий обработки почвы в условиях неравномерного распределения атмосферных осадков с выявлением преимуществ ресурсосберегающей обработки почвы по сравнению традиционными методами.

Полученный результат, способствующий решению важной научной проблемы: экспериментальные данные, позволяют аргументировать необходимость перехода к новой системе земледелия, способной ответить на вызовы, с которыми сталкивается современное

сельское хозяйство, включая деградацию почв и глобальное потепление. Результаты исследований подтверждают увеличение влагоемкости почвы при сохранении растительных остатков кукурузы на поверхности почвы с помощью No-till, с одновременным снижением затрат на производство озимых зерновых колосовых культур. Они служат убедительным научным подтверждением необходимости одобрения стратегии устойчивого развития сельского хозяйства, обеспечивающей защиту природных ресурсов и минимизацию негативного воздействия сельскохозяйственной деятельности на окружающую среду, с одновременным повышением конкурентноспособности фермеров.

Практическое значение: проведенное научное исследование вносит вклад в углубление знаний в области возделывания полевых культур при использовании различных систем земледелия в различных климатических условиях. Анализ полученных данных подтвердил возможность отказа от механической обработки почвы при соблюдении целостной системы земледелия, основанной на применении обработки почвы, использовании растительных остатков, применении органических удобрений и т.д. Полученные результаты позволяют расширять площади под консервативную систему земледелия при соблюдении устойчивого менеджмента черноземной почвы.

Значение для применения: результаты исследований по консервативной системе земледелия (КСЗ) являются важнейшим элементом перехода к устойчивым методам ведения сельского хозяйства. Адаптируя консервативную систему земледелия к конкретным местным условиям, эти результаты служат прочной основой для обучения и информирования фермеров, студентов и научных работников в целях внедрения устойчивой системы земледелия, адаптированной к современным сельскохозяйственным проблемам.

ANNOTATION

Dorin Cebanu “Conservation Agriculture System in the Northern Part of Moldova”, PhD thesis in agricultural sciences, Balti, 2025

Structure of the thesis: introduction, 5 chapters, general conclusions and recommendations, 117 pages of basic text, bibliography from 109 sources, 42 tables, 34 figures. The obtained results were published in 9 scientific papers.

Keywords: conservation agriculture, soil fertility, soil organic matter, sustainable and resilient soil management, chernozem, soil degradation, global warming, carbon sequestration, crop production, crop rotation.

The purpose of the work consists in examining the possibility of adopting No-till technology for the cultivation of winter cereal crops, especially winter wheat and winter barley, in the context of respecting a diversified crop rotation on the Typical Chernozem of the Balti steppe.

The objectives of the research: include the study of climatic conditions, the evaluation of the yield of winter cereal crops according to different agricultural practices, the determination of water consumption and the stocks of soil moisture during the vegetation period, the analysis of the effects of crop rotations and plant residues on agricultural production and evaluation of the impact of No-till technology on the possibility of adaptation to droughts typical for the North part of the Republic of Moldova.

Scientific novelty and originality: derives from the holistic and integrated approach to various aspects related to agricultural practices, cultivation technologies through their influence on soil and agricultural production. The paper is distinguished by its detailed analysis of the impact of No-till technology on the production of winter cereal crops, including winter wheat and winter barley, with special attention to crop rotations and crop residues management practices. Another relevant aspect consists in evaluating the possibility of water accumulation in the soil by using different cultivation technologies, under the conditions of uneven distribution of atmospheric precipitation, highlighting the advantage of the conservative tillage system in relation to conventional practices.

The result obtained that contributes to the solution of an important scientific problems: consists in arguing the need for the transition to a new agricultural system, capable to responde to the challenges faced by modern agriculture, including soil degradation and global warming. The results of the research confirm the increase in soil capacity to accumulate water by keeping the surface of the soil covered with crop residues, with the simultaneous reduction of production costs for winter cereal crops. The obtained results provide solid scientific support for

adoption of a sustainable agricultural strategy, capable to protect natural resources and to minimize the negative impact of agricultural activities on the environment.

Theoretical significance: the scientific research carried out contributes to the deepening of knowledge in the field of cultivation of field crops, using different farming systems in different climatic conditions. The analysis of the obtained data confirmed the possibility of refusing to tillage the soil in case of respecting the entire agricultural system, based on crop rotation, the use of plant residues and organic fertilizers etc. Experimental data allow the promotion of the conservative farming system by respecting a sustainable and resilient management of the chernozem soil.

Applicative value: the results obtained within the framework of the research carried out on the Conservation Agriculture System (SCA) represent an essential pillar in the transition towards sustainable agricultural practices. By adopting the conservation farming system to site - specific local conditions, these results serve as a solid basis for educating and informing farmers, students and scientific workers in order to make the transition to a sustainable farming system adapted to the current challenges of agriculture.

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