

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Liming Efficiency of Leached Black Soil in The Conditions of The Forest-Steppe of The Volga Region.

A Kh Kulikova*, A V Dozorov, N G Zakharov, E A Cherkasov,
N A Khayrtdinova, I R Kasimov, and A Yu Naumov.

FSBEI HE Ulyanovsk State Agrarian University named after P.A. Stolypin 432017, Russia, Ulyanovsk, Novyy Venets Boulevard, 1.

ABSTRACT

The paper presents results of studying chalking efficiency of leached black soil when cultivating spring wheat in the conditions of the forest-steppe of the Volga region. It was established in field experiments that liming of leached black soil significantly reduces soil acidity: exchangeable by 0,21-0,38 pH_{KCl} units, hydrolytic by 0,22 – 0,41 mg / kg of soil depending on the application dose (2-6 t / ha) in the first year. Improvement of soil medium in terms of acidity contributed to an increase in the yield of spring wheat by 0,18-0,20 t / ha in case of using chalk in pure form and by 0,17-0,28 t / ha in combination with NPK, in farm conditions by 0,4 – 0,8 t / ha.

Keywords: leached black soil, soil acidity, liming, spring and winter wheat, crop yield.

**Corresponding author*

INTRODUCTION

The appropriate soil medium reaction, determined by a sufficient amount of calcium and magnesium in the soil-absorbing complex, is the foundation that ensures the efficiency of all technological methods aimed at increasing crop yields and product quality. Soil acidity has a great influence on soil chemical and biochemical processes, on microorganism activity, and consequently on growth and development of plants. Increased soil acidity is one of the main factors of low level of soil fertility and it also limits the production of high, ecologically safe and biologically good agricultural products. A drastic means of neutralizing the acidity of soils is liming, that is, the introduction of materials containing CaCO_3 and MgCO_3 into the soil [1 - 6].

The relevance of the liming problem in Russia is predetermined by vast areas of acidic soils (more than 35 million hectares). Ulyanovsk region is not an exception in this respect, about 50% of its arable land consists of soils with an acid reaction of the soil medium. The deterioration process of soil acid regime is progressing and is caused by almost complete cessation of chalking by mid 1990 s, while the anthropogenic impact on the soil is only increasing. And, unless urgent measures are taken to eliminate the acidity of soils, including black soil, which occupies more than 60% of arable land, it will inevitably become a limiting factor in formation of high crop yields.

The above mentioned aspects have determined the purpose of our studies - to establish the liming necessity and dose of leached black soil in the conditions of the Volga forest-steppe.

Objects and methods of research

The research was carried out on the experimental field of FSBEI HE Ulyanovsk SAU in 2015 - 2017. Its objects were: soil - leached black soil, medium-heavy, medium loamy with a humus content of 4,58%, available phosphorus and potassium compounds (according to Chirikov) 182 and 146 mg / kg, respectively, exchange acidity – 5,46 pH_{KCl} units, hydrolytic – 3,43 mg- eq / 100 g of soil; spring wheat of Margarita variety of Ulyanovsk Scientific Research Institute selection; chalk of Shilovskoye deposit of Ulyanovsk region with CaCO_3 + MgCO_3 content of 98,5%.

The scheme of the experiment is as follows: 1. Control, 2. CaCO_3 2 t / ha, 3. CaCO_3 4 t / ha, 4. CaCO_3 6 t / ha, 5. NPK 40 kg of active substance/ha, 6. NPK + CaCO_3 2 t / ha, 7. NPK + CaCO_3 4 t / ha, 8. NPK + CaCO_3 6 t / ha. The full dose of lime (6 t / ha) was calculated taking into account the hydrolytic acidity and the CaCO_3 content in the lime material.

The total area of the plots is 60 m^2 (6x10), the registration plot area is 32 m^2 (4x8), their location is random, the repetition is fourfold.

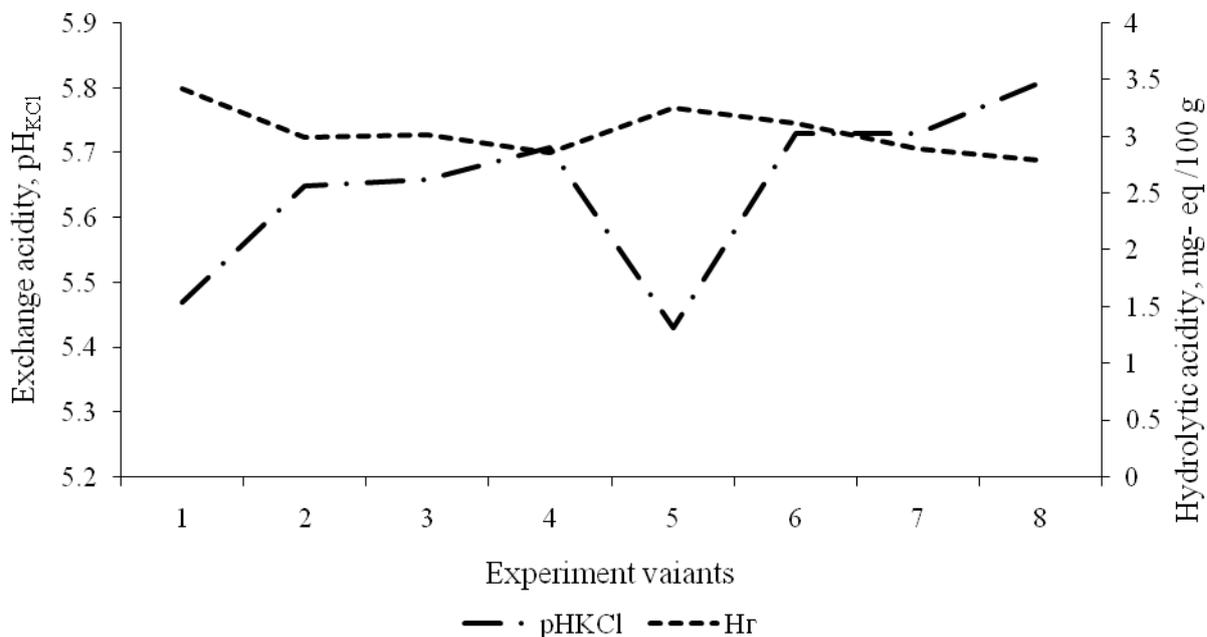
In addition, in 2015 - 2017, we conducted farm tests on the effectiveness of leached black soil liming in OOO "Khleborob" in Ulyanovsk region. The soil of the experimental field is medium loamy leached black soil. The total area of the plots is 5008 m^2 (16x313), registration area is 3612 m^2 (12x301), the repetition is threefold. The lime dose was calculated taking into account the shift in the exchange acidity of pH_{KCl} from 5,2 to 5,6 units. The scheme of the experiment is given in Table 1.

Field experiments and laboratory analyses were carried out in strict accordance with the methodological requirements and State Standards.

RESULTS AND THEIR DISCUSSION

The application of chalk in the soil in appropriate doses was carried out before primary soil tillage in autumn of 2015. Changes in exchange acidity of the soil arable layer due to liming were already apparent by the beginning of spring wheat vegetation (2016). A significant improvement of leached black soil acid regime was observed by the end of crop vegetation and the soil acquired a reaction of a medium close to neutral (pH_{KCl} in case of a lime dose of 6 t / ha was 5,71 units). Application of mineral fertilizers into the soil was accompanied by acidification of soil solution, while liming in combination with NPK improved the acid regime of the soil (from 5,51 pH_{KCl} units at the beginning of the vegetation to 5,81 units at the end, the lime dose was 6 tons / ha). A similar pattern was observed for hydrolytic acidity, which decreased by the end of vegetation

with liming at a dose of 4 tons / ha in pure form from 3,42 to 3,01, in combination with NPK from 3,25 to 2,89 mg- eq / 100 g of soil (figure).



Influence of liming on acidity parametres of leached black soil

The results of the experiment were confirmed in farm conditions of OOO "Khleborob" of Ulyanovsk district in 2015-2017. (Table 1).

Table 1 - Dynamics of acidity of leached black soil depending on liming (pH_{KCl}, units, Hr, mg-eq / 100 g of soil)

№	variant	Before liming 07.07.2015		During harvesting			
		pH _{KCl}	Hr	Winter wheat 27.07.2016		Spring wheat 15.09.2017	
				pH _{KCl}	Hr	pH _{KCl}	Hr
1	Control (without liming)	5,20	4,50	4,90	4,00	5,17	4,86
2	N30P30K30 (NPK)	5,30	4,35	5,00	4,11	5,15	5,33
3	CaCO ₃ 4.44 t/ha	5,30	4,48	5,60	2,53	5,60	3,13
4	N ₃₀ P ₃₀ K ₃₀ +CaCO ₃ 4,44 t/ha	5,20	4,06	5,50	2,70	5,60	3,10
	HCP ₀₅	0,15	0,20	0,14	0,21	0,18	0,60

A pronounced tendency to acidification of soil medium was observed in the control variant and in application of mineral fertilizers: the hydrolytic acidity in the variant with NPK increased by 0,98 mg-eq / 100 g within 2 years. The acidity shift of pH_{KCl} was 0,30 units in case of liming and the soil became close to neutral reaction of the medium.

Both winter and spring wheat require soil fertility, including its acidity: the most suitable for them is reaction of soil solution close to neutral with pH_{KCl} 6,0 – 7,3 units. Improvement of acidity due to liming has significantly increased crop yield (Tables 2 and 3).

Table 2 - Yield of spring wheat depending on liming in the field experiment in FSBEI HE Ulyanovsk SAU

№	variant	Crop yield, t/ha	Deviation from control (in variants 5, 6, 7 – from NPK variant)	
			t/ha	%
	Control (without liming)	2,05	-	-
1	CaCO ₃ 2 t/ha	2,13	0,08	4
2	CaCO ₃ 4 t/ha	2,23	0,18	9
3	CaCO ₃ 6 t/ha	2,25	0,20	10
4	NPK	4,10	2,05	200
5	NPK + CaCO ₃ 2 t/ha	4,27	0,17	4
6	NPK + CaCO ₃ 4 t/ha	4,28	0,18	4
7	NPK + CaCO ₃ 6 t/ha	4,38	0,28	7
	HCP ₀₅	0,16		

As follows from the research results, the reaction of soil solution to a high content of nutrients in the arable layer had a significant effect on the formation of the yield of spring wheat and grain increase due to liming was from 0.18 to 0,20 t / ha, or 9% of the chalk dose of 4 t / ha, 10% - of 6 t / ha.

The yield of spring wheat doubled due to application of nitrophos in the doses of nitrogen, phosphorus and potassium, of 40 kg of active substance / ha each in favorable weather conditions of the water-temperature regime that were in 2016. Nevertheless, liming in combination with fertilizers allowed to receive additionally 0,17 - 0,28 t / hectare of wheat grain.

Table 3 - Yield of winter and spring wheat, depending on liming in farm conditions OOO "Kheborob"

variant	Winter wheat, 2016 r			Spring wheat, 2017 r		
	yield, t/ha	Deviation from control		yield, t/ha	Deviation from control	
		t/ha	%		t/ha	%
Control (without liming)	5,0	-	-	4,0	-	-
N30P30K30 (NPK)	5,1	+0,1	+2	4,2	+ 0,2	+ 5
CaCO ₃ 4.44 t/ha	4,8	- 0,2	- 4	4,4	+ 0,4	+ 10
N ₃₀ P ₃₀ K ₃₀ +CaCO ₃ 4,44 t/ha	4,8	- 0,2	- 6	4,8	+ 0,8	+ 20
HCP ₀₅	0,3			0,4		

The results of farm experiments showed that despite a marked improvement of soil acidity, it remained in the category of acid and liming did not affect winter wheat yield in the first year. Acidification of the soil in case of application of mineral fertilizers also didn't lead to evident effectiveness. Liming has a prolonged effect, which was observed in the second year: the yield of spring wheat increased from 0,4 t / ha (10%) in case of lime application (4,4 t / ha) in pure form to 0,8 t / ha in combination with NPK (20%). Thus, liming allowed to increase the efficiency of mineral fertilizers on acid soil by 15%. Similar results are given in the works of a number of Russian and foreign authors [4, 7-10].

CONCLUSIONS

1. Liming of leached black soil (pH_{KCl} 5,46 units and Hr 3,43 mg-eq / 100 g of soil) contributed to a significant improvement in its acid regime: in the first year, the shift of pH_{KCl} due to CaCO₃ of 2 t / ha was 0,18 units, 4 t / ha - 0,19 and 6 t / ha - 0,24 units. Consequently, the hydrolytic acidity decreased from 3,43 to 2,86 mg-eq / 100 g. A similar pattern was observed in case of soil liming in combination with mineral fertilizers N₄₀P₄₀K₄₀. Results of field experience were confirmed in farm conditions.

2. Liming of leached black soil made it possible to obtain additionally 0,18-0,20 t / ha of spring wheat grain due to lime application in pure form and 0,17-0,28 t / ha in combination with mineral fertilizers; in farm conditions, 0,4 and 0,8 t/ha, respectively.

REFERENCES

- [1] Shilnikov, I.A. Liming - the main factor of soil fertility preservation and increase of crop productivity / I.A. Shilnikov, N.I. Akanova, N.A. Zelenov // Achievements of science and technology of the AIC. - No. 1. - 2008. - P. 21 - 23.
- [2] Shilnikov, I.A. The nature-oriented value of soil liming / I.A. Shilnikov, G.E. Grishina, N.I. Akanova // Niva of the Volga region. - 2008. - No. 2. - P. 17 - 20.
- [3] Ivoylov, A.V. Efficiency of fertilizers and liming of leached black soils / A.V. Ivoylov. - Saransk. - Publishing house of Mordovian University. - 2015. - 264 p.
- [4] Liming Acid Soils in Central B. C. Minisry of agriculture Angus Campbell Road Abbotsford, B. C. Revised December. – 2015. – 5 p.
- [5] Jaskulskal, D. Effect of limiting on the change of some agrochemical soil properties in a long-term fertilization experiment. /Jaskulski, M. Koberski // Plant Soil Environ. – 2014. – Vol. 60. – №. 4. – P. 146 – 150
- [6] An, Y. H. Mechanisms of bacterial adhesion and pathogenesis of implant and tissue infections / Y. H. An, R. B. Dickinson, R. J. Doyle // Handbook of bacterial adhesion: principles, methods, and applications. – 2000. – № 2. – P 1 – 27.
- [7] Pushkareva, N.G. Liming and soil enzyme activity / N.G. Pushkareva, R.D. Makovskiy, E.I. Sarapultseva, N.N. Pavlova // Agrochemical vestnik. - № 3. – 2008. – P.7-9.
- [8] Shilnikov, I.A. Increase of soil fertility in crop rotations based on chemical melioration / I.A. Shilnikov, N.I. Akanova, E.V. Kurnosova, G.E. Grishin, S.V. Kizinen, M. Yu. Loktionov // Niva Povolzhya. – 2013. - № 2 (27). – P 72-76.
- [9] Galishin, R.R. Liming and phosphatization of soils - the basis of high crop yields / R.R. Galishin, F.N. Gallyamov / in digest: Youth science and AIC: problems and prospects. Materials of VII All-Russian science and practical conference of young scientists. Bash SAU, 2014. – P. 13-15.
- [10] Buny, A. Effects of Liming Acidic Soils on Improving Soil Properties and Yield of Haricot Bean //Environmental & Analytical Toxicology. – 2014. – Volume 5. – Issue 1. – 4 p.