ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Accumulation Ions of Salts and Nutrients in Plants Due to Soil Salinity and Changes in Mineral Nutrition.

Alla Anatolievna Belovolova*, Natalia Viktorovna Gromova, Elena Alexandrovna Salenko, Valentin Vasilevich Ageev, and Anatoly Ivanovich Podkolzin.

Stavropol State Agrarian University, Zootekhnicheskiy lane 12, Stavropol 355017, Russia.

ABSTRACT

Saline chernozems of Central Ciscaucasia have unfavorable properties that reduce the productivity of cultivated plants. Individual cultures can accumulate appreciable amounts of mineral salts in their tissues when growing on saline soil, which can play a role in phytomelioration of these lands. With soil salinity, the accumulation of nutrients in plants decreases, which is also a cause of inhibition of their growth and productivity. Improvement of the nutritional regime of the soil by introducing nitrogen-phosphorus fertilizer into the saline soil reduces the accumulation in the plants of salinizing ions and stimulates the formation of their growth parameters.

Keywords: salinity, fertilizers, plants, mineral salts, ions of salts, ash, productivity.

Corresponding author

ISSN: 0975-8585

INTRODUCTION

In Central Ciscaucasia, chernozems are widespread, characterized by high salinity and solonetsousness. They are very unfavorable for the growth of cultivated plants properties. According to the granulometric composition, they are represented by clay soils and the content of clay fraction in them is more than 65%. These soils are characterized by a high density of 1.40-1.58 g / cm^3 at 1.20 g / cm^3 for zonal chernozems. They have a high adsorption capacity, which determines the maximum hygroscopicity (13-15%). The amount of moisture inaccessible to plants, leading to a steady wilting in solonetsous soils varies from 15 to 19%, whereas in typical chernozems it is 12-13%.

When characterizing the degree of salt tolerance of individual crops as one of the criteria of this property, researchers take into account the intensity of absorption and the accumulation of salts from the saline substrate. This approach is of particular interest from the point of view of assessing the possibility of cultivated plants in the implementation of phytomelioration of saline lands and the need to develop ameliorative crop rotations. However, the scientific literature on this issue contains very little information that is contradictory. Some authors believe that the salt tolerance of plant species is characterized by a less intense absorption of salts, others come to the opposite conclusion. There is evidence of an increase in the accumulation of mineral salts in plants only with a significant increase in their salts in the soil.

RESULTS AND DISCUSSION

The amount of ash in the leaves of plants can be considered an indicator of their fitness for salinity. According to some authors, the more ash, the better the plant is adapted to the conditions of growth.

Studies have been carried out on the effect of mineral salts on the accumulation in the plants of the main nutrient elements. The plants were grown and the introductory cultures on the Gelrigel nutrient mixture with the addition of NaCl and Na_2SO_4 in the concentrations, which determined the same osmotic pressure (2 and 6 atm).

In our studies, higher ash content of the aboveground parts of plants on saline soils was characterized by sunflower and sorghum (Table 1).

Table 1: Content of ash and salt ions in the above-ground mass of plants on saline soil (vegetation experience, 45-day-old plants)

Cultivated crop	Ash, %	Ions content , %				
		SO_4^{2-}	Cl^-	Ca^{2+}	Mg^{2+}	Na^+
Sunflower	18,78	1,73	0,138	2,24	0,29	0,86
Sorghum	19.92	0,54	0,113	0,95	0,34	0,44
Winter wheat	13,35	0,36	0,113	0,54	0,23	0,22
Winter barley	13.92	0,43	0,102	0,63	0,24	0,48
Oats	15,64	0,72	0,114	0,68	0,30	0,58
Corn	15,58	1,07	0,090	0,64	0,28	0,89
Peas	13,86	0,8	0,105	0,98	0,26	1,05

Sunflower plants were distinguished by a higher content of sulfate ion, chlorine, calcium and magnesium. The remaining cultures for the accumulation of ash and individual ions, although varied, but the apparent dependence of their concentrations on the degree of salt tolerance of plants was not traced.

Comparison of the mineral part of the tested cultures with their growth on weakly and strongly saline soils showed that in sunflower and sorghum, an increase in salinity is associated with an increase in the total ash content of tissues by 0.96-3.08%. In the remaining cultures, such a connection was not found, and this gives reason to believe that in most field crops the biological absorption of mineral salts, in comparison with their reserves in the soil, is insignificant and they can not play a significant role in phytomelioration of saline lands. At the same time, the penetration and accumulation of salinizing ions in certain amounts is one of the causes of the inhibition of plant growth when the soil is salinized. Therefore, measures aimed at reducing the accumulation in the plants of ions of harmful salts, which include improving the regime of mineral nutrition, are relevant.

When the medium becomes saline, the supply of nutrients to the plants and their utilization decreases with simultaneous increase in the concentrations of various salinizing ions.

It was found that even small concentrations of these salts reduce the accumulation of nutrients in plants. At the same time, the reaction of cultures, depending on the nature of the salt and the level of salt tolerance, is not the same. With an increase in the concentration of sodium chloride, the content of nutrient elements in plants is reduced to a greater extent in comparison with the iso-osmotic concentration of sodium sulfate (Table 2).

The accumulation in plants of potassium decreased, the phosphorus was reduced to a lesser extent. The plants of winter wheat have minimal changes in the nitrogen content. The accumulation of nitrogen and phosphorus is markedly reduced in maize, which is characterized by sensitivity to salinity and a significant inhibition of growth.

Table 2: Effect of sodium salts for accumulation of nutrients in the overground weight of plants (45-day plants)

Cultivated crop	Variant	% on absolutely dry weight			% to control		
		N	P_2O_5	K_2	N	P_2O_5	K_2
Winter wheat	Nutrient mixture (control)	4,58	1,47	7,13	100	100	100
	Nutrient mixture +NaCl–0,3 %	4,07	1,44	5,02	88,8	91,1	70,4
	Nutrient mixture +NaCl–0,8 %	4,20	1,05	3,78	91,7	71,4	53,0
	Nutrient mixture + Na_2SO_4- 0,6 %	4,43	1,30	4,49	96,72	88,4	63,0
	Nutrient mixture + Na_2SO_4 - 1,2 %	4,29	1,16	4,38	93,45	78,9	61,4
Sunflower	Nutrient mixture (control)	3,88	1,55	6,78	100	100	100
	Nutrient mixture +NaCl–0,3 %	3,40	1,44	4,88	87,6	92,9	72,0
	Nutrient mixture +NaCl–0,8 %	3,22	1,02	3,96	83,0	65,8	52,4
	Nutrient mixture + Na_2SO_4 - – 0,6 %	3,46	1,38	3,90	89,2	89,0	57,5
	Nutrient mixture + Na_2SO_4 - 1,2 %	2,80	1,24	3,76	72,2	80,0	55,4
Corn	Nutrient mixture (control)	6,33	1,69	5,47	100	100	100
	Nutrient mixture +NaCl–0,3 %	4,28	1,44	3,32	67,7	85,2	60,7
	Nutrient mixture +NaCl–0,8 %	4,09	1,30	3,32	64,6	76,9	60,7
	Nutrient mixture + Na_2SO_4 – 0,6 %	4,59	1,38	2,93	72,5	81,6	53,6
	Nutrient mixture + Na_2SO_4- 1,2 %	4,07	1,29	3,30	64,3	76,3	60,3

In the vegetation experiment on solonetz soil, a decrease in the accumulation of elements is also noted in maize and is more pronounced in nitrogen and potassium. In plants of winter wheat and sunflower there was an increased content of nitrogen and phosphorus.

Table 3: Effect of fertilizers on the accumulation of nutrients in plants on solonetz soil

Cultivated crop	Variant	% on absolutely dry weight			% to control		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O
Winter wheat	Control (non-ground soil)	2,18	0,36	4,19	100,0	100,0	100,0
	Control (solonets without fertilizers)	2,31	0,45	3,97	105,9	125,0	94,7
	Solonets+ N_1P_1	3,84	0,56	5,60	176,1	155,5	133,6
	Solonets + N_1P_2	3,62	0,70	5,47	166,0	194,4	130,5
Sunflower	Control (non-ground soil)	1,61	0,30	6,08	100,0	100,0	100,0
	Control (solonets without fertilizers)	1,72	0,40	6,62	106,8	133,3	108,9
	Solonets+ N_1P_1	2,97	0,44	5,87	184,5	146,7	96,5
	Solonets + N_1P_2	3,10	0,65	6,30	192,5	216,7	103,6
Corn	Control (non-ground soil)	2,21	0,35	5,75	100,0	100,0	100,0
	Control (solonets without fertilizers)	1,97	0,34	5,02	89,1	97,1	87,3
	Solonets+ N_1P_1	3,49	0,42	4,32	157,9	120,0	75,1
	Solonets + N_1P_2	3,66	0,60	4,45	165,6	171,4	77,4

The increase in the content of nitrogen and phosphorus in the plants of winter wheat and sunflower on a fertilized background was 76.1, respectively; 55.5% and 84.5; 46.7% (Table 3).

A significant increase in the phosphorus content in plants was noted when fertilizers were applied in the ratio N: P = 1: 2. In plants of winter wheat and maize against this background, the accumulation of nitrogen continued.

The increase in the concentrations of nutrients and especially phosphorus and potassium on the background of fertilizers in maize plants is less pronounced in comparison with both winter wheat and sunflower.

This, obviously, is due to the peculiarities of the mineral nutrition of corn at the initial stages of ontogeny and its more pronounced oppression on solonetz soil.

According to a number of authors, when the level of mineral nutrition increases on a saline background, the content of ions of mineral salts in plants decreases.

In the plants we studied, the content of sodium, chlorine and sulfate ions increased on solonetz soil. Changes in the accumulation of calcium and magnesium in them were less pronounced (Table 4).

The introduction of a nitrogen-phosphorus fertilizer led to a reduction in the accumulation in plants of predominantly chlorine and sulfate ions, and to a greater extent this trend was manifested in the variant with the introduction of a double dose of phosphorus against the background of nitrogen. There was also an increase in the calcium content in plants, which is obviously due to its increase in the soil as a result of the calcium-containing superphosphate as a fertilizer.

The total ash content varied significantly in sunflower, and the effect of fertilizers on this indicator in crops was not the same.

Table 4: Effect of fertilizers on the accumulation of salt ions in plants on solonetz soil

Cultivated crop	Variant	Ash, %	Content, %				
			Ca^{2+}	Mg^{2+}	Na^{+}	Cl^{-}	SO^{2-}_4
Winter wheat	Control (non-ground soil)	14,89	0,57	0,21	0,09	0,08	0,41
	Control (solonets without fertilizers)	14,50	0,63	0,22	0,29	0,11	0,60
	Solonets+ N_1P_1	16,38	0,59	0,24	0,36	0,11	0,34
	Solonets + N_1P_2	16,24	0,69	0,19	0,37	0,08	0,37
Sunflower	Control (non-ground soil)	17,84	1,17	0,27	0,29	0,11	0,53
	Control (solonets without fertilizers)	21,70	1,70	0,29	0,55	0,11	1,05
	Solonets+ N_1P_1	20,10	2,46	0,27	0,59	0,11	0,49
	Solonets + N_1P_2	21,17	2,12	0,23	0,54	0,10	0,35
Corn	Control (non-ground soil)	15,88	0,93	0,28	0,18	0,06	0,69
	Control (solonets without fertilizers)	16,19	0,83	0,29	0,49	0,10	0,56
	Solonets+ N_1P_1	14,59	1,09	0,26	0,42	0,10	0,42
	Solonets + N_1P_2	14,26	1,17	0,27	0,40	0,11	0,40

CONCLUSIONS

Changes in the content of salinizing ions and nutrients in plants in the direction of a noticeable increase in the latter reflect the intensity of their growth. At the same time, the linear growth of plants, the size of their leaf surface and the accumulation of dry mass by the above-ground organs are significantly increased on fertilized backgrounds, which was especially noted in sunflower and winter wheat.

The mass of the above-ground organs of these crops increased by 30.7-59.5% when applying fertilizers (N_1P_1), even with respect to plants growing on non-saline control. Even higher, these indicators due

to increased development of the leaf surface were on the background of N_1P_2. Consequently, the increase in plant growth on saline soil when fertilizers are introduced is associated with an increase in the supply of nutrients to them, a reduction in the accumulation of mineral salt ions in them, and depends on the biological fitness of the crop to salinity.

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