WATER -PHYSICAL PROPERTIES OF CHERNOZEM SOILS UNDER NO-TILL AND MINIMUM TILL TECHNOLOGIES OF WHEAT CULTIVATION

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Abstract

The paper presents results of preliminary research on the full or partial reduction of mechanical soil operations, that is perspective research direction. The reduced soil ploughing technologies are not well tested in Kazakhstan soils. Therefore, any information and knowledge for better understanding the influence of minimum till and no-till technologies on soil characteristics under the dry-steppe conditions of northern Kazakhstan is important. Reduced soil cultivation technologies have been successfully applied in some other countries, however the climatic conditions of dry-steppe are unique and requires detailed studies. Moisture deficit in the chernozem soils of dry-steppe area of northern Kazakhstan remains one of the most urgent problems of the Republic's agricultural sector. Solving this problem can be achieved based on water and energy saving technologies such as no-till and minimum till may. The aim of the research was to study the effect of minimum and no-till technologies on soil water and physical properties, as well on content of soil organic matter.

Keywords: soil moisture; dry-steppe; no-till; minimum-till

INTRODUCTION

An important link in the system of measures to ensure a high culture of farming, increase soil fertility and crop yields is a rational soil cultivation, which improves its air, water, temperature and nutrient regimes. Cultivating plants on the soil, the man tries to obtain as much production as possible from the unit of its area. For this, we impose various meliorative and agrotechnical treatments, thereby changing the quality of soils. These impacts lead to an increase or decrease in soil fertility, which is always associated with the composition and properties of soils.

All existing adapted soil treatment systems have one common drawback, they are very energy intensive. Therefore, ecologically-energy-saving but-till technology was widely introduced, which was widely used in Brazil, Argentina, USA, Canada, Australia, France and other countries (Baker et al., 1996; Derpsch and Friedrich, 2009; Baccouri, S. 2008; Antonio

C.A. Carmeis Filho, 2016). Reduced till technologies is being tested in Kazakhstan, on chernozem soil of Kostanai Institute of Agriculture.

Water-physical properties of soils have a very direct impact on the life and development of plants, so their correct regulation is one of the most important tasks of the study (Shaver et al., 2002).

The study region of northern Kazakhstan is characterized with sharp-continental climate that is subject to wind and water erosions. The area is experiencing lack of precipitation what is serious problem for agricultural production, considering that the region belongs to the main grain production area in the Republic (Saljnikov, 2004).

Moisture deficit in the chernozem soils of steppe area of northern Kazakhstan remains one of the most urgent problems of the Republic's agricultural sector. It is obvious that solving the problems can be achieved based on water-, soil-, energy- and resource-, saving technologies. The technologies such as no-till and minimum till may serve as a key lever for the farmers of the region.

In the conditions of non-irrigated monoculture of wheat these technologies can significantly improve soil fertility through better control of wind and water erosions, through improve of soil physical properties, and soil organic matter content. Also, no-till and minimum till technologies considerably reduce number of soil operations thus reducing all other costs.

Kazakhstan was a leader in Eastern Europe and Central Asia regions in introduction of zero-technologies in 2008 and keeps leading positions. Introduction of no-till technology on 1 million 800 thousand hectares in Kazakhstan, resulted in increase of wheat production in 2012 year for 717.9 thousand tonnes.

The aim of the research was to study the soil water-physical and main agrochemical properties under minimum and no-till technologies.

MATERIALS AND METHODS

The research was done based on Kostanai Research Institute of Agriculture. The soil samples were taken from the key soil profiles on chernozems on no-till and minimum till plots. The soil profiles were set up on a hollow sloping plain of the upper floodplain terrace on the right bank of the Tobol River, which is composed of Quaternary alluvial deposits, sandy loams, sands, clayey sands, loams and clays. The climatic data of the studied area in the studied period is presented in Table 1.

Table 1. Distribution of precipitation in vegetation season in studied years for studied region, mm

Years	May	June	July	August	SUM
Many-year average	31.0	45.0	50.0	30.0	156
2012	28.1	26.8	23.0	101.1	179
2013	20.6	9.7	106.6	-	146.9

On the no-till and minimum till treatments the depth of carbonates, structure, density, moisture characteristics were determined. Content of humus was determined by Tyurin methods; total nitrogen was determined by Kjheldal methods; carbonates by gas-volumetric method; Soil pH -potentiometrically in water solution; specific gravity – by pycnometer; soil moisture -by thermal drying; wilting point – by calculation from maximum hygroscopic value (using coefficient 1.34) (Mineev, 2001).

RESULTS AND DISCUSSION

The studied 2012 and 2013 the most important moths in vegetation of wheat (May-July) were very dry. Correlation analyses between cereal quality and amount of precipitation showed that grain yield depends on the precipitation of June-July, while the quality of grain depends on the precipitation of August-September. The more precipitation in June-July the higher grain yield, and the less precipitation in August -September at higher air temperature the technological characteristics of grain are better (Kabanov, 1975).

Water physical properties of the studied chernozem soil depending on the applied technologies of cultivation are presented in Table 2.

An average moisture content in surface 0-10 cm significantly differed between cultivation technologies. No-till technology maintained the highest accumulation of moisture in all soil depth up to 50 cm, while the traditional tillage maintained the least. The same trend was observed for the moisture reserve, maximum hygroscopic humidity and wilting point by soil layers. Similar results were obtained by other studies (Herero et al., 2001; Antonio C.A. Carmeis Filho, 2016).

Wilting point at no-till technology was not decreasing by depth, but slight increase was observed, while in case of traditional ploughing wilting point was decreasing along soil depth. Specific gravity of soil was highest in 0-10 cm at traditional cultivation and lowest at minimum till treatment.

The most optimal soil density was observed at no-till technology (1.07 g/cm^3) against 1.23 and 1.19 g/cm^3, in minimum and traditional cultivation technologies, respectively.

Table 2. Water-physical properties of chernozem soil at no till, minimum and traditional technologies of wheat cultivation

Depth, cm	Average moisture content, %	Average soil density, g/cm^3	Total porosity, %	Full moisture capacity, %	Moisture reserve, m^3	Maximum hygroscopic humidity, %	Specific gravity, %	Wilting point, %
No till								
0-10	14.05a	1.07a	58a	54.21a	15.03a	7.99a	42.97a	10.71a
10-20	21.15	1.06	58	54.72	22.42	8.56	35.59	11.47
20-30	21.22	1.05	58	55.24	22.28	8.52	35.72	11.42
30-40	17.75	1.09	57	52.29	19.35	8.50	37.65	11.39
40-50	14.57	1.16	54	46.55	16.90	8.30	37.10	11.12
Minimum till								
0-10	10.92b	1.23b	51a	41.46b	13.43b	6.51ab	37.57b	8.72b
10-20	15.52	1.26	50	39.68	19.55	6.40	30.45	8.58
20-30	13.92	1.30	48	36.92	18.09	6.45	29.91	8.64
30-40	10.25	1.55	38	24.52	15.88	3.93	22.11	5.27
40-50	9.15	1.60	36	22.50	14.64	8.09	21.36	10.84
Traditional till								
0-10	6.25c	1.19a	57a	52.29a	6.81c	5.87ab	50.19c	7.86b
10-20	13.82	1.15	54	46.95	15.89	5.56	38.11	7.45
20-30	11.70	1.29	49	37.98	15.09	4.98	33.91	6.67
30-40	10.02	1.30	48	36.92	13.03	5.31	34.98	7.11
40-50	9.05	1.40	44	31.43	12.67	3.84	31.33	5.14

Higher moisture accumulation and better physical properties of soil under no-till technology is directly associated with the minimization of mechanical operations on soil. Less mechanical disturbance of soil and absence of ploughing allow to keep crop residues intact on soil surface (Shaver et al., 2002).

The wheat stubble stands protect soil from drying via reduction of evaporation, which contribute not only to soil physical protection from wind and water erosions but also contribute to soil organic matter. This is confirmed by higher content of humus under no-till technology comparing to minimum till (Table 3).

Contents of humus, hydrolysable nitrogen, total nitrogen and total K_2O were significantly higher under no-till technology.

The high stubble left in the fields at no-till technology retains and accumulates more snow, and the crushed and scattered straw due to biological degradation improves the structure and quality of the soil. All these measures contribute to retaining moisture in soil that is the most important factor of sustainable production of wheat in non-irrigated regions of the Kazakhstan.

Table 3. Chemical properties of chernozem soil at minimum and no till technologies of wheat cropping

Depth, cm	Humus, %	Carbonates	pH	Hydrolysable N, %	Total N, %	Total K_2O
			No-till			
0-10	4.96a	0	7.94a	39.2a	0.266a	1.74a
10-20	4.56	0	7.90	36.4	0.266	1.70
20-30	3.75	0	8.05	33.6	0.238	1.64
30-40	3.55	0	8.24	28.0	0.210	1.53
40-50	3.24	2.39	8.45	19.6	0.182	1.53
			Minimum till			
0-10	4.05b	0	7.0b	11.2b	0.168b	1.53a
10-20	3.55	0	7.3	8.4	0.168	1.38
20-30	3.04	0	7.4	11.2	0.168	1.35
30-40	1.93	0	7.7	5.6	0.098	1.01
40-50	0.91	0.09	8.0	5.6	0.042	0.74

Content of soil humus and total nitrogen were significantly higher under No-till, but content of hydrolysable N under No-till versus minimum till was almost 4-times more. This phenomenon is explained by composition soil organic matter, which consists of fractions differing in time residence. The so-called light fraction OM is a more labile, i.e. faster decomposes. The bulk of light fraction OM comes from plant residues. In our case it is wheat residues. Under non-disturbed crop residues status, the more “light” fraction is accumulated on soil surface, which serves not only as a physical protection of soil but also as a permanent source of labile organic matter (Saljnikov-Karbozova, 2004). The improved soil microbiology status of soil under no-till also contributes to the better biological cycling of SOM (Helgason et al., 2010).

The preliminary studies on the effects of minimum tillage and no-till technologies on soil properties showed that reduced mechanical operation on soil and direct seeding positively influenced soil water-physical properties and enhanced soil organic matter content. These studies are being continued to reveal effects of the applied technologies on crop production, other soil properties, and to see longer effects of studied minimum and no-till technologies on chernozem soil in dry-steppe area of Kazakhstan.

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