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Change of water regimen of typical chernozem depending on systems of soil cultivation

Tsentylo L.

National University of Life and Environmental Sciences of Ukraine, 15 Heroiv Oborony Str., Kyiv, 03041, Ukraine; e-mail: agrokolos@i.ua

The purpose. To determine influence of different systems of basic soil cultivation on water regimen of soil and productivity of cultures of crop rotation. **Methods.** Field, statistical (statistical analysis of results of researches). They spent experiments according to conventional procedures in farming agriculture. Weather conditions during researches on the average were typical for Kyiv area, however, differed on rainfall amount and sum of active temperatures above 10°C in separate months and years. Therefore productivity of crops varied. **Results.** Water permeability of soil at shallow subsoiling with simultaneous slotting was in 1,4 – 1,6 times above, than at moldboard soil cultivation. At shallow subsoiling cultivation with simultaneous slotting available water capacities were on 5,6 – 21 mm above, than at moldboard one. Water accumulation efficiency at subsoiling cultivation was on 2 – 10 % below, than at subsoiling with simultaneous slotting. In alternative with application of regular subsoiling productivity of Lucerne was on 0,2 t/hectares below, than at moldboard. At application of shallow subsoiling with simultaneous slotting productivity lowered slightly. Use of subsoiling cultivation significantly lowered productivity of winter wheat in comparison with productivity at use of moldboard cultivation. Productivity of summer barley at shallow cultivation with simultaneous slotting was on 5,1% above, than at moldboard cultivation. **Conclusions.** Application of shallow subsoiling cultivation with simultaneous slotting formed the best conditions for rational use of stores of soil moisture. The highest productivity of winter wheat and summer barley was formed in alternative with shallow subsoiling cultivation and simultaneous slotting. The productivity of Lucerne gained at moldboard cultivation was on 1,5% above, than at subsoiling cultivation and on 5,1% above, than at shallow subsoiling cultivation with simultaneous slotting.

Keywords: *water permeability, available water capacities, productivity, moldboard cultivation.*

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One important factor in increasing crop yields is the proper use of basic tillage systems. In the context of global warming, reduced precipitation, the use of traditional basic tillage does not always justify itself. Therefore, the development and research of new systems of basic tillage should contribute to improved moisture accumulation, rational use of plant moisture and prevention of its unproductive costs through evaporation.

Analysis of recent studies and publications. Lack of moisture during the growing season often leads to a sharp fluctuation of the crop by years [1], so all agrotechnical measures, including mechanical tillage, should first of all be directed to the accumulation, conservation and rational use of moisture by plants.

Rain and irrigation are the main source of providing plants with accessible moisture. During the growing season, precipitation is particularly important. At the beginning of spring vegetation, the available moisture in both arable and meter soil is 70-80% of the marginal field moisture capacity [2].

Most scientists in their publications argue that it is advisable to conduct non-polishing treatments for better moisture content of plants. Yes, FF Lauckart [3] explains this advantage by lowering moisture loss by reducing soil porosity, improving microrelief, and maintaining stubble on the surface of the field.

Due to this, the disc compared to the usual plowing on the typical black earth, according to Yu.I. Vizuzova [4], contributes to the increase of soil moisture reserves by 80-320 m per hectare of arable land. This is the opinion of other scholars [5, 6]. The ambiguity of views has led us to study this question regarding the cultivation of soil for barley, winter wheat and maize.

The purpose of the research is to determine the influence of different systems of basic tillage on the water regime of the soil and the yield of crop rotation.

Materials and methods of the study. The experimental part of the work was carried out on the experimental field of the Scientific and Educational Innovation Center of Agrotechnology PLC «Agrofirm Kolos» (2011 – 2017) of the Skvyra district (Kyiv region) in the stationary experiment, a comparative evaluation was conducted to study the soil protective effectiveness of the variants of the basic cultivation of the soil.

The alternation of crops in the experiment is as follows: alfalfa – winter wheat – corn for grain – barley with alfalfa sowing.

1. Shelf tillage - control;
2. Non-shelf multi-depth tillage;
3. Shallow unpolished tillage with simultaneous sliding

Soil of the experimental field is typical chernozem. Humus content in the cultivated layer 4.6 – 4.8% (according to Tiurin), lightlyhydrogenated nitrogen (Cornfield) – 14.4 mg/100 g of soil, mobile phosphorus (Chirikov) – 15,2 mg/100 g of soil, exchangeable potassium – 15.2 mg/100 g of soil (Chirikov). The soil volume in the equilibrium state is 1.24 g/cm^3, hydrolytic acidity – 1.14 mg ek/100 g soil, saline pH – 6.4.

In the control variant, the basic tillage was performed by PLN-3-35 in a ring-spur roller unit, under winter wheat to a depth of 20-22 cm, corn to grain - 25-27 cm, barley - 20-22 cm.

In the second embodiment, the main soil cultivation was carried out by chisel deep-ripening AGH - 1.8 by 20-22 cm, pre-sowing cultivation KN-4.8.

In the third embodiment, the basic tillage was carried out by 10-12 cm with a 35-40 cm flattening of the flat-cutter PNN-2.5.

The placement of options is systematic, the size of the sowing area is 8.5 * 40 = 340 m^2, accounting 6.5 * 30 = 195 m^2. Repeat three times. Soil samples were taken up to 100 cm.

Investigation of the water properties of the soil was carried out at the beginning and at the end of the growing season: soil moisture was determined by layer thermostatic-weight method according to S. A. Vadunina, Z. A. Korchagina (1986), stocks of available moisture - by the method of calculation of B.A. Dospekhov, I.P. Vasilyeva, A. M. Tulikova (1977), soil permeability - using a PVN device by the method. N. S. Nester.

The findings of the study. Research results. Water permeability greatly influences the water balance and the precipitation. The value of water permeability is especially great on the slope lands, which are subject to erosion processes [7].

Water permeability is greatly influenced by soil tillage, its intensity and depth. Researches by V.V. Medvedev [8] have shown that soils in natural conditions have better filtration properties than those that are burnt for a long time. This is due to the fact that in the old-earth soils a plow sole was formed, which retains the penetration of water into the deeper layers of the soil, as well as the lost continuity of soil pores formed by dead roots and mesofauna [9].

The study of the water permeability of the chernozem typical showed that the experimental site is characterized by unsatisfactory and satisfactory estimates according to N.A. Kachinsky. In most terms, the determination of water permeability values did not exceed 1 mm/min.

Under the influence of tillage systems, the water permeability of the soil varied. In both the first and the seventh year of the study, the highest water permeability was observed in the variant, where the shallow tillage was performed with a simultaneous slit. In this variant, in 2011–2012, 37.0 mm of water was absorbed in the first observation period, and 2 times less in shelf processing. In the following times, the advantage of unmanned tillage over plowing was 7.3 mm. In 2016–2017, this dependence persisted, and the advantage of small unpolished tillage with a slit in the first and third time of observations was 12.0 and 22.8 mm, respectively (Fig. 1).

The permeability of shallow tillage with simultaneous tapping was 1.4–1.6 times higher than that of soil tillage. The option of uncultivated tillage, made to the depth of plowing, occupied an intermediate position.

Substantial increase in water permeability during shallow tillage, compared with shelving, is explained by the better structural condition of the soil, the absence of soil crust, the presence of mulch and crevices, as well as the active life of soil fauna.

The mulch in the optimal amount increases the temperature of the soil in winter and lowers in the summer, removing peaks of temperatures and thus creating optimal conditions for the activity of the soil biological complex. It delays excessive evaporation of moisture from the soil, promotes even distribution of water in both the surface and in the lower layers, which increases the humidity.

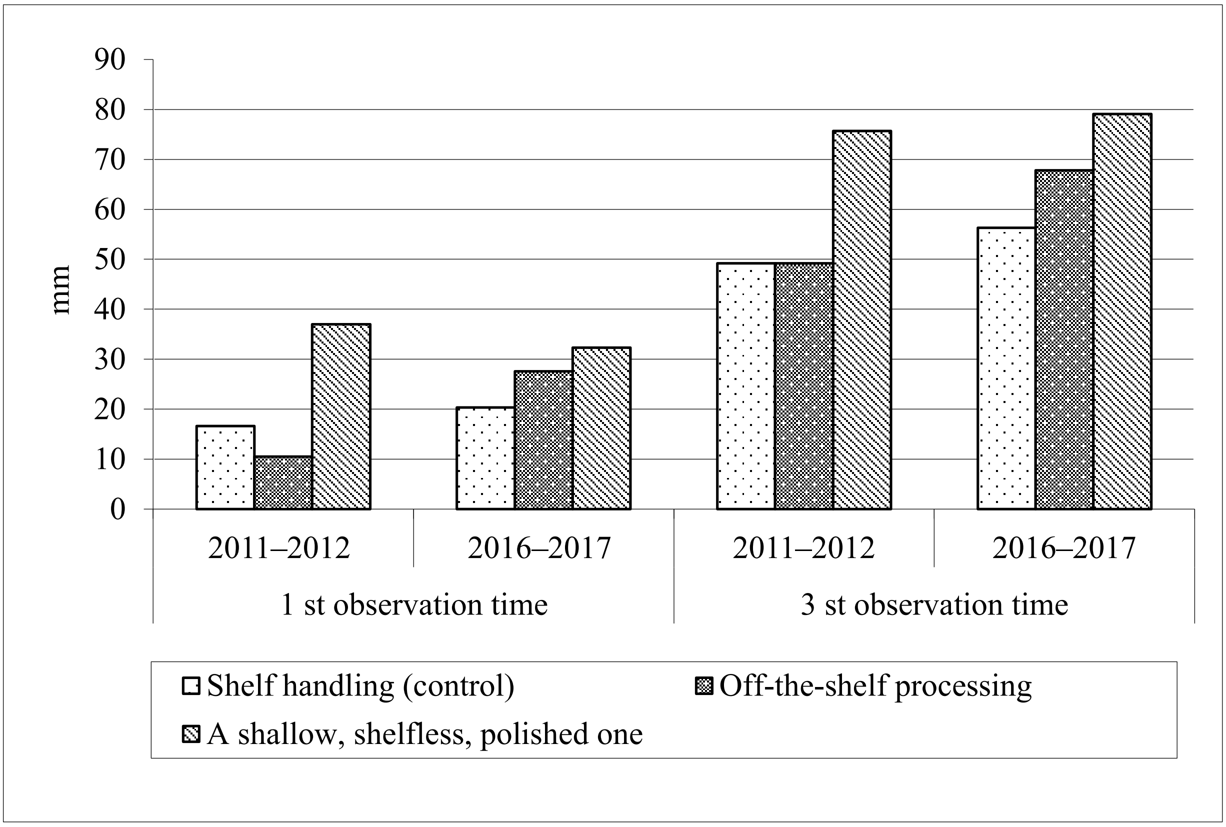

Fig. 1. Water permeability of black soil typical for different soil tillage systems, mm

Greater snow accumulation and less depth of soil freezing during fieldless cultivation contributed to the increase of moisture reserves. According to OG Tarariko [10], the moisture in the meter layer by spring increased by 10% more than during the cultivation of spring crops in variants with fieldless cultivation carried out to the depth of plowing. However, the maximum moisture-accumulating effect is obtained by shallow, non-polishing treatment with punching. Here, stocks of available moisture increased by 12–21 mm, or by 16–17% (Table).

On winter wheat and perennial grasses, fieldless cultivation together with crevassing increased moisture reserves by 7–12 mm, which is caused by the transfer of surface runoff of meltwater into groundwater.

Maximum moisture accumulation efficiency is achieved by shallow tillage of the soil carried out with simultaneous tapping. In this embodiment, depending on the culture grown, the available moisture was 5.6–17.6 or 6.5–21 mm higher than that of the shelf cultivation. Similar research results were obtained on chernozem soils [11, 12, 13] The moisture accumulation efficiency of field-free tillage conducted at plowing depth was slightly lower and was 2–10%.

In the event that the same amount of precipitation falls and their supply to the soil, different moisture reserves accumulate, as those plants that have a high water consumption utilize it more.

We have established correlations between the total porosity and the available moisture reserves at the end of winter wheat growing r = –0.21 ± 0.37, the regression equation B = 51.2–0.025X, which indicates a weak inverse correlation dependence.

Moisture-cumulative efficiency of different systems of basic tillage for growing crops (layer 0-100 cm)

Soil cultivation variant	Stocks of available moisture, mm		Moisture has accumulated	
	before entering winter	after snow melting	mm	±% to control
Barley, 2012–2015				
Shelf handling (control)	125,8	244,0	118,2	–
Off-the-shelf processing	118,8	249,6	130,8	10,6
A shallow, shelfless, polished one	127,2	266,2	139	17,6
Alfalfa, 2013–2016				
Shelf handling (control)	69,3	139,4	70,1	–
Off-the-shelf processing	60,9	137,7	76,8	9,5
A shallow, shelfless, polished one	69,4	151,2	81,8	16,6
Winter wheat, 2013–2017				
Shelf handling (control)	88,7	205,0	116,3	–
Off-the-shelf processing	92,3	210,7	118,4	1,8
A shallow, shelfless, polished one	96,2	219,0	122,8	5,6

Therefore, shallow, non-shelf tillage with simultaneous sliding increases the filtration capacity of the soil, which is an important factor in increasing the available moisture.

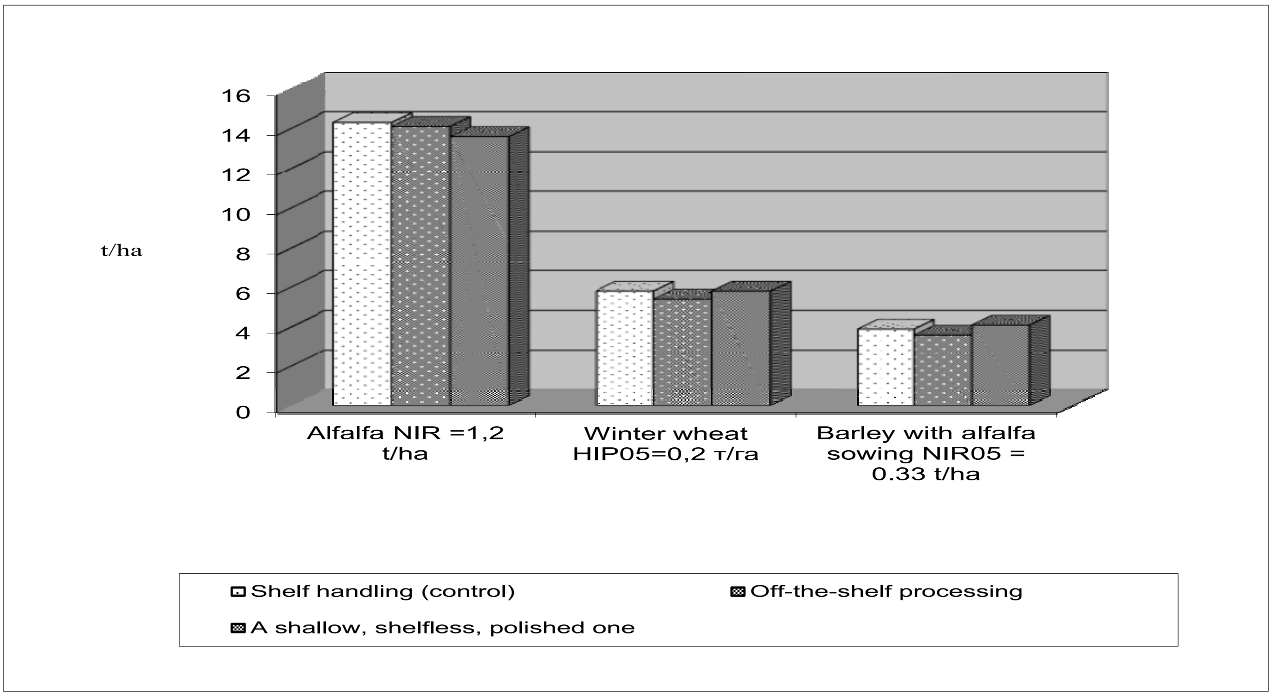

Fig. 2. Yield of crop rotation crops, t/ha (2011-2017)

An indicator of the evaluation of different tillage systems, as well as other agrotechnical measures, is the quantity and quality of the crop yield [14, 15].

Soil tillage systems had a negligible effect on alfalfa yield. Thus, the highest yield of alfalfa was obtained in the control variant - 14.4 t/ha (Fig. 2).

In the variant where systematic chisel processing was used, the alfalfa yield was 0.2 t/ha. lower than the shelf cultivation. The use of shallow, non-shelf tillage with simultaneous tapping has led to an insignificant decrease in yield. Thus, the yield of green alfalfa mass is 0.7 t/ha lower than the control, NIR_{05} - 1.2 t/ha.

The yield of winter wheat in the years of studies was average and amounted to 4.6-6.7 t/ha.

Among the soil cultivation options, the highest winter wheat yields were for shelf and shallow tillage with simultaneous clearing of 5.8 t/ha. The use of non-polishing chisel soil cultivation led to a significant decrease in winter wheat yields compared to pole cultivation.

Yield of spring barley for shallow tillage with simultaneous shrinkage was 5.1% higher than the use of shelf tillage.

Conclusions

The use of shallow, non-shelf tillage with simultaneous tapping formed the best conditions for the rational use of soil moisture. The highest yields of winter wheat and barley were formed on the variant of shallow tillage with simultaneous tapping. The alfalfa yield was 1.5% higher in shelf processing compared to non-polishing processing and 5.1% with shallow non-polishing processing with simultaneous tapping.

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