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POTASSIUM REGIME OF IRRIGATED CHERNOZEMS IN VARIOUS AGROTECHNICAL BACKGROUNDS

Oksana TSURKAN[1], Svetlana BURYKINA[2], Galina SUKHORUKOVA[1], Yaroslav BILANCHYN[1], Alla PIATKOVA[1], Tamara LEAH[3]

[1]Odesa "I. I. Mechnikov" National University, Frantcuz'kiy blvd,. 48/50, Odessa, Ukraine, 65058. E-mails: otsurkan75@gmail.com; grunt.ggf@onu.edu.ua; avpyatkova2011@gmail.com;
[2]Odessa State Agricultural Experimental Station of the National Academy of Agrarian Sciences of Ukraine, 24 Mayakskoe Street, smt. Khlebodarskoe, Belyaevsky district, Odessa region, Ukraine, 67667. E-mail: burykina@ukr.net
[3]"N.Dimo" Institute of Pedology, Agrochemistry and Soil Protection, 100 Ialoveni Str., Chisinau, Moldova, 2070. E-mail: tamaraleah09@gmail.com.

Corresponding author: tamaraleah09@gmail.com

Abstract

The study analyses the changes of the fractional composition of potassium of the main soils of southern Ukraine – ordinary chernozem and southern chernozem under influence of irrigation and fertilization systems. The research was conducted in two stationary experiments, laid on chernozem ordinary (11-year of crop rotation) and on chernozem south (3-year multifactorial experiment). It is established that under the influence of irrigation in ordinary chernozem the sum of groups of potentially available potassium in a layer of 0-30 cm increases by 40.3 and 57.5% in comparison with rainfed conditions. The content of exchangeable potassium in chernozem usually varies considerably depending on the soil moisture (r = -0.80). The norm of fertilizers – manure 200 t/ha + $N_{200}P_{200}K_{60}$, introduced under the basic cultivation of the first crop rotation, in the aftermath after 11th year provides a positive balance of exchangeable potassium in ordinary chernozem even with a decrease in the initial content in 2.1 times. In the southern chernozem, the total amount of potentially available potassium is much lower than in chernozem ordinary: 19.0% in the layer 0-30 cm and from 45.5 to 52.6% with a depth of 120 cm. The distribution of the depth and direction of irrigation and fertilizer systems are similar to those of ordinary chernozem.

Key words**:** ordinary chernozem, southern chernozem, irrigation, fertilizers, potassium regime

INTRODUCTION

Potassium belongs to the group of main elements that determine the geochemical features of the landscape, the conditions for the migration of other elements. Among the elements of mineral nutrition consumed by plants in the largest quantities, potassium holds one of the first places. Under the conditions of high potassium presence, the following qualities of the agricultural products improves: content of sugar in fruits and vegetables, starch – in potatoes, fat – in the oilseeds, the filling in grains of cereal crops, the strength of fibres in the barns.

The potassium in the soil increases the water-retaining capacity of cells, affects the plant's resistance to drought and crops' infestation of diseases [15]. This element contributes to the increased winter and frost resistance of winter wheat, as well as the frost resistance of spring crops [11]. In ordinary and southern chernozems of heavy granulometric composition, the gross content of potassium is quite high and ranges from 2.1 to 2.4% [17], though its main share constitutes a potential reserve of an exchangeable equilibrium. The gross availability of the element to plants depends on many factors, the main among which is the moisture regime and scientifically grounded use of fertilizers.

In the period of intensive use of chemicals in agriculture, most of Ukraine's soils had a high degree of supply with exchangeable potassium. Since 1991, the level use of mineral fertilizers has decreased: in 1991-

1995 biennium average was 73 kg (active substance - a.s.) of NPK, in 1996-2000 – 19 kg a.s. of NPK. Since 2001, a gradual increase has been observed and currently 43 kg a.s. NPK has been achieved, including only 8 kg of K_2O per hectare of sown area [6]. As we can see, the level of potassium fertilizers is very low. Some authors [7] consider that the important determinant of this phenomenon resides in the belief of many researchers, farmers, and specialists of the Ministry of Agrarian Policy and Food of Ukraine that most of the soils of the Forest-Steppe and Steppe areas, especially the heavy granulometric composition, are well-supplied with the potassium available to plants. However, the data collected during the recent agro-chemical survey reveals that the area of soils with low and average content of exchangeable potassium and the growth of its balance deficit from (-56.4) kg/ha in 2001 to (-64.2) has increased as for 2009 [12].

With the increase in the level of agricultural technology, spreading the use of techniques aimed at the accumulation and preservation of soil moisture, and the optimization of nitrogen - phosphorous nutrition, the agrochemical and economic effect of the use of potassium fertilizers on the ordinary and southern chernozems (the zone of the Steppe) has increased significantly. The role of potassium in irrigation and the application of high doses of nitrogen-phosphorus fertilizers in intensive crop rotation is especially evident [8].

Primarily, the plants assimilate the most mobile forms in the process of nutrition which is potassium of the soil solution. Then they consume exchangeable forms and during the development of the plant – unchangeably fixed forms, which must be taken into account when describing the fertility of soils with respect to potassium [13].

There is no consensus among the scientists about the effect of the long-term systematic introduction of fertilizers on the content of certain potassium fractions and their correlation in soils. For example, according to the studies of Nosko and Gladkyh on ordinary chernozems, it is established that when systematically applying medium and elevated potassium fertilizer rates, the content of mobile potassium increases by 23-37%, easily soluble and loosly-bond – by 30-35%, exchangeable – by 80-110% up to a depth of 100 cm [16]. According to their data, this process occurs even with a poor balance of potassium in crop rotation.

There also exist studies which confirm the same peculiarity in respect to the mobile element of the podzolic chernozems [3]. Data obtained on the chernozem drainage demonstrates that even for a positive balance of potassium, its accumulation occurs mainly in light - exchangeable forms. Alongside with this, as the content of potassium increases, its strongly bonded fractions also go up [14].

In contrast, Voronkov and Khramtsov argue that the systematic use of mineral fertilizers and straw as a source of organic matter did not significantly affect the accumulation of exchangeable forms of potassium in the recovered chernozem, which, in their opinion, is explained by the high dynamism of equilibrium between them [21]. The relative stability of the content of exchangeable potassium was observed in their experiments during 15-18 years with an annual carryover of 25-37 kg/ha.

In a stationary experiment on a dark-grey podzolic soil, fertilizer systems for the period from 2001 to 2012 provided an increase in the content even of the gross forms of potassium: mineral to a depth of 60 cm, organic and organic-mineral to 80 cm. In addition, they significantly changed the ratio of different forms of potassium to a depth of 60 cm; at a depth of up to 1 m, there was a sharp decrease in the exchangeable form almost to the indicators of the control variant.

According to the conclusions of Lopushnyak [10], an organic-mineral system with organic fertilizer saturation of 15 t/ha of crop rotation area has provided the highest rates of water-soluble, exchangeable and unchangeably fixed potassium in soil as compared to mineral and organic systems.

The influence of irrigation regimes on the state of the chernozem potassium stock was practically not studied, except for individual studies [18, 19, 23]. Some authors noted the effect of soil moisture on the mobility of potassium fractions and the evidence of its available form in soils of the steppe and dry-steppe zones [24], the Carpathians [22] and meadow-chernozem soils [9].

Thus, if the data on the effectiveness of long-term use of fertilizers in relation to the potassium regime of soils is quite contradictory, and in the conditions of irrigation is practically absent, it is necessary to systematize already received results and accumulate new types of soils, climatic zones and research methods for the establishment of certain regularities.

The aim of the study is to investigate the effect of long-term irrigation and fertilizer on the potassium regime of chernozems.

MATERIALS AND METHODS

Observations were conducted in two stationary experiments.

First, the irrigation regimes on different backgrounds of soil cultivation (ploughing to a depth of 25-27 cm to 40-50 cm) and organic-mineral fertilizer system within the Southern Bug Irrigation System were studied. The water from the South Bug river was used for irrigation. The chemical composition of hydrocarbon-calcium water with mineralization of 300-680 mg/dm^3 is as follows: among anions, hydrocarbon predominates (171.3-288.9 mg/dm^3) – an average of 54.1% of the sum of all anions; among cations – calcium (43.1-82.4 mg/dm^3), which is an average of 40.6% of their amount. The irrigation rate in the years of research from 1,200 to 3,500 m^3/ha. Irrigation rate 350-600 m^3/ha.

The soil ordinary chernozem is a shallow semi-humus lethargic on the loess (study field of the Ochakiv station). The average amount of humus in an arable layer of 0-30 cm – 4.81%, the content of which on the profile has gradually decreased. Among the absorbed bases, calcium prevailed (80.7-84.7%), the amount of sodium absorbed was negligible and amounted to 0.1% of absorption capacity. A characteristic feature of the soil is the high pH of the aqueous extract: the plough-treated horizon of 7.8-7.9, the under plough horizon and below – exceeded 8.2. Carbonation was noted from a depth of 40-50 cm.

Rotation of crops: corn for grains, winter wheat, corn for green feed, annual grasses, fodder beet, corn soda with silage, corn mix with perennial grasses. Agricultural procedures for crops cultivation is typical for this zone.

Variations of fertilizer systems: 1. 40 t/ha manure + $N_{60}P_{60}K_{15}$; 2. 100 t/ha manure + $N_{100}P_{100}K_{30}$; 3. 200 t/ha manure + $N_{200}P_{200}K_{60}$. Fertilizers were introduced once for rotation under the corn for basic cultivation. The repetition of the experiment is four times, the area of the plot is 0.15 hectares, the location is renamed. Potassium chernozem stock is presented depending on irrigation norms and fertilizer system, because there were no significant differences in ploughing variants.

The second multifactorial field experiment was laid on the territory of the Nizhnednistrovsk irrigation system at the fields of "Agrofirma Petrodolynskoe" in Odessa region. The type of crop rotation is grain and feed. Alternate crops: maize for silage, winter wheat, fodder beet. Agricultural procedures for crops cultivation is typical for this zone.

The source of irrigation in the Nizhnednistrovsk Irrigation System is the Dniester River. Total mineralization of water from March to October varies within 430-648 mg/dm^3. The dominant anion is a hydro-carbonate, the content of which varies from 195.2 to 274.5 mg/dm^3, and the averaged value is 52.3% of the sum of the content of all anions. Content of other anions: SO_4^{2-} – 75,2-171,8 mg/dm^3 or 27.6%; Cl^- – 32-76,7 mg/dm^3 or 19.8%; CO_3^{2-} – 0-9,0 mg/dm^3, or 0.4%. Irrigation rates: maize for silage – 300 m^3/ha – 5 irrigations; winter wheat – water storage – 400 m^3/ha and 3 plots of 300 m^3/ha; fodder beet – 300 m^3/ha – 11 irrigations.

The soil is southern low-humus heavy-bodied chernozem on loessed loam. Humus content in the arable layer is 3.4%. The capacity of the humus horizon does not exceed 60 cm and the humus content in its lower part is 1%. The composition of the absorbed bases is dominated by calcium, content of which in the arable layer is 26.5 mmol/100 g of soil, with the depth down to 23.3. The amount of saturated sodium is 1.4-1.2%. Carbonation is noted from a depth of 50-60 cm, but the field is aligned with this indicator only from 60-80 cm; the pH of the aqueous extract in the arable horizon ranges from 6.9 to 7.0.

The effectiveness of 19 variants of fertilizer systems was studies, the potassium fund was investigated on seven variants: 1. Control (without fertilizers); 2. Manure 40 t/ha – background; 3. Background + $P_{180}K_{180}$; 4. Background + $N_{180}P_{180}K_{180}$; 5. Background + $N_{180}K_{180}$; 6. Background + $N_{180}P_{180}$; 7. Background + $N_{300}P_{180}K_{300}$. The fertilizers were introduced once for rotation for corn silage. The area of the sown area is 550 m^2, the location is renamed, the repetition is 4 times. The exchangeable potassium was determined by the Maslova method [4], the fractional composition of potassium by the Dashevsky method in the modification of the Sokolovsky NSC ISSAR [1, 20].

RESULTS AND DISCUSSIONS

Under conditions of irrigation in ordinary chernozems, the sum of potassium groups in the layer of 0-30 cm increases by 40.3 and 57.5% (Table 1).

Table 1. The fractional composition of potassium in ordinary chernozems with irrigation

Variant	*Depth of sampling, cm*	*Readily-soluble*	*Exchange-able*	*Hydro-lyzed*	*Unchange-ably fixed*	*Sum*
		mg/100 g of soil				
Dryland	0-30	1.5	17.5	43.5	350.0	412.5
	30-50	1.0	16.5	49.0	495.0	561.5
	50-80	0.5	10.5	52.5	320.0	383.5
	80-120	0.5	10.5	39.5	300.0	350.5
	120-150	0.5	9.0	39.5	350.0	399.0
Irrigation 70-80 %	0-30	1.3	13.5	54.0	510.0	578.8
	30-50	1.0	16.5	49.0	475.0	541.5
	50-80	0.5	15.5	45.5	345.0	406.5
	80-120	0.5	8.5	43.5	415.0	467.5
Irrigation 80-90%	0-30	2.0	20.0	97.5	530.0	649.5
	30-50	0.8	13.5	51.0	477.0	542.3
	50-80	0.5	15.5	45.5	360.0	421.5
	80-120	0.5	21.0	45.5	375.0	442.0

Source: Own determination.

It is depending on the irrigation regime, in the horizon of 30-50 cm, changes in relation to the rainy conditions range from 3.3 to 9.9%, and in the layer 80-120 cm – higher than the control variant in 33.4 and 26.6.

At the same time, the changes in the content of the easily soluble and exchangeable forms are not significant, and the potential reserves increase to a large extent. Hence, an increase in the content of potassium that is easily hydrolysed, the more significant, the more intense irrigation. A similar trend is also applicable to the unchangeably fixed group.

According to Zhukov and Nikitina [24], it is due to the predominance of hydrosulphite minerals in the content of silty fraction, alkaline reaction of soil solution, saturation with divalent bases, high content of organic matter and periodic drying of soils.

According to Zhantalay [23], irrigation increases the content of hydrocarbons in the soil and the gross content of potassium, as well as the intensification of the processes of meltmorillonite’s ilitization, where in the process it loses the ability to expand the lattice and turns into mixed-layer hydrosulfide - montmorillonite formation.

Study of fractional composition of potassium of southern chernozems under irrigation conditions within the limits of the Nizhnednistrovsky irrigation system showed that the sum of potassium groups in them is much lower than in ordinary chernozems – in the layer 0-30 cm at 19.0% and from 45.5 to 52.6 % with a depth of 120 cm (Table 2). Probably this is due to the gross reserves of potassium. The distribution on the profile is identical – there is a slight uniform decrease in potassium content with depth.

Compared with ordinary chernozems, in the southern chernozems, the proportion of light-hydrolytic potassium increases slightly and proportion of unchangeably fixed decreases accordingly. It is evident that the content of

In the most mobile (readily soluble) reliability of the changes is the lowest. With increase of the potassium bond strength with the soil environment, the reliability of its content in this group increases. The unchangeably fixed potassium is most closely related to the soil, which stipulates high reliability of this indicator. It should be noted that in all variants of the experiment in the layer of 30-40 cm the content of the unchangeably fixed potassium is sharply reduced, which can be explained by the high biological activity of the irrigated soil in the indicated layer.

the first three groups of potassium – readily soluble, exchangeable and hydrolysed – throughout the profile, with the background of all variants of the experiment, have very low reliability. This can be explained by the fact that the potassium of these three groups is characterized by mobility and is easily transformed from one to another depending on the environment.

Table 2. The fractional composition of potassium in the southern chernozem depending on the fertilizer system with the background irrigation (mg/100 g of soil, n=5).

Variant	*Depth of sampling, cm*	*Readily-soluble*			*Exchangeable*			*Hydrolyzed*			*Unchangeably fixed*			*Sum*
		$\bar{x}$	$S\bar{x}$	*In % from sum*	$\bar{x}$	$S\bar{x}$	*In % from sum*	$\bar{x}$	$S\bar{x}$	*In % from sum*	$\bar{x}$	$S\bar{x}$	*In % from sum*	
Control without fertilizers	0-30	0.51	0.05	0.15	9.44	0.17	2.82	49.70	0.52	14.87	274.60	10.98	82.15	334.25
	30-40	0.22	0.01	0.07	6.70	0.15	2.19	44.90	0.62	14.67	254.30	2.80	83.07	306.12
	40-50	0.17	0.02	0.07	5.05	0.30	1.99	43.80	1.41	17.24	205.00	5.15	80.70	254.02
	50-80	0.11	0.01	0.05	4.31	0.49	2.05	39.80	0.46	18.89	166.50	4.01	79.01	210.72
	80-120	0.10	0.01	0.06	3.73	0.29	2.25	36.11	0.35	21.73	126.20	4.86	75.96	166.14
Background 40 t/ha of manure	0-30	0.16	0.02	0.05	11.02	0.57	3.71	48.68	0.28	16.38	237.36	10.47	79.86	297.22
	30-40	0.08	0.01	0.03	6.38	0.35	2.36	44.19	0.54	16.38	219.19	4.00	81.23	269.84
	40-50	0.10	0.00	0.04	5.07	0.02	2.02	44.56	0.78	17.76	201.22	9.50	80.18	250.95
	50-80	0.10	0.01	0.04	4.89	0.11	2.11	40.16	0.33	17.32	186.66	8.28	80.52	231.81
	80-120	0.09	0.01	0.05	3.99	0.19	2.03	39.95	0.28	20.32	152.61	4.18	77.61	196.64
Background + $N_0P_{180}K_{180}$	0-30	0.48	0.01	0.17	12.01	0.53	4.38	52.37	0.84	19.08	209.60	18.70	76.37	274.46
	30-40	0.32	0.03	0.12	7.16	0.20	2.58	48.80	0.76	17.59	221.10	14.07	79.71	277.38
	40-50	0.09	0.01	0.03	12.01	0.53	4.26	48.80	0.76	17.33	220.74	13.57	78.38	281.64
	50-80	0.06	0.00	0.02	5.29	0.15	1.78	45.27	0.26	15.25	246.21	15.78	82.95	296.83
	80-120	0.17	0.02	0.08	4.01	0.19	1.90	39.51	0.77	18.75	167.08	18.76	79.27	210.77
Background + $N_{180}P_{180}K_{180}$	0-30	1.97	0.05	0.64	13.28	1.07	4.31	59.58	1.25	19.34	233.30	20.17	75.71	308.13
	30-40	0.22	0.01	0.07	5.95	0.28	1.98	46.17	0.78	15.34	248.62	3.24	82.61	300.96
	40-50	0.23	0.02	0.07	5.81	0.30	1.79	50.58	0.81	15.57	268.14	4.64	82.57	324.76
	50-80	0.18	0.01	0.07	4.25	0.12	1.74	44.18	0.46	18.09	195.57	1.55	80.09	244.18
	80-120	0.12	0.01	0.06	4.19	0.28	2.16	42.01	0.44	21.66	147.62	9.52	76.12	193.94
Background + $N_{180}P_0K_{180}$	0-30	0.27	0.03	0.09	7.95	0.52	2.79	51.33	1.29	17.99	225.74	6.19	79.13	285.29
	30-40	0.20	0.03	0.07	5.07	0.34	1.74	44.78	0.33	15.39	240.99	4.62	82.80	291.04
	40-50	0.13	0.02	0.05	5.95	0.19	2.08	48.23	0.50	16.88	231.37	5.97	80.99	285.68
	50-80	0.10	0.01	0.04	5.50	0.31	2.14	41.34	0.50	16.06	210.50	15.72	81.77	257.44
	80-120	0.21	0.02	0.10	4.49	0.35	2.23	38.01	0.31	18.87	158.76	4.43	78.80	201.47
Background + $N_{180}P_{180}K_0$	0-30	3.41	0.15	0.98	16.16	1.04	4.66	62.97	0.95	18.15	264.46	11.77	76.21	347.00
	30-40	0.39	0.02	0.12	6.36	0.14	1.88	54.73	1.09	16.20	276.38	5.84	81.80	337.86
	40-50	0.11	0.00	0.04	7.43	0.42	2.45	46.17	0.75	15.25	249.04	1.87	82.26	302.75
	50-80	0.13	0.01	0.06	4.44	0.13	2.02	40.75	1.09	18.57	174.07	5.88	79.34	219.39
	80-120	0.21	0.01	0.10	4.98	0.13	2.42	39.90	0.61	19.43	160.28	2.56	78.04	205.37
Background + $N_{300}P_{180}K_{300}$	0-30	0.34	0.04	0.13	10.05	0.15	3.77	49.66	0.90	18.61	206.78	10.82	77.50	266.83
	30-40	0.29	0.02	0.08	7.79	0.53	2.27	47.20	1.43	13.73	288.55	4.58	83.92	343.83
	40-50	0.16	0.01	0.05	6.05	0.22	2.01	43.55	0.35	14.50	250.50	9.72	83.43	300.26
	50-80	0.19	0.01	0.09	4.97	0.09	2.38	38.46	0.21	18.42	165.12	10.19	79.10	208.74
	80-120	0.22	0.01	0.11	4.81	0.06	2.42	39.29	0.21	19.77	154.40	4.30	77.70	198.72

Source: Own determination.

As our long-term studies have shown, the layer of chernozem ground of 30-40 cm with irrigation is sharply different from other horizons in all soil, to a certain extent and according to the mobile indicators.

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The application of fertilizers almost did not affect the content of readily soluble potassium, only on a background of balanced nutrition (background + $N_{180}P_{180}K_{180}$) its content in the arable layer increased by 3.9 times compared to absolute control.

This variant was distinguished by the most even distribution of potassium in groups in the arable horizon. Under the organic fertilizer system, the lowest content of readily soluble potassium (0.16 mg/100 g) was observed. It can be noted that the application of manure facilitates the transfer of potassium into more tightly connected forms.

The study found that the content of exchangeable potassium in chernozem usually varies significantly depending on the moisture content of soil samples. In the damp, there is a significant decrease compared to air-dry in all layers of soil, both in irrigated areas: from 1.7 to 2.9 times, and in areas without irrigation: 2.2-4.4 times (Figure 1, 2).

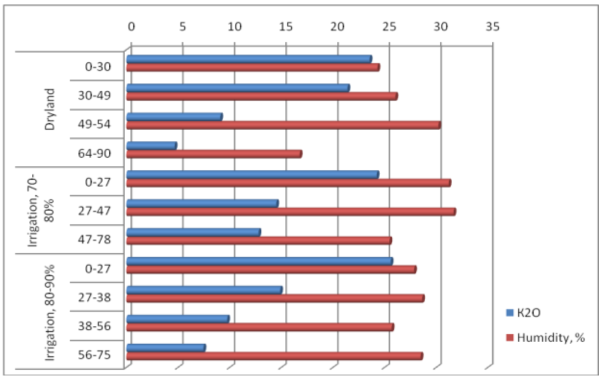

Fig.1. Effect of soil moisture level on the content of exchangeable potassium (mg/100 g soil) in ordinary chernozem (fresh soil samples)
Source: Own determination.

The high correlation value revealed the dependence of the content of exchangeable potassium on the soil moisture: r = - 0.80. The data is reliable at a Student's level of significance 0.01. Fewer fixation of potassium on wet soils compared with drying was noted in the experiments of Kucher [9].

The influence of the moisture condition of the samples on the variability of potassium forms in chernozem and grey forest soils in the Carpathian Highland region was noted by Warhol [22], but the direction of these changes was the opposite: wet samples showed a significant increase, compared to dry, exchangeable forms of potassium, while the amount of non-exchangeable – changed insignificantly.

As a rule, domestic and foreign soil scientists explain this by the nature of the mineralogical composition of the soil and their ability to retain and fix potassium during humidification and drying [2, 5].

The content of exchangeable potassium determines the degree of plant provision with this element of nutrition. We investigated changes in its content, depending on the soil and year of aftermath of the fertilizer systems.

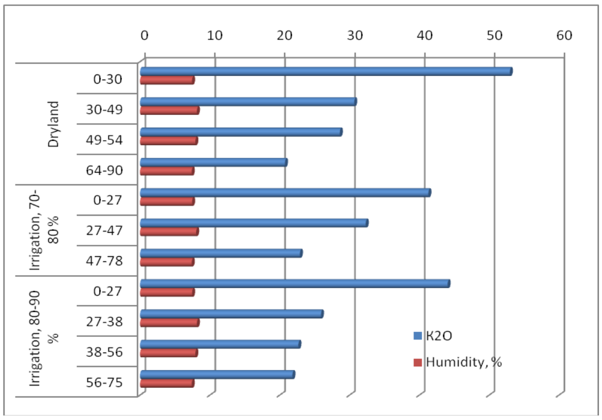

Fig.2. Effect of soil moisture level on the content of exchangeable potassium (mg/100 g soil) in ordinary chernozem (air-dry soil samples)
Source: Own determination.

Due to increase in the moisture content of irrigated soil in comparison with the non-irrigated, as well as the higher yield of agricultural crops, the content of exchangeable potassium under the influence of 11 years of irrigation decreased almost twice throughout the profile of ordinary chernozem to 120 cm (Table 3, 4).

Table 3. The content of exchangeable potassium in ordinary chernozem in the result of different fertilizer rates, mg/100 g of soil

Variant	*Depth of sampling, cm*	*Initial state*	*Year after fertilizers*				
			3rd	*4th*	*7th*	*8th*	*11th*
40 t/ha of manure + $N_{60}P_{60}K_{15}$	0-30	58.9	24.8	28.0	54.5	28.2	31.5
	30-50	36.7	16.9	20.2	29.7	18.7	23.7
	50-80	30.8	13.4	13.4	22.4	15.2	18.6
	80-120	29.4	9.6	7.5	13.1	11.4	13.0
100 t/ha of manure + $N_{100}P_{100}K_{30}$	0-30	57.7	24.3	35.8	26.3	26.6	39.2
	30-50	37.5	24.3	13.2	18.7	22.7	19.5
	50-80	32.5	16.7	9.4	9.1	17.2	16.2
	80-120	29.4	14.3	6.2	7.1	10.7	11.9
200 t/ha of manure + $N_{200}P_{200}K_{60}$	0-30	63.5	35.2	37.3	40.0	35.5	30.4
	30-50	38.7	35.7	18.9	17.8	21.7	25.3
	50-80	34.7	19.6	7.4	11.7	15.7	16.4
	80-120	29.4	14.5	6.2	7.4	11.0	9.3

Source: Own determination.

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The reason for this phenomenon may be an increase in the biological activity of irrigated soil, as in this case, the content of $N\text{-}NO_3$ increases. And as known, $N\text{-}NO_3$ is an antagonist of exchangeable potassium, and according to our calculations, the content of $N\text{-}NO_3$ and K_2O is closely correlated ($r = -0.9$; the data is reliable at the Student's level of significance 0.01).

In conditions of experiment, despite the different amount of introduced potassium fertilizers, the content of exchangeable potassium was almost unchanged in the variants of fertilizer systems. But at the time of the end of the rotation (the 11th year after the fertilizer) the content decreased compared to the initial one: on fertilizer system with a minimum norm of mineral fertilizers in 1,9 times, in average – in 1.5 times and with a maximum – in 2.1 times.

Table 4. The content of exchangeable potassium in southern chernozem in the result of different fertilization rates, mg/100 g of soil

Variant	*Depth of sampling, cm*	*The initial state, n = 18*	*Year after fertilizers*		
			1st	*2nd*	*3rd*
			corn for green feed	*winter wheat*	*fodder beets*
Control without fertilizers	0-30	14.8	9.8	8.5	1.6
	30-40	10.0	6.6	8.7	0.7
	40-50	9.8	5.4	1.6	1.3
	50-80	6.6	6.2	8.2	0.7
	80-120	6.7	6.5	6.0	0.6
Background 40 t/ha of manure	0-30	16.6	9.6	16.0	3.1
	30-40	11.8	6.8	10.2	1.4
	40-50	11.3	5.4	8.7	1.6
	50-80	9.2	3.7	7.4	1.2
	80-120	6.7	3.6	6.6	1.2
Background + $N_0P_{180}K_{180}$	0-30	12.3	12.1	32.2	1.4
	30-40	8.6	6.2	6.0	1.3
	40-50	8.1	4.1	3.9	0.8
	50-80	6.0	4.1	4.8	0.7
	80-120	5.3	3.0	6.1	0.6
Background + $N_{180}P_{180}K_{180}$	0-30	9.7	22.3	25.3	2.1
	30-40	5.5	11.4	6.1	2.0
	40-50	8.9	9.1	6.1	1.7
	50-80	6.6	10.3	5.3	1.7
	80-120	6.2	8.6	5.2	1.3
Background + $N_{180}P_0K_{180}$	0-30	12,2	24,7	34,0	1,7
	30-40	9,6	13,4	10,1	0,9
	40-50	9,6	12,2	8,2	0,8
	50-80	7,2	14,4	7,3	0,6
	80-120	5,4	12,0	6,2	0,6
Background + $N_{180}P_{180}K_0$	0-30	13,6	10,1	18,0	1,3
	30-40	9,2	5,4	12,7	0,8
	40-50	7,6	6,0	9,1	0,8
	50-80	8,4	5,3	6,6	0,7
	80-120	6,6	5,3	4,4	0,6
Background + $N_{300}P_{180}K_{300}$	0-30	12,0	9,0	26,1	3,4
	30-40	8,9	5,0	15,2	2,1
	40-50	8,9	3,5	21,5	1,1
	50-80	7,8	6,1	15,0	1,0
	80-120	6,4	5,1	12,6	1,0

Source: Own determination.

However, while on the background of the first two fertilizer standards in the crop rotation, a negative potassium balance is formed, its deficit-free balance (Table 5) - +533.3 kg/ha per rotation of crop rotation is created at the background of the maximum (manure 200 t/ha + $N_{200}P_{200}K_{60}$).

On the southern chernozems before the laying of the experiment, the soil content of exchangeable potassium was characterized as medium-sized (Table4). In the control version, without introducing the main fertilizer over the years, gradual reduction of exchangeable potassium to a low level of supply occurs.

Table 5. The balance of nutrients in crop rotation for ordinary chernozem

Variant	Indicators	Nutrition elements, kg/ha		
		N	P_2O_5	K_2O
manure 40 t/ha + $N_{60}P_{60}K_{15}$	Added with fertilizers	426	322	285
	Off set of crops and non-produc-tive losses	709,7	285,1	678,1
	Difference	**-283,7**	**+36,9**	**-393,1**
manure 100 t/ha + $N_{100}P_{100}K_{30}$	Added with fertilizers	790	530	660
	Off set of crops and non-produc-tive losses	749,9	300,3	710,3
	Difference	**+40,1**	**+229,7**	**-50,3**
manure 200 t/ha + $N_{200}P_{200}K_{60}$	Added with fertilizers	1430	910	1290
	Off set of crops and non-produc-tive losses	797,9	319,7	756,7
	Difference	**+632,1**	**+590,3**	**+533,3**

Source: Own determination.

The most favourable potassium regime was on the background of the introduction of organic-mineral fertilizers: manure 40 t/ha + $N_{180}P_{180}K_{180}$ and manure 40 t/ha + $N_{180}K_{180}$.

The dynamics of the content of exchangeable potassium in soil over the years to a certain extent characterizes the crops' need in potassium fertilization. Its lowest content was indicated in the autumn after the harvest of fodder beets, which is explained by the increased need of this crop in potassium.

At the same time, it is likely that potassium was actively used at the end of the vegetation of beets, which did not allow to restore the stocks of its exchange forms at the expense of more tightly connected. The corn for green feed and winter wheat do not use potassium from the soil in large quantities until the end of the growing season.

CONCLUSIONS

The research allowed to draw the following conclusions:

-Under the influence of irrigation in ordinary chernozems the content of potentially available potassium in the layer of 0-30 cm increases by 40.3% and 57.5% in comparison with rainfed conditions.

-The content of exchangeable potassium in ordinary chernozem varies considerably depending on the soil moisture content (r = -0.80). In moist ones there is a significant decrease compared to air-dry on all layers of soil. both in irrigated areas (from 1.7 to 2.9 times). and without irrigation (2.2-4.4 times).

-Fertilizer norm of manure 200 t/ha + $N_{200}P_{200}K_{60}$, introduced under the main cultivation of the first crop rotation in the aftermath of 11 years provides a positive balance of exchangeable potassium in ordinary chernozem even with a decrease of the initial content in 2.1 times.

-In the southern chernozem. the total amount of potentially available potassium is much lower than in ordinary chernozem: in 19.0% in a layer 0-30 cm and from 45.5 to 52.6% with a depth of 120 cm. The nature of the distribution of depth and direction of irrigation and fertilizer systems are similar to ordinary chernozems.

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