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The New Method of Restoring Soil Fertility and Increase of Drought Resistance of Corps

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Abstract – **The new method of crop cultivation based on the transformation of the soil structure at the plant root system, secures up to 25% increase of harvest (at the extremely dry seasons as well).**

Keywords – **Combined-Layered Tillage, Soil Fertility, Drought Resistance, Topsoil Modeling.**

I. Introduction

A very severe drought is an actual subject in vast areas of risky farming. According to the long-term observation even the Central Europe with sufficient rainfalls constantly experiences either the spring- or the spring-summer- or the summer- or the summer-autumn- droughts that greatly hamper the crop development.

Earlier the main role against the drought in areas of risky farming was assigned to protective shelterbelt forest. Later it was found that anticyclones forming in dry seasons generated hot air mass that overpassed shelterbelt forest and dried the field that could not significantly improve the water supply to plants of the whole region. That measure became unpractical while irrigation in large areas economically is unreasonable. That's why the main directions in the struggle with drought are the drought-tolerant seeds varieties and the agro-technical methods of soil moisture improvement.

Based on the vegetative, microplot, simulated and field experimental results, the scientists of the Moscow Research Institute of Agricultural Science "Nemchinovka" developed the new method of restoring soil fertility and increase drought resistance of corps.

This article is not subjected to the detailed description of the developed technology, while the summary of the basic principles and scientific approach in solving the droughts problem in relation to the Central Europe will be presented below.

II. Materials and Method

If to keep the soil in Non-Chernozem area without plowing for a several years in a raw and to carry out the surface moldboardless tillage only, it will lead to the differentiation of the upper and lower layers of the topsoil horizon by the physical, chemical and biological characteristics. The lower layer will become less favorable for development of the root system of plants than the upper one [1, 2]. Unplowed subsurface will became even in worse conditions due to the regular over-moistening in autumn-, winter- and spring- seasons [3].

The purpose of moldboard plowing is to move the upper most cultivated soil horizon to that part of the plowing soil layer, which responsible for the development of the root system of the plants and the yield of crop [4].

The trials and experiments led by Professor Sergey Sdobnikov confirmed the differentiation in fertility of topsoil: the upper layer shows the higher fertility through atmospheric occurrence and activities of fungi and aerobic bacteria. The continual impact of these natural actions to the soil determines the humus location with its sharp decrease in the depth of soil. Because of the moldboard plowing with layers reversion the tilled land contained the even amount of humus while moldboardless tillage causes the sharp differentiation of humus distribution. After 2 years of moldboardless tillage the upper layer becomes twice as more fertile then the lower one, and after 6 years is 4 times more (Table 1).

Table 1: The fertility of the upper and lower parts of the arable layer depending on the soil tillage (average result of two experiments)

Layer of soil, cm	Moldboard annualplowing	Moldboardless tillage			
		1 year	2 years	5 years	6 years
Nitrification capac. of the soil, mg $N\text{-}NO_3$ per kg of soil					
0-8	14,2	23,8	21,5	22,3	28,8
12-20	15,7	10,3	8,7	9,0	8,7
Ratio of layers	0,9	2,3	2,5	2,5	3,3
Yield productivity per unit, g					
0-8	5,9	9,1	11,8	13,7	14,3
12-20	7,8	6,1	5,4	4,9	3,4
Ratio of layers	0,8	1,5	2,2	2,8	4,2

The root system of plants responses to the chemotropism and intensively develops in the layer with nutrients and stable moisture that ensure higher fertility.

If the root system of the plants located at the surface it will be affected by moisture shortage in the dry season. The upper layer of 0-10 cm could dry up to a dead water supply for twenty days even in case of the short-term rainless. While the most favorable conditions for plant growth thanks to nutrients and stable moisture produced by the lower layer. This statement experimental confirmed by the results of microplot and field trials showed that in the dry seasons the productive moisture was 15-20 mm higher in the layer of 20-30 cm than in the surface. In case of the surface location of the root system the critical moisture shortage was observed in the middle of the plant growing period when the spring moisture reserve was exhausted. Across all years of research the highest moisture capacity and the yield of spring wheat have been observed on the option where the fertilizer was added the lower layer (Table 2).

Table 2: Yield of spring wheat (g/m2) depending on the arable soil structure

Humus in the layer (cm)	Effect on the 1st culture (average for 3 years)	Aftereffect			Effect in a total of 4 years		
		2nd culture	3d culture	4th culture	harvest	incremental	
						g/m^2	%
0-8	62	92	118	63	336	-	–
8-16	66	127	118	71	370	34	10,1
16-24	80	128	133	73	412	76	22,3
24-30	87	133	136	78	432	96	28,6

Thus, in the spring-summer drought the roots of plants are directed to a source of nutrients located in the lower layer, and the first, create well-developed root system, and the second, reduce the negative impact of drought as the roots reallocated to the most moisture soil layer. [5]

Further research carried out on sod-podzolic soil proved the differentiation of layers, roots chemotropism and advantage of adding fertilizer at the lower layer that secured crop yields even in extremely dry seasons.

It has been found that the lower layer of the topsoil in case of adding fresh organic substance contains the optimal level of redox soil potential thanks to reduced oxygen concentration through microorganisms' active consumption and limited air exchange. In case of maintaining a high level of general biological processes (CO_2 emissions, urease activity and nitrification capacity) the microbiological soil activity changes in the direction of strengthening the transformation of soil organic matter by the endothermic reactions of humus compounds and reducing the exothermic decomposition to the final product.

In case of moldboard annual plowing the experimental results showed the soil fertility of the upper and lower layers are aligned through the layers reversion and mixing fertility characteristics. As soon as moldboard plowing terminated the fertility of the upper layer increases while the lower one drops. Therefore, applying the various soil tillage by methods and depth and fertilizers addition, different topsoil structures can be modeled: homogeneous (aligned in fertility) or heterogeneous (with the advantage of the upper layer), or in several years of surface blade tillage with topsoil layers reversion – back-heterogeneous (with the advantage of the lower layer).

The researches have derived the need to form a heterogeneous structure of the soil with the placement of fertile interlayer in the lower layer of the topsoil and in the subsurface. On the Chernozem soil this can be implemented through the natural differentiation of the soil fertility when the movable nutrients elements accumulated in the upper layer during the several years of atmospheric occurrence are moved down by moldboard plowing through full layer reverse. The nature improves fertility in the upper layer, while the farmer transforms the soil providing the favorable back-heterogeneous structure.

For low-humus soils required the constant fertility replenishment, back-heterogeneous structure of the topsoil is created by regular supplement of enriched organic substance as mix of the upper layer, dung or compost, green manure and perennial grasses. It is recommended to hold the moldboard plowing with full layer reverse to create an enriched soil interlayer.

Experiments show that different types of organic fertilizer adding in lower layer and their further transformation in case of oxygen shortage ensures an efficient use of the products of mineralization without the losses, with double increase of the fertilizer impact (Table 3).

Table 3: Crop yields and crop rotation productivity in the modeling field experiment (hwtfodder units/ ha)

№ option	Options	Winter wheat	Bar-ley	Oats	Perennial grasses		Winter wheat	Harvest of fodder units for 6 years	Incre-mental, %
					1st year	2nd year			
1	Background ($N_{60}P_{60}K_{60}$ annually)	46,1	36,5	43,1	124,1	74,3	45,0	329,3	-
2	Background + tillage of topsoil to 30-45 см	46,8	38,6	44,6	115,0	77,0	42,9	333,0	1,1
3	Background + 1 ton of lime in the layer of 30-45 cm	49,0	40,1	47,9	131,6	81,6	45,5	352,5	7,0
4	Background + manure 100 t/ha in the layer of 0-30 cm	52,2	42,2	49,2	131,5	79,8	44,0	356,8	8,4
5	Background + manure 100 t/ha in the layer of 25-30 cm	57,1	44,6	52,0	144,8	89,9	47,9	390,6	18,6

6	Background + manure 100 t/ha in the layer of 30-36 cm	55,0	43,8	51,8	156,3	92,6	50,8	395,1	20,0
7	Background + manure 100 t/ha in the layer of 30-45 cm	50,9	42,8	52,1	145,7	88,4	45,6	375,4	14,0

Based on this the agronomical methods of formation of topsoil back-heterogeneous structure were developed and applied by the regular incorporation of organic fertilizer pre-mixed with the upper layer of soil to the lower layer of topsoil by using modern molded plows and two-layer plows.

The recommended system of topsoil tillage includes the regular alternation of surface moldboardless tillage and moldboard plowing with layer reverse that supports the continuous process of transformation of organic substance in the lower layer of topsoil with increase of the fertilizer impact by 2-3 times and the humus growth by 2,5- 3 times comparing the annual plowing.

The agro technology consists of basic and additional parts. In the basic part at the beginning of crop rotation layer plowing is carried out with deep placement of organic fertilizer (manure) in an amount necessary to create the sufficient balance of humus in the soil.

In order to raise the moisture of subsurface in the dry season the lime (3.4 t / ha), zeolite and other organic substances with water sorbents characteristic are supplemented to fertilizer. The depth of fertilizers allocation is determined by the depth of topsoil with 2-3 cm plow-in of subsurface. On chernozem and grey forest soils plowing depth is adjusted to 30-35 cm, on sod-podzolic - to 25-27 cm.

For all further crops the shallow moldboard ormoldboardless tillage to a depth of lower organic layer (25 cm) are held. Mineral fertilizers are supplemented at preplant tillage and in rows at seeding while the rest of elements of the farming techniques are applied based on agronomic characteristics of culture.

The basic part of the technology involves the creation and preservation of interlayer enriched by organics at the lower layer of the topsoil within full crop rotation, where the organic substance decomposition occurs under anaerobic conditions mainly. This has a great impact on the topsoil and subsoil enrichment since it constrains the excessive mineralization of organic substance and the loss of mineral forms at irrigation, increases humus accumulation and moisture supply, while it raises of agro and agro-chemical soil fertility indicators, ensures the root system deepening, reduces the weedy fields and increases the harvest crop.

In the additional part of the technology plowing-in to the lower moisture organic interlayer consisted of perennial herbs, chopped straw or green manure is held 2-3 times per crop rotation.

III. Results

According to the integrated observational data the average productivity of crop rotation increased by 20% and the potential realization of the plants productivity by 23% based on agricultural technology described above (Table 4).

Table 4: Changing of soil characteristics and plant productivity for two rotations of eight-field crop rotation

Technolgy	Humus	pH	Hydro lyticacidity	S-value	NO_3	$P_2 0_5$	$K_2 0$	The average productivity crop rotation, hwtfodderunit/ha	Plantpro ductivity %
			meq./ 100 g ofsoil		mg/100 g soil				
Normal	2,2	5,8	2,2	14,2	13,7	31,4	16,3	251,8	62
New	2,5	6,1	1,6	18,6	16,4	36,0	26,0	308,0	85

Fresh organic fertilizer should be plow-in at a depth of 6-8 cm higher than the dung supplement that provides the contact between two organic layers and extra intensifying of microbial processes in the area of fertilizer concentration. This increases the duration of the fertilizers aftereffect and enhances the benefits of back-heterogeneous structure of the topsoil.

Scientific priority for the defined development based on scientific discovery "The humification activation facilitated by the decomposition of organic high-carbon compounds in the soil" (certificate number MAA-NO №187 dated 22.01.2001), assigned to the Moscow Scientific Research Institute of Agriculture "Nemchinovka", Russian patents №919620 dated 28.07.1993; № 2138069 dated 20.03.2000; № 239659 dated 10.07.2010 (authors Sergey Sdobnikov, Vladimir Kirdin).

The advantage of the new method called as the combined-layered tillage was confirmed by the results of production trials in all weather conditions.

In the article we have presented only one part of agricultural crops cultivation technology that has an effect on the moisture content of plants: combined-layered tillage and fertilization in crop rotation to help counteract towards drought period of the plants growth effectively.

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