

Original Article

Influence of Soil Tillage Systems upon Physical and Biological Properties of the Soil in the Long Term Field Experiments

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Abstract

The paper presents the results of research on the influence of primary soil tillage in long term field trials at the Experimental Farm "Chetrosu", Anenii Noi district, Republic of Moldova. Primary soil tillage has not influenced initial reserve of soil water in spring. Primary tillage with tools paraplow type contributed to the differentiation of arable layer after physical properties. The soil on paraplow variant was compacted up to 1.13-1.31 g/cm³ in the 0-10 cm layer, in the 10-20 cm layer from 1.17-1.49 g/cm³ and a little less 1.18-1.45 g/cm³ in the layer of 20-30 cm. The variants of soil tillage with tools paraplow type have increased infestation of crops and soil with weeds, especially with perennial weeds that are difficult to control. The experiments in pots has settled that paraplow tillage of the soil during a long period (19-20 years) has decreased the fertility of 0-30 cm layer by 21-22% compared to plowing.

Keywords: primary soil tillage, water content, bulk density, soil structure, weed infestation, differentiation of soil layer.

1. Introduction

Tillage was always a matter of contention throughout human history. Our land was not an exception. Have sparked heated controversy in Bessarabia, for example, in the late nineteenth and early XX century. The polemics on the issue, to plow or not to plow the soil? [1].

Ivan Ovsinskii an well-known agronomist who worked in Bessarabia, in his book "The New Farming system" published in 1909 recommend for dry areas to avoid carrying plowing and tillage to a depth of 5 cm [5]. Farmer Edward H. Faulkner in his famous book "Ploughman's Folly" first published in 1945, harshly criticized the use of the plow as tillage tool [4].

In Moldova, the important experiments on primary soil tillage were carried out at Kishinev Agricultural Institute (now State Agrarian University of Moldova) and at the Scientific Research Institute of field crops in Balti.

At SAUM research has been carried out by M. Sidorov, Vanikovici Gh, Coltun V., Zdravcov Il., Coltun Maria, Vasilev M. et al. At the SRIFC important research were conducted by Chibasov P., Cebotari C., Boincean B. et al. Without fertilizers, the plowing with moldboard plow with deep jointer has a great positive influence on production field crops.

However, a different response on plowing depth was established for cereals, technical and fodder crops.

Sugar beet, maize, potato and alfalfa require deep plowing, the average plowing depth of soil for grain legumes and sunflower; tilling soil at 10-12 cm is abundant for cereals in case of succession by other crops, for which deep plowing has been carried out.

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2. Material and Method

In the crop rotation of agrotechnics section of the Experimental Farm "Chetrosu" in 1976 and 1979 were initiated research experiments with different primary tillage methods with the aim to minimize them. Which are continued until present. The soil of the field is presented by calcic chernozems a strong clay loam, silty loess. The thickness of humus horizon is 90-100 cm. The water table is at 25m depth. Weak effervescence with 10% HCl at the surface and increases with depth. Thickness of horizons is as follows: A₀ 0-25 cm, 25-48 cm A, B 48-70 cm. B2 70-92 cm, BC 92-172 cm, C deeper than 172 cm. Humus content in arable layer in the fifties was- 3.68%, currently from 2.70 to 2.92%.

The crops in experiment are alternate in the following order: peas, winter wheat, sunflower, corn, corn for silage, winter wheat, soybeans, corn. Variants of soil tillage a next: 1) plowing with moldboard plow at different depths in accordance with biology of crops (plowing); 2) tillage with tools paraplow type at the same depths as in variant plowing with moldboard plow (paraplow); 3) combined, alternating moldboard plow with paraplow plow with predominance of moldboard plow (combined I), 4) combined, alternating moldboard plow with paraplow plow with predominance of paraplow (combined II). For winter wheat over all soil tillage variants soil was tilled with disc harrow. Area of plots 120-200 m², 3 repetition. Soil moisture was determined by drying in an oven - Gravimetric method [2]. Reserve of water in the soil, total consumption of water and water consumption coefficient by model described in [7]. Bulk density was assessed by the method of N. Kacinski, soil structure was assessed by the method of N. Savinov by dry sieving, sifting in the water - with and without

preventive capillary saturation [7]. Infestation of fields and soil by weeds by recommended methods [2]. Permeability of soil for water by PVN-00 device of Nesterov [7]. Experiments in pots with growing volume of 5.2 kg dry soil at 60% from Maximal Water Capacity, replication 3-6 multiple. The maintenance of crops was identical in all variants of experiment. Weed control was carried out by mechanical means: cultivation and hand hoeing. Fertilization in crop rotation system - application of 50 tons of manure once in rotation.

In this article are generalized data obtained over the years based on the influence of primary soil tillage on soil moisture, total water consumption and coefficient of soil water consumption;

Influence of basic processes of soil tillage on bulk density, soil structure, permeability of soil for water, density of weed population in crops and in soil. A special place is occupied in article research results achieved in pots of vegetation in determining differentiation phenomenon of arable soil layer under influence of soil tillage.

3. Results and Discussions

Tillage systems by the effect on the structure and porosity changes clues soil hydro and physical indicators (especially capillary capacity and field capacity water) permeability and forces acting on soil water (suction), evaporation and total water reserve in the soil [3]. The field of experimental plots is located in an area with insufficient rainfall. The average yearly rainfall is 476 mm. Table 1 shows the water consumption of wheat crops in the 29 year of experience. The data presented shows that the primary soil tillage method does not have a significant influence on spring moisture content. Differences appear to harvesting.

Table 1. Water consumption of winter wheat crops, 2004

Variants of experiments	Initial reserve of water, mm,	Precipitations x 0.7 mm	Final reserve of water mm	$\sum E$, mm	Yeald, t/he	Water consumption coefficient m ³ /t of seeds
Plowing	103.3	261.8	7.3	357.8	4.33	826.3
Paraplow	98.4	261.8	18.4	341.8	4.08	837.7
Combined -I	105.7	261.8	24.6	342.7	3.88	883.2
Combined- II	93.4	261.8	1.53	341.6	4.33	788.9

Soil water permeability was assessed in acute drought conditions (1994-1996) and data obtained showed that two very important factors were identified: 1) the presence of soil cracks and 2) continuity of pores in the soil, higher in case of tillage with paraplow than plowing with moldboard. Bulk density is an index that characterizes most certainly influence of tillage

methods. Data from 17 years of primary soil tillage experiments soil showed that the variant plowing bulk density was optimum wholly within the arable layer.

The soil on paraplow variant was compacted up to 1.13-1.31 g/cm³ in the 0-10 cm layer, in the 10-20 cm layer from 1.17-1.49 g/cm³ and a little less 1.18-1.45 g/cm³ in the layer of

20-30 cm. Combined variants I and II occupies an intermediary between plowing and paraplow variant. Soil structure was assessed after 18 years of experience.

It was found that the moldboard plow tillage creates a uniform layer of structure with a water-stability of 31.2% in the 0-30cm layer to wet sieving capillary without saturation. Soil layer under soil tillage with paraplow plow differs sharply by structure: the level of water- stability aggregates of 0-10 cm layer was 35.0%, while in the layer 20-30 cm-58, 7% [6]. Weed density of crops and seedbanks.

Primary soil tillage and crop care system influences the type and degree of weed. In long standing experience Zdravcov II. Evaluated different methods of primary soil tillage based upon the composition of the soil weed species and

weed influence on crop yield crop rotation. He concluded that depending on the type and degree of weed, must work constantly to correct primary soil tillage system.

Once during the rotation of a crop rotation with 7-fields is highly effective plowing at a depth of 50 cm. Highest degree of weed was noticed on tillage without turning shallow furrow [8]. In our experiences as we have said we have applied herbicides, weed control is only mechanically. Research results presented in table 2 are after 30 years of performing experience.

The data presented show that weed density in paraplow variant is almost four times higher than the weed density in plowing variant. Also paraplow variant increases the weed density of perennial weeds. In addition paraplow increase the weight of green dry weeds in experiment.

Table 2. Weed density of sunflower crops, 2005

Variants of experiments	Weed density, m ⁻²		Weight of weeds, g/m ²	
	Total	Including perennials	Green	Dry
Plowing	37.7	8.0	163.5	59.6
Paraplow	135.4	11.4	303.6	101.4
Combined -I	104.5	8.2	198.1	68.8
Combined- II	183.3	7.1	296.1	112.9

In table 3 are presented data on the subject of weed seeds in the soil.

From them we see that in humid conditions of variant paraplow increases considerably amount of weed seeds in the surface layer. In general, seedbank of weed seeds is very high and

therefore systematic soil tillage for a long time, at the right time and of good quality didn't clean the soil from the seeds of weeds. Besides, the variant paraplow increase weed density with hard fought weed species - perennials: *Cirsium arvense*, *Convolvulus arvensis*, *Sonchus arvensis*.

Table 3. Seedbank of weeds seeds in soil after peas (mil./he)

Variants	Soil layer	1995, after 20 years of experiments	1996, after 18 years of experiments	Media
Plowing	0-10	304	183	185
	10-20	230	278	254
	20-30	346	680	341
	Total	880	1141	1010
Paraplow	0-10	706	706	706
	10-20	535	169	352
	20-30	130	92	111
	Total	1371	967	1169
Combined -I (for peas plowing)	0-10	454	358	406
	10-20	164	501	333
	20-30	100	153	126
	Total	718	1012	865
Combined -II (for peas paraplow)	0-10	661	413	537
	10-20	230	517	373
	20-30	185	262	224
	Total	1076	1192	1134
Media		1011	1078	

Table 4. The influence of mineral fertilizers upon production of grain of spring barley, Odesskii 100, g/pot

Variants of experiments		19 years of experiments		20 years of experiments	
Fertilizer	Soil stratum, cm	Soil taken from plowing variant	Soil taken from paraplow variant	Soil taken from plowing variant	Soil taken from paraplow variant
Control (no fertilizers)	0-10	5.0	9.2	2.3	2.2
	10-20	6.3	4.8	2.8	2.1
	20-30	6.3	0.8	1.6	0.1
N ₁₅₀	0-10	4.6	10.0	4.2	4.1
	10-20	5.6	4.7	5.2	2.3
	20-30	4.7	0.4	3.8	0.02
P ₁₀₀	0-10	8.7	14.1	4.5	4.7
	10-20	11.8	10.8	4.4	3.9
	20-30	10.1	8.8	3.4	2.9
N ₁₅₀ P ₁₀₀	0-10	8.7	7.5	6.7	7.3
	10-20	6.8	6.4	8.2	7.1
	20-30	6.2	7.4	7.5	5.0

4. Conclusions

Initial soil water reserve in spring is not significantly influenced by the primary soil tillage.

Plowing with moldboard plow increases soil permeability by loosening, but over time decreases faster than in the case of plowing with paraplow. Soil during dry period form cracks and from their size depends the initial permeability.

Primary tillage with tools paraplow type contributed to the differentiation of arable layer after physical proprieties. The soil on paraplow variant was compacted up to 1.13-1.31 g/cm³ in the 0-10 cm layer, in the 10-20 cm layer from 1.17-1.49 g/cm³ and a little less 1.18-1.45 g/cm³ in the layer of 20-30 cm.

Primary tillage with tools paraplow type lead to increasing of weed density and seedbank of weed seeds in the soil. The variant paraplow increases weed density with hard fought weed species- perennials.

Primary tillage with paraplow leads to a powerful differentiation of different soil layers by effective fertility. Tests in growing pots have shown that soil tillage with paraplow decreases soil fertility due to phosphorus deficiency, the amount of which decreases with depth in a far superior position, compare to plowing with moldboard plow.

Tillage of the soil with paraplow for a long term (19-20 years) decreased fertility of 0-30 cm layer to 21-22% compared to plowing.

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