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Influence of soil tillage techniques of different intensity on agrophysical fertility parametres, symbiotic activity and formation of pea and soybean seed yield

The article represents results of field experiments on efficiency studying of different methods of primary soil tillage and cultivation technology of pea and soybean. It is stated that methods of primary soil tillage influence agrophysical parametres of soil fertility, determine symbiotic potential and pea and soybean seed yield.

Key words: moldboard tillage, surface tillage, flat carved tillage, symbiotic potential.

Modern agricultural production, aimed primarily at ensuring high economic indicators, contributes to the development of such negative processes as dehumification, destructurization, and soil compaction when producing agricultural products. The recent increasing anthropogenic impact on soil also reveals such phenomena as chemical pollution, decalcification and alcalination [1].

Soil tillage is the most important element in the complex of measures to increase the yield of agricultural crops, which is potentially able to ensure the conservation and reproduction of fertility [2]. The intensity of primary tillage affects the structural-aggregate composition, density and nutrient regime of soil [3]. This determines its influence on the air, thermal and, in particular, water regime of the soil. It is the primary treatment that determines the intensity of a number of biological, physical-chemical, physical processes and the phytosanitary state of crops.

When growing grain legumes, special attention should be paid to creating conditions that increase the activity of symbiotic nitrogen fixation, the amount of which is directly determined by the density and humidity of the root layer of the soil. The climatic conditions of Ulyanovsk region, characterized by insufficient moisture and periodic droughts, determine the need to assess the effect of primary tillage intensity on agrophysical indicators of fertility and to identify the response of the symbiotic apparatus of various grain legumes.

The purpose of the research: to study the influence of various methods of primary tillage in the technology of pea and soybean cultivation on bulk density, water regime, symbiotic activity and the formation of seed yield.

Objects and methods of research. The research was conducted in 2014-2016 on the experimental field of Ulyanovsk State Agricultural Academy. Field

trial was laid in fourfold repetition, in accordance with the method and technique of setting field experiments in stationary areas, the placement of the plots is systematic, biased. The size of the plot is 50 m^2. The soil of the experimental site is leached black soil, medium-heavy, medium loamy. The effectiveness of application in cultivation technology of peas, soybeans, fodder beans and lupine of three methods of basic tillage - plowing, flat-carved and surface tillage (scuffing) was studied in the experiment. All the techniques were carried out on August 25-26. The depth of dumping and flat-carved loosening was 25-27 cm, scuffing was 10-12 cm.

Results of the research. The intensity degree of the impact on the soil, determining its bulk density, affects the activity of a number of biological processes: enzymatic activity, cellulose-decomposing capacity, respiratory rate, as well as species composition of microflora and percentage of humus [4].

In our studies, the density of soil in pea and soybean crops changed depending on the methods of primary soil tillage (Table 1).

1. Soil bulk density (g / cm^3) and moisture consumption in pea and soybean crops (mm), depending on the methods of primary soil tillage, 2014-2015.

Crop	Variant	Bulk density in the layer of 0-30 cm		Supply of productive moisture in the layer of 0-30 cm, mm.		Decreased / increased, –/+	Precipitation, mm.	Total consumption, mm.
		Before sowing	Before harvesting	Before sowing	Before harvesting			
2014								
Pea	Surface tillage	1,14	1,20	152,1	141,1	-11	174,2	185,2
	Moldboard tillage	1,12	1,17	154,7	140,9	-13,8	174,2	188,0
	Flat carved tillage	1,13	1,18	154,0	140,6	-13,4	174,2	187,6
Soy bean	Surface tillage	1,17	1,24	167,0	152,2	-14,8	247,9	262,7
	Moldboard tillage	1,15	1,18	175,9	146,0	-29,9	247,9	277,8
	Flat carved tillage	1,16	1,20	174,1	144,0	-30,1	247,9	278,0
2015								
Pea	Surface tillage	1,17	1,21	188,0	170,0	-10,0	189,6	199,6
	Moldboard tillage	1,15	1,18	189,2	167,8	-21,4	189,6	211,0
	Flat carved tillage	1,16	1,19	190,6	169,3	-25,3	189,6	210,9
Soy bean	Surface tillage	1,18	1,22	186,5	180,0	-6,5	264,0	270,5
	Moldboard tillage	1,16	1,19	190,0	166,1	-23,9	264,0	287,9
	Flat carved tillage	1,19	1,21	193,4	170,2	-23,2	264,0	287,2

Studies have shown that the largest porosity in the entire arable layer is formed and maintained on a variant with moldboard tillage, where the soil density in the 0-30 cm layer before sowing peas fluctuated in the years ranging from 1,12 to 1,15 g / cm^3, before sowing soybean – 1,15-1,16 g / cm^3. The insignificant increase in soybean crop density is the result of natural soil compaction and is explained by a later sowing of this crop. The suitable density of soil for the development of grain legumes is limited in the range of 1,1-1,3 g / cm^3 [5]. The results of our studies show that the types of primary tillage studied are capable of providing an acceptable for their further development density of the root layer by the time of sowing of peas and soybeans.

Before harvesting, the soil density increases in all variants, the lowest values remain on the variant with moldboard tillage, where it was 1,17-1,18 g / cm^3 in the 0-30 cm layer in pea crops, in soybean crops – 1,18-1,19 g / cm^3.

By the harvesting time, the density of soil of pea crops increased to 1,20-1,21 g / cm^3 on the surface tillage variant, of soybean crops - up to 1,22-1,24 g / cm^3, reaching the maximum in comparison with the other variants and confirming the results of the previous studies conducted in 2011-2013. [6].

In the agricultural conditions of the forest-steppe of the Trans-Volga region, soil moisture is in the first minimum and it often acts as a factor which greatly reduces the effectiveness of agrotechnical methods and plant productivity [7].

Density, which determines the structure peculiarities of the arable layer, directly affects the ability of the soil to form a productive supply of water. By the end of the growing season, the reserves of productive moisture in a meter layer of pea and soybeans crops dropped considerably due to plant transpiration and the evaporation of moisture from the soil surface.

The differences in the reserves of productive moisture before sowing peas and soybeans in 2014 were determined by the different sowing time of the above cultures- the precipitations dropped before soybean planting increased the moisture content in a meter layer up to 167,0-175,9 mm.

The total moisture consumption in pea and soybean crops was determined, mainly, by the duration of plant vegetation - in soybean crops it reached 262,7-278,0 mm in 2014 and 270,5-287,9 mm in 2015. Typical for both crops reduction of the total moisture consumption in the variants without primary tillage is determined by a decrease in biological productivity of plants and, as a consequence, a decrease in their water demand.

The provision of agricultural crops with moisture depends both on the amount and distribution of precipitation during the growing season, and on the physical properties of the soil. To assess the conditions of plant development, the calculation of the hydrothermal coefficient is frequently applied. The HTC changed from 0,08 (July) to 0,89 (June) from May to August in 2014. In 2015, during the same period, HTC values varied from 0,36 in June to 2,04 in July. In general, it can be noted that the meteorological conditions in both years of research were acceptable for pea crops, using the moisture of autumn-winter and summer precipitation, the plants completed their vegetation before its deficit began. As for soybeans, the conditions of 2015 turned out to be more favorable, since abundant

precipitation - more than 100 mm during July – coincided with the period of fruit formation.

The conditions for moistening the soil root layer determine the peculiarities of the interaction of nodule bacteria with the host plant, regulate their activity, quantity, mass and duration of vital activity [8]. The root system and nodules develop normally under favorable weather conditions, plants intensively use atmospheric nitrogen. High positive temperatures and the absence of precipitation negatively affect the symbiotic apparatus, thereby reducing the productivity of plants as a whole.

We determined the general (TSP) and active symbiotic potential (ASP) of peas and soybeans, which is the most prominent feature of symbiotic apparatus, which combines the mass of nodules and the duration of their functioning (Table2).

2. The total (numerator) and the active (denominator) symbioticpotential of peas and soybeans, kg · day / ha

Crop	Variant	Development phase				
		Stem formation, third true leaf	flower-bud formation - flowering	Beginning of seed filling period	End of seed filling period	During the vegitation period
2014 г.						
Pea	Surface tillage	437,3 271,5	1843,9 1843,9	1064,1 434,3	–	3345,3 2549,7
	Moldboard tillage	706,5 469,9	7149,8 7149,8	2057,3 806,8	–	9913,6 8426,5
	Flat carved tillage	633,2 368,4	2596,4 2596,4	1482,6 553,2	–	4712,2 3518,0
Soybean	Surface tillage	528,3 70,1	5682,8 5682,8	6443,2 4954,6	4211,4 576,9	16865,7 11284,4
	Moldboard tillage	636,4 128,3	6735,6 6735,6	6880,0 6255,6	5950,1 732,8	20202,1 13852,3
	Flat carved tillage	213,4 116,7	6548,1 6548,1	6597,2 5056,7	4634,9 634,8	17993,6 12356,3
2015 г.						
Pea	Surface tillage	584,9 354,5	2606,1 2606,1	1073,6 408,2	–	4264,6 3368,8
	Moldboard tillage	869,4 612,3	6660,1 6660,1	2640,9 1015,7	–	10170,4 8288,1
	Flat carved tillage	679,4 416,8	5532,4 5532,4	2049,7 782,3	–	8261,5 6731,5
Soybean	Surface tillage	163,0 135,8	5633,2 5633,2	7207,5 5599,7	4360,9 629,8	17364,6 11998,5
	Moldboard tillage	473,8 408,4	6682,2 6682,2	7721,9 6334,9	5960,9 816,6	20838,8 14242,1
	Flat carved tillage	432,3 345,8	6099,1 6099,1	7519,5 5785,4	4866,5 659,4	18917,4 12889,7

The greatest values of symbiotic potential were noted in peas and soybean on the variant with moldboard tillage during both years of research. Soybeans preserve the nodules until the phase of full filling, some of them are still active by this time, whereas in peas, they are completely deteriorate by this time. Due to a longer duration of some development phases, the soybean active symbiotic potential significantly exceeds the active symbiotic potential of peas by 1,6-4,4 times. In 2015, soybean showed the highest ASP values in all the variants of the experiment, in comparison with the previous year the increase was from 533.4 kg · dn / ha on the moldboard loosening variant up to 714,1 kg · day / ha on the surface tillage variant. The least fluctuations in terms of the values of ASP, despite more favorable moisture conditions in 2015, were noted in soybeans on the variant of moldboard tillage – the difference was 389,8 kg · dn / ha, which indirectly confirms the stabilizing role of the blade treatment in regulating the soil water regime.

The dynamics of pea ASP values was also determined by moisture conditions and the intensity of primary soil cultivation. The moisture deficit in May 2014 (HTC 0,34) contributed, in comparison with 2015, to formation of 1,3-1,9 times lower values of ASP on variants with surface and moldboard tillage, respectively. The fluctuations were insignificant on the variant with moldboard tillage, in addition, the reverse trend was recorded – the ASP for vegetation in 2014 was slightly higher.

Improvement of conditions of symbiotic nitrogen fixation, determined by the agrophysical parameters of fertility, promoted the growth of the seed yield of pea and soybean (Table 4).

4. Crop yield of peas and soybeans depending on the methods of the primarysoil cultivation (t / ha), 2014-2015.

Crop	Variant of soil tillage	Yield, t/ha		
		2014	2015	On average
Pea	Surface tillage	2,42	2,45	2,44
	Moldboard tillage	2,81	2,87	2,84
	Flat carved tillage	2,67	2,70	2,69
LSD_{05} (least significant difference)		0,13	0,22	–
Soybean	Surface tillage	1,76	1,84	1,80
	Moldboard tillage	2,88	2,98	2,93
	Flat carved tillage	2,00	2,15	2,08
LSD_{05} (least significant difference)		0,19	0,16	–

On average for 2014-2015, the maximum productivity of peas and soybeans was noted in variants with a moldboard tillage and amounted to 2,84 t / ha and 2,93 t / ha, respectively. Surface tillage had a consistent negative effect on productivity of the studied crops, which was seen in a substantial decrease in their yield compared to other methods of primary tillage. Surface tillage was left behind plowing in pea crops by 0,39-0,42 t / ha, in soybean crops - by 1,12-1,14 t / ha.

A significant difference between flat-carved and moldboard loosening in pea crops was noted only in 2014, in soybean sowings it was noticed in both years of research.

Conclusions. When cultivating peas and soybeans, to ensure conditions enhancing their productive potential, it is necessary to conduct moldboard tillage to a depth of 25-27 cm as the primary soil tillage.

By the time of harvesting, , the soil density in peas increased to 1,20-1,21 g / cm3, on surface tillage variant, in soybean crops - up to 1,22-1,24 g / cm^3, reaching a maximum, in comparison with the options of deep loosening. Control of density and humidity regime has a significant influence on the activity of symbiotic activity of pea and soybean crops. In case of moldboard tillage to a depth of 25-27 cm, the pea ASP reaches 8288,1-8426,5 kg · day / ha, the soybean ASP reaches 13852,3-14242,1 kg · day / ha.

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