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Agronomic Efficiency of Potassium Fertilizers in Field Crop Rotation on Well-Cultivated Sod-Podzolic Soils.

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ABSTRACT

The article deals with the research results of organic and mineral fertilizers' influence containing various amounts of potassium and fertilization systems on the field crop rotation efficiency. The field experiment was carried out on a well-cultivated residual carbonate light sod-podzolic soil with a slight loam content. The soil in the experiment is characterized by a high amount of movable potassium. The studies were conducted in the course of a long-term crop rotation period with the following crop succession: potato - barley + clover + clover 1 - clover 2 - fodder beet - oats. A fairly high productivity of 5,5 tonnes/ha of grain units was observed in this crop rotation with the fertilizer application and a high productivity of 4,4 tonnes/ha of grain units without applying fertilizers. This finding confirms the opinion of a high potential fertility of well-cultivated sod-podzolic soils. The clover cultivation for two years considerably increased the soil nitrogen state, but at the same time, reduced the return rate for 1 kg of active substance in a fertilizer in all the experiment variants. The organic system of the fertilizer was inferior in its agronomic efficiency to the mineral one (difference in the return rate for 1 kg of active substance - 24 %). The use of both average and increased and high doses of potassium fertilizers was practically ineffective at all. Of all the crops cultivated in the rotation system, potato was the best to respond to the organic fertilization system, but other crops, though better responded to the mineral fertilizer system. The coefficient of the soil potassium use by grain crops was 6,3 %, by row crops - 25,6 %. Thus with high reserves of soil potassium available for plants, the agronomic efficiency of both average and high single doses of potassium-containing fertilizers is low in field experiment conditions. It is possible to get high and stable yields due to an improvement of the nitrogen state of the soil.

Keywords: fertilization systems, potassium, crop yield, return rate, loose potassium, nitrogen state.

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INTRODUCTION

At present the country's food security is one of the most important objectives. Production of high-quality agricultural products at affordable prices remains an unsolved problem. An important prerequisite to its solution is the use of science-based fertilization systems. One should also take into account the soil and agro-chemical conditions and biological characteristics of crops.

The application of fertilizers is the most important factor of increasing productivity. However, phosphoric and potash fertilizers on well-cultivated soils do not prove to be efficient. In this case, the increase in productivity is achieved by nitrogenous fertilizers. However, the application period of nitrogenous fertilizers should not be long. Otherwise, the amount of potassium in the soil decreases dramatically.

Potassium is one of the main macronutrients required for plant nutrition. Insufficiency of this element results in a yield decrease and, in most cases, reduces the product quality. However, one of the reasons for almost a complete cessation of the potassium fertilizers' use lies in the fact that in agronomic efficiency they are often inferior to nitrogen and phosphorus fertilizers [1, 2]. Such phenomenon adversely affects not only the yield [3, 4, 5, 6, 7], but also leads to the degradation of the potassium state of the soil [8, 9].

RESEARCH TECHNIQUE

A stationary field experiment was conducted in 2002 on well-cultivated light sod-podzolic soil with a slight loam content. The studies were carried out on the basis of the crop rotation: potato - barley + clover - clover 1 year - clover 2 years - beet - oats. The experiment design: 1. control (without fertilizers), 2. manure, 40 t / ha, 3. NP equivalent of NP 40 t / ha of manure + K90, 4. NP equivalent of NP 40 t / ha of manure + K115, 5. NPK equivalent of 40 t / ha of manure (K140). Manure at a dose of 40 t / ha was applied twice per rotation (for row crops), mineral fertilizers for grain and row crops. Clover was grown in view of the fertilizer aftereffect. The area of the plots was 42 m^2, three-time replication. Agrochemical soil parameters at the moment of starting experiments were as follows: humus - 2.46%, pH_{KCl} - 6.4, H - 1.11 mg eq. / 100 g, S - 11.9 mg eq. / 100 g, V - 91 4%, P_2O_5 and K_2O (according to Kirsanov) - 402 and 227 mg / kg. Farming practices in the experiment were conducted in accordance with the zone recommendations.

RESULTS AND DISCUSSION

The resource-saving fertilization system with a deficit balance of both potassium and nitrogen was used in our studies. At the same time, the average annual productivity of crop rotation was high enough - up to 5.5 t / ha of grain units for the main product (table 1). In a variant without a fertilizer the productivity was also at a quite high level and amounted to 4.4 t / ha of grain units. This finding confirms the opinion of a high potential fertility of well cultivated soils [8, 9]. The introduction of two clover fields into the rotation contributed to a significant improvement of the soil nitrogen status. During the 6 years of the study the average content of easily hydrolyzable nitrogen on variants of the experiment increased from 68 to 88 mg / kg, and mineral (average during the growing season) - from 25 to 38 mg / kg. And since, as shown previously [8, 9], on the well-cultivated soil the main effect is achieved by nitrogen fertilizers, the return rate for 1 kg of the active substance of all variants of the fertilization system was low - an average of 5.9 grain units.

Table 1: Agronomic efficiency of fertilization systems in a crop rotation on a well cultivated soil

Fertilizer system variant	Average application per year, kg/ha			Crop rotation productivity			Return rate of 1 kg of active substance, gr.u.
				annual average, t/ha gr.u.	increment		
	N	P_2O_5	K_2O		t/ha gr.u.	%	
Without fertilizers	0	0	0	4,4	-	-	-
Manure, 40 t/ha	67	53	93	5,3	0,9	20	4,2
NPequ.40 t/ha of manure+K_{90}	67	53	30	5,5	1,1	25	7,3
NPequ.40 t/ha of manure+K_{115}	67	53	38	5,5	1,1	25	7,0
NPKequ.40 t/ha of manure+ K_{140}	67	53	98	5,5	1,1	25	5,2
LSD05				0,4			

It has been found that the organic fertilization system was inferior in agronomic efficiency to the mineral one (the difference in the return rate of 1 kg of active substance - 24%). Nitrogen of manure applied twice in the rotation was used by the rest crops in a crop rotation in aftereffect. In variants with the mineral fertilization system the equivalent dose of nitrogen was shared between the four crops.

The existing experiment design does not allow us to identify the effect of each nutrient (including potassium), which manure is composed of. But, there is a possibility to assess the expedience of raising the doses of a potassium fertilizer from average to very high (variants 3 - 5 of the experiment). As we can see from table 1, raising the dose of K_2O from 90 (variant 3) to 140 kg / ha (variant 5) was absolutely ineffective. This phenomenon is primarily due to a sufficiently high content of available potassium in the soil. It is also explained by its mobilization under the effect of nitrogen fertilizers. The action of symbiotically fixed nitrogen by crops of red clover (average dose of nitrogen fertilizers - 67 kg / ha) in this regard is of great importance. This factor for variants without fertilizers and with fertilizers was practically equivalent, the dependence coefficient in the use of mobile soil potassium in the fertilization system was not observed in our experiments (table 2). The consumption of a significant amount of potassium from the subsoil horizon by clover could contribute to the leveling of this value in variants of the experiment, taking into account the features of the root system. And the share of clover accounted for one-third of the total potassium removal per rotation.

Table 2: The use of soil potassium and fertilizers by crops in the crop rotation

Variant of the experiment	Annual average K_2O removal, kg/ha	Balance of K_2O, kg/ha	Coefficient of application of K_2O, %	
			soil	fertilizers
Control-0	106	-106	15	-
Manure, 40 t/ha	142	-45	15	39
NPeq.40 t/ha of manure+K_{90}	136	-106	14	100
NPeq.40t/ha of manure+K_{115}	140	-102	16	89
NPKequ.40 t/ha of manure+ K_{140}	143	-50	20	40

In general, for the rotation potatoes were better to respond to a lower efficiency of the organic fertilization system (by 24% in the return rate of 1 kg of active substance). Although in this case, another circumstance could be important : unlike the second row crop, fodder beet, potato opened the crop rotation and, therefore, clover after effect could not have any influence on its development. The advantage of the mineral fertilization system (variants 3 - 5) is especially clearly manifested in the second crop after manure application for which 50% of nitrogen dose was directly applied. It was equivalent of 40 tonnes of manure.

Differences in response to fertilizers of row and grain crops decreased against the background of multiple reduction in the return rate of active substance of fertilizers by the yield due to the introduction of the two fields of clover into the crop rotation. On average in the studied variants of the fertilization system, the yield increment in row crops accounted for 32%, 26% was in cereals. Despite the fact that the utilization coefficient of mobile soil potassium by cereals (6.3%) was 4 times less than by row crops (25.6%).

CONCLUSIONS

Thus with high reserves of potassium in the soil available to plants the agronomic effectiveness of both average and high single doses of potassium-containing fertilizers in field rotation conditions is low. For the purpose of saving the resources the potassium mobilization can be achieved by improving the nitrogen status of the soil or applying high doses of a nitrogen fertilizer, or by the introduction of catching crops in a crop rotation.

Besides, it is also necessary to take into account the high efficiency of manure at a dose of 40 t/hectare in potato planting. The yield increase at the same time reaches 3,1 - 5,7 t/hectare relative to the fertilized field and 8,9 t/hectare in comparison with the control field. Mineral fertilizers are less effective in this case. It is recommended to place an emphasis on mineral fertilizers for fodder beet since they have turned out to be more efficient than organic. It is advisable to apply high doses of potash fertilizers while growing meadow clover on soils with the high level of potassium. In this case the yield increase of clover herbage will reach 1,7 t/hectare.

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Table 3: Influence of fertilization systems on the crop yield and consumption of potassium by them in a crop rotation

Variant of the fertilizer system	Annual average yield, t/ha	Yield gain,%		Coefficient of K_2O application, %	
		total	from potassium	soil	fertilizer
1	2	3	4	5	6
Potato					
Without fertilizers	29,7	-	-	36	-
Manure, 40 t/ha	38,6	30	not determ.	35	44
NPeq.40t/ha of manure+K_{90}	35,5	20	not determ.	35	61
NPeq.40t/ha of manure+K_{115}	33,2	12	not determ.	40	43
NPKequ.40 t/ha of manure+ K_{140}	32,9	11	not determ.	48	43
LSD_{05}	2,9				
Barley					
Without fertilizers	2,81	-	-	6	-
Manure, 40 t/ha	3,07	9	not determ.	6	afteref*
NPeq.40t/ha of manure+K_{90}	3,38	20	not determ.	6	afteref*
NPeq.40t/ha of manure+K_{115}	3,46	23	not determ.	7	afteref*
NPKequ.40 t/ha of manure+ K_{140}	3,46	23	not determ.	7	9
LSD_{05}	0,18				
Clover (green weight)					
Without fertilizers	31,0	-	-	16	-
Manure, 40 t/ha	35,7	15	not determ.	15	afteref*
NPeq.40t/ha of manure+K_{90}	36,3	17	not determ.	15	afteref*
NPtq.40t/ha of manure+K_{115}	37,2	20	not determ.	17	afteref*
NPKequ.40 t/ha of manure+ K_{140}	38,0	23	not determ.	17	afteref*
LSD_{05}	1,3				
Fodder beet					
Without fertilizers	16,5	-	-	13	-
Manure, 40 t/ha	22,7	38	not determ.	11	16
NPeq.40t/ha of manure+K_{90}	23,8	44	not determ.	11	48
NPeq.40t/ha of manure+K_{115}	24,1	46	not determ.	12	43
NPKequ.40 t/ha of manure+ K_{140}	24,9	51	not determ.	15	38
LSD_{05}	1,5				
Oats					
Without fertilizers	2,43	-	-	6	-
Manure, 40 t/ha	2,51	3	not determ.	6	afteref*
NPeq.40t/ha of manure+K_{90}	3,46	42	not determ.	5	afteref*
NPeq.40t/ha of manure+K_{115}	3,51	44	not determ.	6	afteref*
NPKequ.40 t/ha of manure+ K_{140}	3,49	44	not determ.	8	16
LSD_{05}	0,17				

afteref* - aftereffect

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