MAIZE PRODUCTIVITY IN ACCORDING TO FERTILIZATION LEVEL ON THE CAMBIC CHERNOZEM IN LONG-TERM EXPERIENCES

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Abstract

The evaluation results of the maize-grain yield cultivated on the Chernozem Cambic according to the level of fertilization and agrometeorological conditions of the years 2012-2017 are presented. Maize-grain yields obtained from the unfertilized variant (witness) varied from 2.25 t/ha to 6.03 t/ha. Administration of fertilizers on the natural background on average for 5 years led to the increase of maize yields from 3.48 t/ha to 5.47 t/ha, the production crop yield was 27-57%. At phosphorus levels, the crop yield increased from 11 % on the level of 1.5 mg to 25-28 % on the level of 3.0-3.5 mg/100 g of mobile phosphorus in soil versus the background level $N_{120}K_{30\ mg/100\ of\ soil}$. In the $P_{3.5}K_{30\ mg/100\ of\ soil}$ (PK) variant, the increase in harvest vs. control was 27%. In nitrogen variant on the PK background in doses of 30-150 kg/ha the increase in maize production was 39-57% compared to the control variant and 12-30% to PK variant. The optimal soil phosphorus level for cambic chernozem in grain maize cultivation was 3.0-3.5 mg/100 g of soil (Machigin method) and the optimal nitrogen doses were 90-120 kg/ha.

Key words: chernozem cambic, fertilization level, long-term experience, maize grain, productivity

Productivity of agricultural crops largely depends on the humidity and the actual fertility of the soils. Research in the Republic of Moldova has shown that the average multiannual rainfall provides the production of 5.6 t/ha of corn for grain. On account of the natural fertility of soils, 3.1 t /ha of corn grain can be obtained (Andries S., 2007; Почвы Молдавии, 1986).

The non-utilized production of maize under the soil moisture conditions consists 2.5 t/ha. This production can be covered with increasing soil fertility by administering mineral fertilizers and improving recommendations on their rational use.

The agricultural soils in the Republic of Moldova are relatively rich in humus, the weighted average content being 3.1%. During the process of mineralization of annual organic matter in the soil, about 74 kg/ha of nitrogen is produced, which is not enough for obtaining profitable maize grain productions.

According to the phosphorus content the soils of the Republic of Moldova are poor. According to the results of the last cycle of agrochemical mapping of agricultural soils, about 60% of the area under investigation has a degree of assurance below the optimum soil phosphorus content.

Up to 90% of agricultural soils are relatively optimally ensured with potassium accessible for plants. The main reservoir of potassium available is the exchangeable form, which is largely restored based on the disintegration of potassium minerals in the soil (Burlacu I, 2000; Andrieş S., 2011, Recommendations, 2012).

From the soil nutrition regimes in the Republic of Moldova in the first minimum are nitrogen and phosphorus. In order to improve the fertilization system of cambic chernozem, the productivity and quality of maize for grains was evaluated according to the level of mineral fertilization and agrometeorological conditions of the years 2012-2017.

MATERIAL AND METHOD

Field investigations were carried out within the long-term Experimental Station of the ”Nicolae Dimo” Institute of Pedology, Agrochemistry and Soil Protection from Ivancea commune, Orhei district, founded in 1964 on the Cambic Chernozem clayey-loamy.

The humus content in the arable soil layer is 3.4%; pH_{H2O} - 6.8; $\sum Ca^{2+} + Mg^{2+}$ = 37.4 me/100 g soil. Since 2000, the Experimental Station is registered in the European Soil Organic Matter Network (EUROSOMNET).

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In the field crop rotation are grown: winter wheat, maize for grain, sunflower, winter barley, rape and leguminous (alfalfa, peas, beans, soybean). The preceding crop for maize was winter wheat and winter barley. The field experiments were performed in 4 repetitions. The surface of the experimental plot was 200 m^2.

Investigations were carried out on the following levels of mineral nutrition: phosphorus mobile in soil - 1.0 (natural background); 1.5; 2.0; 2.5; 3.0; 3.5; 4.0 and 4.5 mg/100 g; exchangeable potassium in soil - 29 - 32 mg/100 g soil. The phosphorus and potassium content of the soil was determined by the Machigin method (extracted in 1% ammonium carbonate solution, 1 : 20, pH-9).

The levels of mobile phosphorus in the soil were maintained by offsetting the phosphorus export by the preceding crop with the application of phosphorus fertilizers to the basic soil work. Potassium fertilizers from 2010 to present do not applied to these experiences.

The nitrogen fertilizer doses were applied annually - 0, 30, 60, 90, 120 and 150 kg/ha.

RESULTS AND DISCUSSIONS

The amount of precipitation, as well as their distribution during plant growing period, has conditioned the productivity of corn for grains. During the agricultural investigation years (2012-2015 and 2017) the agrometeorological conditions were different. From five research years at the ”Ivancea” Experiential Station - two years have been relatively dry (2012 and 2015), with a humidity deficiency of 17-21% over the multiannual average, less drought was 2014.

The quantity of atmospheric precipitation in the years 2013 and 2017 exceeded the standard norm by 115% and 108%, respectively. The average atmospheric precipitation for five years was 26 mm, less than the multiannual average, constituting 526 mm (*table 1*).

Table 1

Quantity of atmospheric precipitation at the ”Ivancea” Experimental Station in the years 2012-2017

Year	Months IX-III		IV		V		VI		VII		VIII		IV-VIII		Agricultural year*	
	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%
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
2017	251	97	99	236	46	87	60	76	91	149	49	82	345	117	596	108
Average for 5 years	256	100	44	105	69	130	52	66	73	120	30	51	269	91	526	95
Multiannual average	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 01.09.2011 - 31.08.2017.*

Atmospheric precipitation during the cold period of the year (September-March) created the favorable humidity conditions in early spring period, which influenced the normal growth and development of corn plants. The amount of atmospheric rainfall in the cold season at the Experimental Station was near standard norm, accounting 97-114% of the multiannual average, except for 2012 with the amount of rainfall of only 60% and the year 2015 - by 127% above the norm.

The atmospheric rainfall for the active crop field period (April to August) in five years of research decreased by an average of 9% over the multiannual average, and by 2015 they were 55% less, constituting 134 mm.

The drought effect was most pronounced in June, July and August, where the monthly rainfall decreased to 75% over the multiannual average norm and air temperatures exceeded the norm by 2.0-3.9^{0}C (*table 1*).

The application of mineral fertilizers on the cambic chernozem has positively influenced the growth and development of maize crops. The production of maize for grain increased on average from 3.48 t/ha in the control (witness) variant to 5.47 t/ha on fertilized variants (*table 2*).

The increase (spore) in maize yield on the fertilized variants increased in average by 27.6 - 57.2% compared to the natural fund (background).

Table 2

Grain corn yield obtained on cambic chernozem in dependence of the fertilization level, t/ha

Variant	Preceding crop, year of maize cultivation					Average, t/ha	Spore, %
	wheat				barley		
	2012	2013	2014	2015	2017		
Control	2.25	6.03	3.76	2.63	2.72	3.48	-
$N_{120}P_{1.0}K$*	3.01	7.18	5.23	3.39	3.37	4.44	27.6
$N_{120}P_{1.5}K$	3.29	7.66	6.15	3.62	3.52	4.85	39.4
$N_{120}P_{2.0}K$	3.42	8.00	6.35	4.06	3.77	5.12	47.1
$N_{120}P_{2,5}K$	3.67	8.01	6.50	4.36	4.09	5.33	53.2
$N_{120}P_{3.0}K$	3.59	7.92	6.35	4.47	4.38	5.34	53.4
$N_{120}P_{3.5}K$	3.69	8.07	6.50	4.32	4.55	5.43	56.0
$N_{120}P_{4.0}K$	3.60	7.98	6.47	4..28	4.44	5.35	53.7
$N_{120}P_{4.5}K$	3.62	8.23	6.03	4.29	4.49	5.33	53.2
$P_{3.5}K$	2.90	7.04	5.23	3.43	3.48	4.42	27.0
$N_{30}P_{3.5}K$	3.06	7.31	6.35	3.71	3.81	4.85	39.4
$N_{60}P_{3.5}K$	3.63	8.20	6.77	4.06	4.46	5.42	55.7
$N_{90}P_{3.5}K$	3.65	8.04	6.58	4.20	4.50	5.39	54.9
$N_{120}P_{3.5}K$	3.69	7.89	6.67	4.52	4.58	5.47	57.2
$N_{150}P_{3.5}K$	3.56	7.82	6.42	4.37	4.37	5.31	52.6

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

At the phosphorus fertilizer levels, maize production increased from 11.8% on the 1.5 mg of mobile phosphorus background to 25.8 - 28.4% - on the 3.0-3.5 mg/100 g of soil against the fund $N_{120}P_{1.0}K_{29\text{-}32}$. On the variant with background $P_{3.5}K_{29\text{-}32}$, the increase in crop yield versus control variant was 27.0%.

In the case of nitrogen variants in doses of 30 - 150 kg/ha on the background $P_{3.5}K_{29\text{-}32}$ (PK), the increase in grain maize production was 4.85 - 5.47 t/ha or 39.4 - 57.2% compared to the control and 12.4 - 30.2% versus PK variant (*table 2*).

In the dry years, the mineral fertilizers have contributed significantly to the formation of maize production. Although the global harvest has declined in these years, productivity in the non-fertilized variant increased in 2012 by 34-64% and by 29-72% in 2015.

The phosphorus fertilizers have contributed in the maize production increasing the yield with 9 - 23% in 2012 and with 7 - 32% in 2015. The nitrogen fertilizers were quite revealing in the production of maize yields, during 2012 and 2015 the maize production increase constituted 5 - 32%.

The quality of maize grain has been directly influenced by the application of mineral fertilizers. Crude protein content in maize grains ranged from 6.2% to 12.3%. The average of maize crude protein in five years of research in the unfertilized variant (control) was 7.7%, increasing on the fertilized variants to 8.0-9.9%.

The so-called "dilution effect" was produced in maize production on the variant $P_{3.5}K$. The maize average yield on this variant was 1.27 times higher than the control, but with a lower protein content (*table 3*).

Table 3

Crude protein content (N, % x 6,25) in maize grains cultivated on the cambic chernozem, %

Variant	Cultivation year					**Average, %**
	2012	**2013**	**2014**	**2015**	**2017**	
Control	9.6	6.2	7.3	8.4	6.8	**7.7**
$N_{120}P_{1.0}K$*	10.8	7.0	8.2	8.9	8.1	**8.6**
$N_{120}P_{1.5}K$	11.2	7.2	8.3	9.1	8.7	**8.9**
$N_{120}P_{2.0}K$	11.3	7.4	8.7	9.3	9.4	**9.2**
$N_{120}P_{2,5}K$	11.8	7.6	8.3	9.2	9.6	**9.3**
$N_{120}P_{3.0}K$	11.9	7.9	8.5	9.2	9.7	**9.4**
$N_{120}P_{3.5}K$	12.0	7.8	8.4	9.3	9.9	**9.5**
$N_{120}P_{4.0}K$	12.0	7.7	8.6	9.2	9.4	**9.4**
$N_{120}P_{4.5}K$	12.0	7.7	8.7	9.3	9.6	**9.5**
$P_{3.5}K$	9.2	6.8	7.0	8.0	7.2	**7.6**
$N_{30}P_{3.5}K$	9.8	7.0	7.3	8.1	7.9	**8.0**
$N_{60}P_{3.5}K$	10.3	7.2	7.6	8.7	8.4	**8.4**
$N_{90}P_{3.5}K$	10.8	7.5	8.3	9.2	9.3	**9.0**
$N_{120}P_{3.5}K$	11.8	7.8	8.7	9.3	9.8	**9.5**
$N_{150}P_{3.5}K$	12.3	8.0	9.2	9.6	10.3	**9.9**

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

The amount of crude protein in maize cultivated per unit area is an integral indicator of crop productivity evaluation. This indicator enables us to determine the agronomic efficiency or yield increase from fertilizers in order to obtain maize production. The amount of crude protein obtained from the cultivation of maize in relation to the level of fertilization on the cambic chernozem is presented in *table 4.*

Table 4

The amount of maize crude protein obtained from the level of fertilization, kg/ha

Variant	Cultivation year					Average, kg/ha	Increase, %
	2012	2013	2014	2015	2017		
Control	216	374	274	221	185	254	-
$N_{120}P_{1.0}K$*	325	502	429	302	273	366	44.1
$N_{120}P_{1.5}K$	368	551	510	329	306	413	62.6
$N_{120}P_{2.0}K$	386	592	552	377	354	452	77.9
$N_{120}P_{2,5}K$	433	609	539	401	393	475	87.0
$N_{120}P_{3.0}K$	427	626	540	411	425	486	91.3
$N_{120}P_{3.5}K$	443	629	546	402	450	494	94.5
$N_{120}P_{4.0}K$	432	614	556	394	417	483	90.1
$N_{120}P_{4.5}K$	434	634	525	399	431	485	90.9
$P_{3.5}K$	267	479	366	274	250	327	28.7
$N_{30}P_{3.5}K$	300	512	463	300	301	375	47.6
$N_{60}P_{3.5}K$	374	590	514	353	375	441	73.6
$N_{90}P_{3.5}K$	394	603	546	386	419	470	85.0
$N_{120}P_{3.5}K$	435	615	580	420	449	500	96.8
$N_{150}P_{3.5}K$	438	626	591	419	450	505	98.8

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

Mineral fertilizer application virtually doubled the quantity of maize crude protein obtained at 1 ha from the natural background. On average, during research years on the fertilization levels, the amount of crude protein increased from 254 kg/ha to 505 kg/ha.

The role of nitrogen fertilizers was significant in maize cultivation. Application of the nitrogen fertilizers at doses of 30-150 kg/ha on the PK background led to an increase in the amount of crude protein from 327 kg to 505 kg/ha (*table 4*).

Increasing yields of mineral fertilizers were significant, from 28.7% to 98.8% compared to the control variant. In variants with phosphorus levels on the $N_{120}P_{1.0}K$ background, the yield from phosphorus action increased from 18.5% to 50.4%. The yield from administered nitrogen doses on the $P_{3.5}K$ background increasing and constituted 18.9-70.1%.

The maximum yield increase for maize production was achieved on variants $N_{120}P_{3.5}K$ - $N_{150}P_{3.5}K$.

CONCLUSIONS

The application of mineral fertilizers on the natural background of the cambic chernozem in long-term experiments has led to the increase of grain maize production by 27 - 57%.

Levels of phosphorus fertilization led to an increase in grain maize yield with 11-28% and the nitrogen fertilizers at doses 30-150 kg/ha yielded a harvest rate of 12-30%.

The maximum increase of crude protein production in maize grains was obtained on the $N_{120}P_{3.5}K$ - $N_{150}P_{3.5}K$ variants.

The optimum level of mobile phosphorus in the soil for cambic chernozem in the cultivation of grain maize was 3.0 - 3.5 mg/100 g of soil (Machigin method) and the optimal nitrogen doses were 90 - 120 kg/ha.

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