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PRODUCTIVITY OF WINTER WHEAT ACCORDING TO THE NUTRITION LEVEL ON THE CHERNOZEM CAMBIC

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Abstract

The harvest of winter wheat on the chernozem cambic in the non-fertilized variant ranged from 1.33 to 3.22 t/ha during 2010-2016. Administration of fertilizers on the natural background on average for 7 years led to the increase of winter wheat yields from 2.51 to 4.75 t/ha, the production increase with 38-89%. On the phosphorus levels the crop yield increased from 19% on the 1.5 mg phosphorus level to 50% on the 3.0-3.5 mg of mobile phosphorus in soil versus the $N_{120}K_{30}$ background. On the variant $P_{30}K_{30}$ the increase in yield was 44% in comparison with control variant. At the nitrogen variants with PK in doses of 30-150 kg/ha the increase in wheat yield was 65-89% compared to the control and 20-45% relative to PK variant. The gluten content in average over 7 years ranged from 23.6% on the unfertilized variant to 29.6% on the fertilized variants. The gluten rate was 25% against the witness variant (23.6%), this is the second group of wheat quality. The optimum level of mobile phosphorus in the chernozem cambic for winter wheat cultivation was 3.0-3.5 mg/100 g of soil (Machigin method), and the optimum nitrogen doses were 90-120 kg/ha.

Key words: *chernozem cambic, fertilizers, nutrition level, productivity, winter wheat.*

INTRODUCTION

Productivity of agricultural crops largely depends on the soil moisture and actual soil fertility. Research conducted in the Republic of Moldova in long-term experience has shown that the average multiannual amount of precipitation ensures the production of 4.4 t/ha of winter wheat, 5.6 t/ha of corn for grains, 35.0 t/ha of sugar beet and 2.7 t/ha of sunflower seeds (Andrieş, 2007; HG nr.841 din 26.07.04, 2004; IPAPS, 2012). On the account of the natural soils fertility the 2.6 t/ha of winter wheat, 3.1 t/ha of corn grains, 26.0 t/ha of sugar beet and 1.5 t/ha of sunflower seeds can be obtained (Почвы, 1986). The untapped value of the harvests in humidity conditions of Moldova is 1.8 t/ha of winter wheat, 2.5 t/ha of maize grains, 9.0 t/ha of sugar beet and 1.2 t/ha of sunflower. These quantities can be covered by increasing the soil fertility through fertilizer management and improving the recommenddations for rational use of fertilizers.

The parameters of agrochemical indices of arable soils are very different and depend on their genesis and degradation form. The humus content in the arable layer (0-30 cm) ranges from 0.8-1.2% (very degraded soil) to 4.2-5.0% (soil with full profile), mobile phosphorus - from 0.6-0.8 mg to 6-8 mg/100 g of soil and exchangeable potassium - from 14-16 mg to 50-60 mg/100 g of soil. The agricultural soils are relatively rich in humus, the weighted average content is 3.1%.

During the organic matter mineralization process, annually about 74 kg/ha of nitrogen is produced in the soil, which is not enough to produce profitable wheat production. Regarding to the phosphorus content the soils in the republic are poor.

According to the last cycle of agrochemical soil mapping, about 60% of the surveyed area have an assurance degree below the optimum content of mobile phosphorus in the soil.

Up to 90% of the country's soils are relatively optimally insured with potassium (20-30 mg K_2O/100 g of soil) available to agricultural plants.

The main available potassium reserve is the exchangeable form, which is largely restored based on the disintegration of potassium minerals in the soil (Andrieş, 2007, 2011; Burlacu, 2000; IPAPS, 2012).

From the soil nutritive regimes in the first minimum is nitrogen and phosphorus.

In order to improve the fertilization system of the cambic chernozem, the wheat productivity and quality were evaluated according to the fertilization level and agrometeorological conditions of the 2010-2016 period.

MATERIALS AND METHODS

Field investigations were carried out at the Long-term Experimental Station (Ivancea, Orhei district), founded in 1964 on the clayey-loamy cambic chernozem. The chernozem cambic is characterised by humus content in the arable layer of 3.4%; pH_{water} - 6.7; ∑Ca+Mg - 37.4 mg/100 g of soil. Since 2000 the station is registered in the Eurosomnet.

In crops rotation were cultivated: winter wheat, corn for grains, sunflower, winter barley, rape and leguminous crops (alfalfa, peas, beans, soybeans). Experiences were performed in 4 repetitions. The plot area was of 200 m^2. Investigations were carried out on the following levels of soil mineral nutrition: *mobile phosphorus* - 1.0; 1.5; 2.0; 2.5; 3.0; 3.5; 4.0; 4.5 mg/100 g of soil; *exchangeable potassium fund in the soil* (Machigin method) has varied in these years, from 29 to 32 mg/100 g of soil. The level of mobile phosphorus in the soil were maintained by offsetting the phosphorus export from preceding crop and applying phosphorus fertilizer to the base tillage. Potassium fertilizers in experiences from 2010 up to the present does not apply. Nitrogen norms were applied annually - 0, 30, 60, 90, 120 and 150 kg/ha in active substance (Andrieș et al., 2014).

The phosphorus and potassium content of the soil was determined by the Machigin method (extracted in 1% ammonium carbonate solution in a ratio of 1: 20, pH-9). According to the Soil classification on mobile phosphorus and exchangeable potassium assurance of the soils in Moldova, the scale has 6 gradations, ranging from less than 1 mg to more than 7 mg/100 g of soil for mobile phosphorus and from less than 5 mg to more than 40 mg/100 g for exchangeable potassium of soils (IPAPS, 2012,).

RESULTS AND DISCUSSIONS

Agrometeorological conditions. The amount of precipitation, as well as their distribution during plant growing, has conditioned the productivity of winter wheat. Over the seven investigation agricultural years, the agro-meteorological conditions were different. From seven years, two years were relatively dry (2012 and 2015), with a humidity deficiency of 17-21% versus the multiannual average amount, fewer the droughts were 2014 and 2016 (Table 1).

Table 1. Amount of the atmospheric precipitation at the "Ivancea" Experimental Station in 2010-2016

Year	IX of 2009* - III		IV		V		VI		VII		VIII		IV-VIII		Agricultural year	
	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%
2010	327	127	44	105	83	156	85	107	58	95	36	60	306	104	633	115
2011	245	95	49	117	26	49	195	247	31	51	17	28	318	108	563	102
2012	153	60	38	90	114	215	48	61	59	97	22	37	281	95	434	79
2013	293	114	20	47	64	121	84	106	126	206	46	77	340	115	633	115
2014	261	102	25	60	112	211	36	46	55	90	20	33	248	84	509	92
2015	325	127	39	93	10	19	33	42	37	61	15	25	134	45	459	83
2016	252	98	31	74	57	107	133	168	3	5	36	60	260	88	512	89
Average	265	103	35	83	66	124	88	111	53	87	27	45	269	91	534	97
Multiannual	257	100	42	100	53	100	79	100	61	100	60	100	295	100	552	100

****Note.*** *The period of the agricultural years is considered 01.09.2009 - 31.08.2016*

Nearly the norm was 2011 with 563 mm, making up 102%, over the norm or so-called "wet years" were 2010 and 2013, respectively 115%. On average of seven years the atmospheric precipitations were with 18 mm less than the multiannual average, constituting 534 mm. Precipitation during the cold period of the year (September - March) created favorable soil moisture reserves at early spring period, which influenced the normal growth and development of wheat plants. The amount of precipitation in the cold season at the station was near normal, representing 95-114% of the multiannual average, except for 2012 with the amount of rainfall of only 60%, as well as 2010 and 2015 with 127% above the norm.

The atmospheric precipitation for the active field crops grow (April - August) in these seven years decreased by 9% on average compared to the multiannual average, and by 2015 they were 55% fewer, constituting 134 mm. The strongest drought occurred in July and August, where the monthly rainfall in the years 2015-2016 decreased by 75-95% over the multiannual average and the air temperatures exceeded the norm by 2.0-3.9°C.

Productivity and quality of the winter wheat. Fertilizers have positively influenced the winter wheat growth and development. Their administration has led to the increase and improvement the production quality compared to the unfertilized variant. The winter wheat production on the unfertilized variant of cambic chernozem varied in seven years, from 1.33 to 3.22 t/ha. The size of the yields obtained on the natural background (fund) was influenced to a large extent by the meteorological conditions, but also by the preceding crop. On average, leguminous as a preceding crop, have increased the grain yield of wheat by 0.5 t/ha, versus sunflower as preceding crop.

The administration of mineral fertilizers on the natural background in seven years on average led to the increase of winter wheat yields from 2.51 to 4.75 t/ha. Winter wheat yield increase (efficiency) obtained was from 38% to 89%. On average, during seven years on phosphorus fertilization levels, the crop yield increased from 19% on the level of 1.5 mg of mobile phosphorus per 100 g of soil to 45-50% - on the level of 2.5-3.5 mg/100 g of soil versus $N_{120}K_{29-32}$ mg/100 g. In variant with fund $P_{3.5}K_{29-32}$ mg/100 g (PK) the increase in yield compared to the control was 44%. In the case of nitrogen variants in doses of 30-150 kg/ha on the background of PK, the increase of winter wheat yield was 65-89% compared to the control variant and 20-45% to the PK variant (Table 2).

In drought years the role of fertilizers has increased significantly in the formation of winter wheat yield. Although the global production has fallen in these years, the productivity compared to the unfertilized variant in 2012 practically doubled from 1.33 t/ha to 1.92-2.68 t/ha. The role of mineral fertilizers was decisive in the formation of winter wheat production.

The quality of the winter wheat was directly influenced by the application of fertilizers. The wet gluten content of wheat grains ranged from 16.0% to 40.8%. The average value of gluten in six years in the non-fertilized variant was 23.6%, increasing by 4.2-6.3% to 27.8-29.9% on the fertilized variants. The so-called "dilution effect" resulted in the production of winter wheat obtained on the $P_{3.5}K$ variant. The wheat harvest on this variant was 1.45 times higher than control, and the gluten content on average was the same - second group (Table 3).

The amount of gluten obtained in the cultivation of bakery wheat per unit area is an integral indicator of crop productivity assessment. This indicator enables us to determine the agronomic efficiency or yield of fertilizers in order to obtain wheat production. The amount of gluten obtained in the cultivation of winter wheat according to the level of fertilization on the cambic chernozem is presented in Table 4.

Table 2. Winter wheat yield obtained on cambic chernozem in dependence of the fertilization level, t/ha

Variant		Preceding crop, year of investigation								Average 2010-2016	The increase %
Nitrogen kg/ha	P_2O_5 mg/100 g soil	Alfalfa 2010	Rape 2011	Pease 2011	Sunflower 2012	Sunflower 2013	Sunflower 2014	Sunflower 2016	Soybeans 2016		
Control	1.0	2.68	2.12	2.67	1.33	2.37	2.76	2.97	3.22	2.51	-
120	1.0*	3.83	2.89	3.44	2.17	2.65	3.34	4.85	4.58	3.47	38.2
120	1.5	4.19	3.18	3.67	2.23	3.77	3.73	5.60	5.24	3.95	57.4
120	2.0	4.25	3.84	4.04	2.32	4.03	4.08	5.81	6.35	4.34	72.9
120	2.5	4.50	4.08	4.41	2.52	4.25	4.26	6.14	6.57	4.59	82.9
120	3.0	4.51	4.12	4.62	2.48	4.65	4.46	6.16	6.76	4.72	88.0
120	3.5	4.62	4.27	4.76	2.60	4.69	4.32	6.02	6.67	4.74	88.8
120	4.0	4.70	4.24	4.69	2.63	4.55	4.26	6.14	6.38	4.70	87.2
120	4.5	4.64	4.26	4.75	2.58	4.58	4.22	6.08	6.60	4.71	87.6
0	3.5	4.49	3.01	3.39	1.92	3.22	3.54	4.21	5.27	3.63	44.6
30	3.5	4.61	3.63	3.93	2.33	4.03	3.93	4.61	6.09	4.14	64.9
60	3.5	4.72	3.87	4.16	2.54	4.22	4.28	5.78	6.36	4.49	78.9
90	3.5	4.73	4.07	4.57	2.68	4.52	4.59	6.32	6.55	4.75	89.2
120	3.5	4.53	4.22	4.74	2.62	4.69	4.19	6.24	6.73	4.75	89.2
150	3.5	4.21	4.05	4.49	2.53	4.58	4.08	6.08	6.46	4.56	81.7

**K - the exchangeable potassium content in the soil is 29-32 mg/100 g of soil.*

Table 3. Wet gluten content in wheat grains cultivated on the cambic chernozem, %

Variant	Preceding crop, year of investigation									Quality group
	Alfalfa	Rape	Pease	Sunflower				Soybeans	Average	
	2010	2011		2012	2013	2014	2016			
Control	30.8	20.4	21.6	32.4	21.2	22.8	18.4	21.6	23.6	II
$N_{120}P_{1.0}K$*	31.2	26.8	25.6	36.0	28.0	29.2	20.8	28.0	28.2	II
$N_{120}P_{1.5}K$	31.2	26.8	25.6	40.8	32.8	29.6	20.8	28.0	29.4	II
$N_{120}P_{2.5}K$	31.8	20.8	27.5	38.4	30.0	30.0	25.6	30.4	29.3	II
$N_{120}P_{3.5}K$	31.8	20.8	28.4	36.4	31.4	30.4	24.6	29.6	29.2	II
$N_{120}P_{4.5}K$	32.0	21.6	25.2	38.8	30.2	29.6	24.0	31.2	29.1	II
$P_{3.5}K$	29.2	16.0	20.8	34.0	23.6	25.2	18.8	21.2	23.6	II
$N_{60}P_{3.5}K$	31.6	22.4	23.2	376	28.8	31.2	20.8	26.8	27.8	II
$N_{90}P_{3.5}K$	30.8	24.4	28.8	37.2	31.2	31.2	25.2	28.4	29.6	II
$N_{120}P_{3.5}K$	32.0	23.2	26.4	38.4	28.0	28.4	26.4	28.8	29.0	II
$N_{150}P_{3.5}K$	32.0	26.0	28.0	38.8	32.8	28.4	26.4	26.6	29.9	II

**K - the exchangeable potassium content in the soil is 29-32 mg/100 g of soil.*

Table 4. Amount of gluten obtained from the cultivation of the winter wheat, kg/ha

Variant	Preceding crop, year of investigation									The increase, %
	Alfalfa	Rape	Pease	Sunflower				Soybeans	Average, kg/ha	
	2010	2011		2012	2013	2014	2016			
Control	825	432	577	431	502	629	546	695	580	-
$N_{120}P_{1.0}K$*	1195	774	880	781	742	975	1009	1282	955	64.6
$N_{120}P_{1.5}K$	1307	852	940	910	1237	1104	1165	1467	1123	93.6
$N_{120}P_{2.5}K$	1431	849	1213	968	1275	1278	1572	1997	1323	128.1
$N_{120}P_{3.5}K$	1469	888	1352	946	1473	1313	1481	1974	1362	134.8
$N_{120}P_{4.5}K$	1485	920	1197	1001	1383	1249	1459	2059	1344	131.7
$P_{3.5}K$	1311	482	705	653	760	892	791	1117	839	44.6
$N_{60}P_{3.5}K$	1492	867	965	955	1215	1335	1202	1704	1217	109.8
$N_{90}P_{3.5}K$	1457	993	1316	997	1410	1432	1593	1860	1382	138.3
$N_{120}P_{3.5}K$	1450	979	1251	1006	1313	1190	1647	1938	1347	132.2
$N_{150}P_{3.5}K$	1347	1053	1257	982	1502	1159	1605	1718	1328	129.0

**K - the exchangeable potassium content in the soil is 29-32 mg/100 g of soil.*

Administration of mineral fertilizers doubled the amount of wet gluten of wheat obtained at one ha from the natural background. During 2010-2016 years, on average, the fertilization levels the amount of wet gluten increased from 375 kg/ha to 802 kg/ha. Application of nitrogen fertilizers was significant at doses of 30-150 kg/ha on the background of PK resulted in a gluten of wheat increase of 378-543 kg/ha. The efficiency of the mineral fertilizers was significant, increasing from 44.6% to 138.3%, compared to the control variant. In order to obtain bread production, the maximum yield was 138.3% for the $N_{90}P_{3.5}K$ variant (Table 4).

CONCLUSIONS

The application of mineral fertilizers on the natural background of cambic chernozems led to an increase in the production of winter wheat by 38-89%. Phosphorus fertilization levels ranging from 1.5 mg to 3.0-3.5 mg/100 g of mobile phosphorus in the soil have led to 19-50% of wheat yield increases, and nitrogen fertilizers at doses of 30-120 kg/ha on the optimum fund $P_{3.5}K_{29-32}$ mg/100 g resulted in an increase of 20-45%. The optimum level of mobile phosphorus in the soil for cambic chernozem in the winter wheat cultivation is 3.0-3.5 mg/100g of soil (Machigin method) and the optimal nitrogen doses are 90-120 kg/ha.

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