UDC 633.15:631.582.1: 631.559

Productivity of grades and hybrids of corn at different fertilizer systems and their permanent growing

Kokhan A.[1], Glushchenko L.[2], Len O.[3], Olepir R.[4], Samoilenko O.[5]

Poltava State Agricultural Experimental Station named after M.I. Vavilov, Institute of Pig Breeding Agro-Industrial Production of NAAS 86 Shvedska Str., Poltava, 36014, Ukraine; e-mail: [1, 2, 5]ds. vavilova@ukr.net, 3alexandrlen@ukr.net, [4]olepir. zoman1981@ukr.net

The purpose. To carry out the impact analysis of anthropogenic (one-crop system, system of fertilizing, grade, hybrid) and natural (temperature and water regimes) factors on productivity of corn and dynamics of elements of soil fertility in conditions of Left-bank Forest-steppe of Ukraine. **Methods.** Field, statistical, laboratory. **Results.** Results are given of long-term researches in growing corn for grain in permanent sowing (one-crop system) and as thus under impact of fertilizing its productivity and soil fertility varied. As a result of agrochemical analysis of soil samples it is fixed that on fertilized plots the content of gross and mobile forms of nutrients was higher, than on not fertilized (control). At the same time irrespective of system of fertilizing the yielded indexes were dynamical on soil profile. In structure of biological groups of weeds late spring made 59 – 64%, early spring — 21 – 27, perennial — 13,9%. **Conclusions.** As a result of researches in typical chernozem in conditions of Left-bank Forest-steppe of Ukraine it has been fixed that anthropogenic and natural factors differently influence the level of productivity of corn for grain and soil fertility at its growing in one-crop system. Thus, productivity of the crop more depends on weather and less — on duration of growing in one place. At mathematical analysis of the gained results of researches in productivity of corn and dependence of its magnitude on fertilizer system, temperature and water regimes it has been fixed that their correlation envelopes a wide spectrum - from straight up to inverse. The carried out account of weeds has shown that on the average for 4 years of researches for 1 m2 of one-crop sowing their amount made 84,9 pieces/m2, whereas in crop rotation — 59,1 pieces/m2, that on 30% is less.

Key words: *soil fertility, one-crop system, one-crop sowing, weather environment, correlation, productivity*

DOI: https://doi.org/20.31073/agrovisnyk201910-03

Formulation of the problem. At the present stage of the development of society, the attraction of natural resources to human production activity has become so large and inclusive, which has significantly disrupted the bonds and balances that have developed in the biosphere for thousands of years. Rational use of land resources and efficient management of these processes are an important component of intensification of agriculture, increase of the economic profit of the commodity producer and improvement of the ecological situation in the region [1].

That is why obtaining timely information on changes in the soil and forecasting the dynamics of its fertility for the future was, is and will be relevant for agrarians. This will enable the identification of optimal economically and environmentally sound agro methods that will help to stop degradation processes in the soil. The most significant diagnostic signs of loss of its fertility - is the decrease in the content of organic matter and its constituent part of the humus, the main macro-and trace elements and the change in acidity [2].

Corn (*Zea mays* L.) is a valuable food, feed and technical culture. In terms of sown area and grain harvest, it ranks third in the world after wheat and rice. In order to meet the ever-increasing demand for grain of this crop without increasing sown areas, corn growing as a monoculture is increasingly included in agricultural practice [3, 4].

According to its biological characteristics, this culture is stable when cultivated in monoculture. At the same time, there is no consensus among researchers on this issue. Some believe that it is resistant to unchanging cultivation, while others refute this statement [5, 6].

The analysis of the results of researches of domestic and foreign scientists does not make it possible to make unambiguous conclusions regarding the productivity of maize, depending on the saturation of its crop rotation and its fertilization. That is why long-term experiments with unchanged crops in the context of global climate change are relevant today, and are currently being conducted both in Ukraine and in other countries, in particular in England, the USA, Germany, etc. [7-10].

Corn is very demanding for the presence of organic matter and nutrients in the soil, only with a content of humus more than 5% and a pH of 6,0 – 8,5 units it is possible to get a good harvest [11]. However, weather conditions, especially in the zone of inadequate moisture, also play a role in the growth, development and formation of the crop, and in some dry years crop yields depend entirely on them [3, 4].

The purpose of the work is to make an analysis of the influence of anthropogenic (monoculture, fertilizer system, varieties, hybrids) and natural (temperature and water regimes) factors on the productivity of maize and the dynamics of soil fertility elements in the conditions of the Left Bank Forest-steppe of Ukraine, on the basis of the obtained own research results.

Materials and methods of research. Studies from 1964 are conducted on the Research Field of the Poltava State Agricultural Experimental Station named after M.I. Vavilov, Institute of Pig Production and Agro-Industrial Production of the National Academy of Sciences of Ukraine. Geographical coordinates: latitude 49^0 40/nz, longitude 34^0 57/sec.d.

The soil of the experimental field - black earth is typical of moderately humus heavy loamy on forest rock. Characterized by the following basic agrochemical and agrophysical parameters: humus content – 4,9-5,2%; nitrogen that is easily hydrolyzed (by Tyurin and Conon) – 119,1-127,1 mg/kg; P2O5 in acetic-acid extract (by Chirikov) – 100,0-131 mg/kg; exchangeable potassium (by Maslova) – 171.0 -200 mg/kg of soil. Soil density is 1,05-1,17 g/cm^3. Total porosity – 55,5-59,8. Field moisture content – 29,7-31,5%. The lowest field moisture content is 29,2-31,5%. Total moisture content – about 39%. The active moisture range is about 25 mm. Humidity of the gap of capillary bonds – 20-22%.

The number of fields in kind is 1. The total area under the study is 8640 m^2, the accounting area is 29,4 m^2. Number of repetitions – 2. Scheme of experiment: 1 – without fertilizers (control); 2, 3 – manure + NPK.

In the experiment, raion varieties and hybrids of corn were grown: from 1964 to 1974 – Bukovinsky 3; 1975 to 1987 – Zherebkivsky 86 MV; 1988 to 2001 – Dnieper 273 MV; 2001 to 2005 - Frame 267 MV; 2005 to 2012 – Podilsky 274 MV; 2013-2017 year – Orzhitsa 273 MV.

Experience with a permanent crop maize is spatially located at a distance of 300 m from the crop rotation site.

Research results. Long-term observation of the yield of maize hybrids, which changed during the research and cultivate them as monoculture, allowed to establish its dynamism (table 1).

1. Productivity of different hybrids of corn on grain for unchanged cultivation, t/ha

Hybrid	Growing season	Fertilizer system			Weather conditions					
					average t air, °C			amount of precipitation, mm		
		without fertilizers (control)	manure 30 t/ha annually + $N_{60}P_{40}K_{60}$	manure 30 t/ha 1 time in 3 years + $N_{51}P_{51}K_{55}$	for vegetation (1.05.–1.09.)	critical period (20.07.–10.08.)	for the agricultural year	for vegetation (1.05.–1.09.)	critical period (20.07.–10.08.)	or the agricultural year
Zherebkivsky 86 MV	1975-1987	3,58	4,27	4,37	19,4	19,6	7,2	234,3	36,9	556,2
Dniprovsky 273 MV	1988-2001	3,51	4,62	4,81	19,1	20,6	8,3	207,4	46,2	526,4
Frame 267 MV	2001-2005	6,63	6,92	7,06	19,2	22,2	8,7	266,3	107,8	575,7
Podilsky 274 MV	2005-2012	4,66	5,98	6,47	20,9	23,6	9,3	199,2	35,4	488,1
Orzhitsa 273 MV	2013-2017	3,69	4,43	4,62	20,9	23,6	9,6	184,6	57,9	529,2

Replacing some hybrids with other hybrids with higher genetic productivity potential, as well as research time, did not have a direct impact on the yield of a given crop. The highest was the figure of 267 MV in the hybrid, and in the areas without fertilizers (control) it was 6,63 t/ha, whereas in fertilized areas: manure 30 t/ha annually + $N_{60}P_{40}K_{60}$ – 6,92 t/ha and manure of 30 t/ha once every three years + $N_{51}P_{51}K_{55}$ – 7,06 t/ha. The lowest yield was recorded in the Zherebkivskyi 86 MV hybrid, respectively 3,58 t/ha in the control and 4,27 in the fertilized areas; 4,37 t/ha. The yields from the fertilizer for the cultivation of these hybrids were 4,4 and 6,5% and 19,3 and 22,1%, respectively.

If the yield of corn hybrid Zherebkivsky 86 MV (1975-1987), which was grown at the beginning of the research to take 100%, then the yield of successive hybrids in areas without fertilizers (control) was the hybrid Dnieper 273 MV (1988-2001) – 98%; Frame 267 MV (2001-2005) – 185%; Podilsky 274 MV (2005-2012) – 130%, and Orjaka 273 MV (2013-2017) – 131%. At the expense of fertilization, the yield of these hybrids increased to 108, 162, 140, 104% and 110, 162, 148, 106%, respectively.

The mathematical analysis of corn yield and its dependence on various fertilizer systems, as well as temperature and water regimes, showed that their correlation relationship covers a wide range: from direct to reverse. So, if the correlation coefficient between the corn yield and the average temperature of the air during the growing season (1.05-1.09), both in non-fertilized areas (r = -0,18), and on the fertilized ones (r = -0,06; 0,03), was completely absent, then the critical period of moisture for corn plants (20.07-10.08) is weak: r = 0,31; 0,22, according to fertilizer. For the agricultural year as a whole, depending on the fertilizer system, the correlation coefficient was a direct average: r = 0,41; 0,47 and 0,33; 0,38.

The correlation between the level of corn yield, fertilizer system and weather conditions in different seasons was somewhat different. If for vegetation in non-fertilized areas (control) it was direct strong (r = 0,72), then on fertilized (manure 30 t/ha annually + $N_{60}P_{40}K_{60}$ and manure 30 t/ha once every three years + $N_{51}P_{51}K_{55}$) – direct average (r = 0,57; r = 0,58). During the critical period of development of plants

(20.07-10.08), according to fertilizer systems – direct strong (r = 0,84; 0,69) and direct average (r = 0,60), and in general for the agricultural year - direct average (r = 0,41) and absent completely (r = 0,15; 0,03).

According to the results of agrochemistry analysis of soil samples, it was found that in fertilized areas the content of gross and mobile forms of nutrients is greater than that of non-fertilized (control). However, on the soil profile, these indicators are quite dynamic irrespective of fertilizer system (table 2).

The carried out record of bullying showed that, on average, for four years, the amount of weed unaltered corn sown at 1 m^2 was 84,9 pcs./m^2, while in the crop rotation it was 59,1 pcs. m^2, that is 30% less. In the structure of biological groups of weeds, the late forests were 59-64%, early spring 21-27% and perennials – 13,9%.

Conclusions

As a result of the conducted research on the permanent cultivation (monoculture) of maize for grain on typical chernozem, in the conditions of the Left Bank forest-steppe of Ukraine, the unequal influence of anthropogenic and natural factors on the level of its yield and soil fertility was established. The mathematical analysis of the results of studies on corn yield and its dependence on fertilizer system, as well as temperature and water regimes, showed that their correlation relationship covers a wide range: from direct to reverse.

The recorded weed accounting showed that on average for four years on 1 m^2 of unaltered crop their number was equal to 84,9 pcs./m^2, while in crop rotation – 59,1 pcs/m^2, which is 30% less.

2. Agrochemical characteristics of the soil for unchanged cultivation corn for grain (typical black earth), 2001

Fertilizer systems	The layer of soil, cm	Content on completely dry soil					Gumus, %	PH		Cached inlets, mg-eq. per 100g				Hr mg-eq. per 100g
		N gross, %	мg/kg					water	salt water	Ca	Mg	K	Na	
			P_2O_5 gross	N easily hydrolyzed	by Chirikov									
					P_2O_5	K_2O								
No fertilizer (control)	0–20	0,221	1198,6	113,5	84,2	171,6	4,89	6,88	5,88	32,64	3,18	2,55	0,45	2,78
		0,219	1185,4	119,7	90,2	169,2	4,79	7,00	6,00	35,11	5,22	2,40	0,55	
	21–40	0,216	1149,2	120,9	66,5	161,2	4,89	7,43	6,88	34,91	5,89	1,77	0,44	1,03
		0,211	1138,1	110,4	61,9	157,8	4,70	7,11	6,55	33,70	5,68	2,01	0,50	
	41–60	0,197	1045,2	84,4	14,5	130,0	3,72	8,10	7,30	62,12	7,24	1,96	0,42	0,52
		0,199	1100,4	80,9	15,1	127,7	3,66	7,27	6,90	37,62	6,95	2,00	0,50	
Manure 30 t/ha 1 time in 3 years + $N_{51}P_{51}K_{55}$	0–20	0,247	1370,2	119,4	142,5	249,6	4,93	7,00	6,45	32,19	5,44	1,77	0,53	1,65
		0,250	1386,5	122,3	127,9	255,4	4,97	6,89	6,49	33,25	5,19	1,89	0,49	
	21–40	0,232	1149,2	102,3	78,0	182,0	4,67	7,23	6,78	34,57	6,28	2,88	0,44	1,03
		0,225	1020,5	120,4	82,4	168,9	4,85	7,19	6,89	33,77	5,43	1,91	0,51	
	41–60	0,167	1045,2	81,5	42,0	147,0	3,61	7,80	7,15	39,96	5,38	2,63	0,48	0,82
		0,173	1099,8	88,.6	46,5	140,4	3,50	7,77	6,95	38,11	5,22	2,26	0,39	

References

1. Tarariko, Yu. A. (2007). Formirovanie ustoychivyih agroekosistem [Formation of sustainable agroecosystems]. Kyiv. (In Russian).

2. Skrylnyk, Ye. V. Kutova, A. M., Filimonchuk, Ya. S., & Moskalenko, V. P. (2015). Vplyv antropohennykh faktoriv na humusnyi stan i vmist pozhyvnykh rechovyn u chornozemi typovomu [The influence of anthropogenic factors on the humus state and the content of nutrients in the chernozem is typical]. *Bulletin of Agricultural Science*, *9*, 12-16. (In Ukrainian).

3. Kryuchkov, A. G. (2006). Osnovnyie printsipyi i metodologiya agroekologicheskogo rayonirovaniya zernovyih kultur v stepi Yuzhnogo Urala [Basic principles and methodology of agroecological zoning of grain crops in the steppes of the Southern Urals]. Moscow. (In Russian).

4. Zhdanov, V. M., & Zorov, A. A. (2004). Vliyanie neparovyih predshestvennikov i fonov pitaniya na urozhaynost yarovoy myagkoy pshenitsyi [The effect of non-steam predecessors and nutritional backgrounds on the yield of spring soft wheat]. *Problems of virgin agriculture: a collection of scientific works dedicated to the 50th anniversary of the beginning of the development of virgin lands.* Orenburg, 118-121. (In Russian).

5. Bondareva, V. Yu. (1986). Vozdelyivanie kukuruzyi na zerno v nasyischennyih sevooborotah i bessmennyih posevah [Cultivation of corn for grain in saturated crop rotations and permanent crops]. Moscow: Agropromizdat. (In Russian).

6. Gangur, V. V. (2010). Tsaritsa poley v monoculture [Queen of the Fields in Monoculture]. *Corn*, *3,* 27-29.

7. Hlushchenko, L. D., Kokhan, A. V., Hanhur, V. V., Olepir, R. V., Len, O. I., & Breheda, S. H. (2018). Produktyvnist zhyta ozymoho za bezzminnoho vyroshchuvannia [Productivity of winter rye for unchanging cultivation]. *Agroecological journal*, *2*, 61-67. (In Ukrainian).

8. Kohan, A. V. Gluschenko, L. D., Len, O. I, Olepir, R. V., Gangur, V. V., & Samoylenko, O. E. (2019). Bessmennoe vyiraschivanie pshenitsyi ozimoy i ee vliyanie na fitosanitarnoe sostoyanie posevov, agrohimicheskoe i agrofizicheskoe sostoyanie pochvyi, uroven produktivnosti [The permanent cultivation of winter wheat and its effect on the phytosanitary condition of crops, the agrochemical and agrophysical state of the soil, the level of productivity]. *Bulletin of the Belarusian State Agricultural Academy*, *2*, 181–186. https://doi.org/10.1134/s0002188119010101 (In Russian).

9. Puget, P., Lal R., Jzzaurradle C., Post M., & Owens L. (2005). Stock and distribution of total and corn-derived soil organic carbon in aggregate primary purticly fractions for different land use and soil management practices. *Soil Science*, *170*, 256–279. https://doi. org/10.1097/00010694-200504000-00004

10. Flessa, H., Amelung, W., Helfrich, M., Wiesenberg, G., Brodowski, S., Rethemeyer, J., Kramer, C., & Grootes, P. (2008). Storage and stability of Organic Matter and Fossil Carbon in a Luvisol and Phaeozem with Continuons Maize cropping: A synthesis. *Plant Nutrition and Soil Sci.*, *171*, 36–51. https://doi.org/10.1002/ jpln.200700050

11. Scherbakov, A. P., Protasova, N. A., Belyaev, A. B., Stahurlova, L. D. *Pochvovedenie s osnovami rastenievodstva* (1996). [Soil science with the basics of crop production]. Voronezh: VGU. (In Russian).