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INFLUENCE OF THE SOIL SOLUTION CONCENTRATION ON RESERVE CONSTITUENTS IN COTTON SEEDS AND METHODS OF ITS OPTIMIZATION

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Abstract – *The influence of the concentration of soil solution on the amount of reserve constituents in cotton seeds was studied. As a result of the studies conducted in conditions of irrigated typical gray soils, data were obtained on the effect of the growing medium with different concentrations and chemical compositions of soil solution on the content of protein, fat (lipids), phytin in seeds of cotton variety Namangan-77. The methods were developed to optimize the concentration of soil solution for plant nutrition. The results obtained are of great scientific and practical importance in the study of exchange reactions between soil solution and plant nutrition, in control of this process through the use of fertilizers and soil cultivation technology, in the determination of the effect of the concentration of soil solution on the amount of reserve constituents in cotton seeds, in scientifically substantiated use of fertilizers and in the educational process in higher educational institutions.*

Key words: *soil, soil solution, anion, cation, concentration, agrotechnical measures, mineral fertilizers, reserve constituents, protein, fat, lipid, phytin, yield.*

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I. Introduction

Soil is the main resource of modernization and rapid development of agriculture, further strengthening food security, expanding the production of environmentally friendly products. Improving soil properties, increasing yields are the key aspects for high and quality yields.

It is known that high and quality crop yields depend primarily on the quality of sown seeds. However, there are a number of requirements for obtaining quality seeds from plants that could achieve the expected goal if they are fully met. One of them is the optimization of the concentration of soil solution for plant nutrition. In this regard, the improvement of ecological conditions of mineral nutrition of plants through the use of certain agrotechnical measures, including the creation of the optimal composition and concentration of soil solution, is an urgent problem of theoretical and practical importance.

Improving soil fertility and crop productivity is closely related to the use of fertilizers. However, the use of fertilizers without taking into account the properties of soil, especially the composition of soil solution, does not lead to the desired results, but, on the contrary, the change in composition and the soil contamination could be observed.

Soil solution is the most mobile part of soil, where various chemical processes take place, and it feeds the plants. Currently, one of the main tasks in agriculture is to maintain the condition of soil solution for optimal plant nutrition.

The optimal concentration of soil solution is an environment that expedites the growth of plants, and in this case, the process of plant nutrition is accelerated and the possibility of obtaining high yields of crops is created. In agriculture, the composition and concentration of soil solution can be controlled by applying fertilizers, tillage, and reclamation measures.

In natural soils, the solid, gas phases and natural vegetation cover influence the content of soil solution. Whereas in irrigated soils, the natural factors affecting soil solution also include agricultural techniques (tillage, application of fertilizers, irrigation, etc.).

When studying soil solution, we should not limit ourselves to studying the solid phase of soil. It should be supplemented with scientific materials on the liquid and gaseous phases of soils. Because all three soil phases are constantly interconnected. From the point of view of agrochemistry and plant nutrition, all, without exception, the properties of soil solution, such as concentration, chemical composition, osmotic pressure and their changes should be known. The vital activity of plants and microorganisms is also impossible without soil solution, which performs a protective and regulatory function and is a source of nutrition.

Studies to determine the influence of the growing medium on the content of protein, fat, phytin in cotton seeds were conducted during the field experiments held by the Department of Soil Science of the National University of Uzbekistan. The subject of research is soil, cotton, soil solution, agrotechnical measures, and mineral fertilizers.

The main purpose of the research is to determine the concentration of soil solution in irrigated soils in different agricultural backgrounds, to study the effect of the growing medium of different concentrations and chemical compositions of soil solution on the content of protein, fat (lipids), phytin in cotton seeds and to develop ways to optimize the concentration of soil solution for plant nutrition.

To achieve this goal, the following tasks were completed: conducting a field experiment on old-irrigated typical gray soil, determining the composition and concentration of soil solution, studying the effect of the chemical composition and concentration of soil solution in various

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agricultural backgrounds on the content of protein, fat (lipids), phytin in cotton seeds and developing optimization methods for the concentration of soil solution for plant nutrition.

Studies on the isolation, determination of the composition and concentration of soil solutions and their effect on the content of protein, fat (lipids), phytin in cotton seeds were conducted by the methods generally accepted in agrochemistry [1, 12, 13, 14, 22, 23]. Nitrogen in proteins was determined by the Pleshkov calorimetric method, fats - by the Soxhlet method, and phytin - by the Kursanov method. The field experiment was conducted in 4 variants with 3 repetitions (Table 1).

Table 1

Field experiment scheme

Variants	Annual fertilizer rate, kg/ha	Distribution of the annual fertilizer rate, kg/ha								
		Autumn plowing		Before sowing			3-4 real leaves	Autumn plowing		Flowering
		P 70%	K 50%	N 30%	P 30%	K 20%	N 20%	N 20%	K 30%	N 30%
1	Контроль	-	-	-	-	-	-	-	-	-
2	N_{200} P_{140} K_{100}	98	50	60	42	20	40	40	30	60
3	N_{250} P_{175} K_{125}	122,5	62,5	75	52,5	25	50	50	37,5	75
4	N_{300} P_{210} K_{150}	147	75	90	63	30	60	60	45	90

Studies of soil solutions were conducted since the establishment of experimental soil science and were initially aimed at developing methods for separating solutions from the solid phase of soil.

Numerous data indicate that the liquid phase of soil is not homogeneous, and this fact explains the difference in the chemical composition of soil solutions obtained under the pressure of various magnitudes [5, 7, 11, 14, 15, 16, 17, 23, 24].

II. Literature review

A number of foreign scientists studied soil solutions. D.M. Bonito [4,], M.E. Essington [6] studied the content of micro-nutrient elements in soil solution; Francisco Javier Cabrera Corral, Santiago Bonachela Castano, Maria Dolores Fernandez Fernandez, Maria Rosa Granados Garcia, Juan Carlos Lopez Hernandez [8] developed lysimetric methods for monitoring the conductivity of soil solution and the concentration of nutrients in greenhouse tomato crops; Kasper Reitzel, Benjamin L. Turner [10] determined the amount of pyrophosphate in soil solution by hydrolysis of pyrophosphatase; Arne Verstraten, Johan Neirink, Gerrit Janow, Natalie Kools, Peter Roskams, Maarten Hens [2] established the effect of a decrease in atmospheric precipitation on the chemical composition of forest soils; Jose Bernardo Moraes Borin, Felipe de Campos Carmona, Ibanor Anginoni, Amanda Posselt Martins, Isadora Rodriguez Jaeger, Elio Marcolin, Gustavo Cantori Hernandez, Estefania Silva Camargo [9] studied the chemical properties of soil solutionю.

According to Asgeir Rosseb Almas, Hilmar Thor Svarsson, Tore Krogstad [3], the distribution of phosphorus in soil determines the flux and delivery of labile phosphorus to soil solution.

The data obtained by Yusuke Unno, Hirofumi Tsukada, Akira Takeda, Yuichi Takaku, Shunichi Hisamatsu [25] indicate that the distribution coefficient of soil organic matter solution in soil is a key factor for radioactive iodization in surface and underground soils.

S. Sidikov, M. Ermatova, Z. Abdushukurova [21] studied the effect of the chemical composition and concentration of soil solution in various agro phones on the content of nutrients in the cotton variety Namangan-77 and its yield. They found that at a low concentration of soil solution, the plant develops poorly, it cannot absorb a sufficient amount of nutrients, while a high concentration of the solution also negatively affects the plant. The optimal concentration is the most favorable environment for plant development, which helps accelerate the absorption of nutrients by the plants and ensure high crop yields.

S. Sidikov, M. Ermatova, Z. Abdushukurova, O. Ergasheva, N. Tashmetova [19] studied the effect of plant residues on the amount and quality of humus, the degree of humification of individual organs of cotton, alfalfa and ephemera, their effect on the content and composition of organic matter soil at a weak concentration of soil solution. According to the research results, the humus balance and the humification coefficient were calculated. When composting the soil with cotton organs and alfalfa roots and ephemeral vegetation, the greatest increase in humus was obtained from the introduction of ephemeral roots, all cotton organs and alfalfa roots. The calculated humification coefficient typical for cotton leaves was 20%, for alfalfa roots - 15%, for ephemeral roots - 16%, for cotton roots - 12%.

S. Sidikov, M. Ermatova, N. Tashmetova [20] studied the chemical composition and concentration of soil solution of the desert zone soils under conditions of intensive farming.

III. Analysis

As a result of the studies conducted, data on the chemical composition and concentration of soil solution of irrigated automorphic soils were obtained; as well as the change in the content of protein, fat (lipids), phytin in cotton seeds, depending on the chemical composition and concentration of soil solution.

Heavy and high-quality yields of cultivated plants depend on the intensity and productivity of physiological and biochemical processes occurring in them. Reserve constituents in seeds (proteins, lipids, phytin) are mainly synthesized from carbohydrates formed during photosynthesis in the green parts of the plant from CO_2 in the atmosphere and water. Only nitrogen, phosphorus and other minerals necessary for the synthesis of proteins of the developing plant and the forming seeds come from the soil.

The parent soil material from which organic compounds are built enters the seeds through the vegetative organs of the plant. The movement of assimilators from leaves and roots into seeds and the subsequent synthesis and deposition into the reserve constituents are complex physiological and biochemical processes. The intensity of these processes depends on the conditions of the growing medium, primarily, the concentration and composition of soil solution.

Concentration of soil solution in different agricultural backgrounds. Fig. 1 shows the average indices of the chemical composition of soil solution from the upper horizons of the old-irrigated typical serozem, obtained from four variants of the field experiment.

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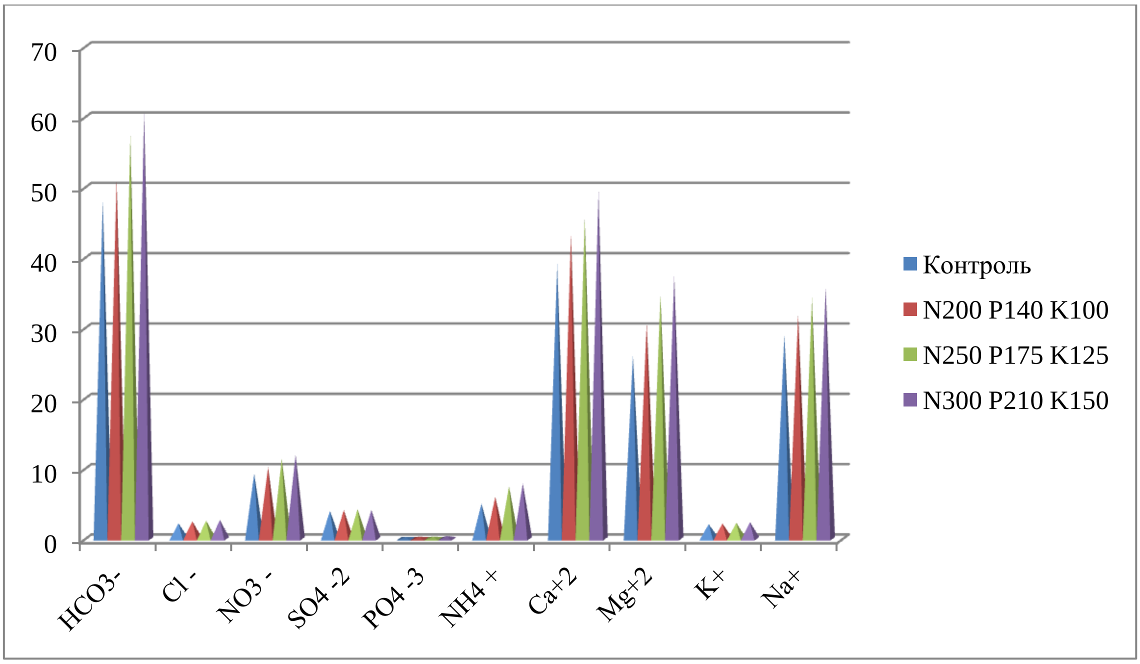

Fig. 1 Chemical composition of soil solution in different agricultural background, mg/l

From the data shown in Fig. 1, it is seen that there is a noticeable difference between the variants of the experiment in the composition of soil solution. The composition of the soil solution of all variants contains a relatively high number of ions of HCO_3^-, Ca^{+2}, Mg^{+2} and Na^+. The smallest number of anions and cations was determined in the soil solution of the check variant.

The use of fertilizers led to an increase in the number of anions and cations in soil solution. In the plow horizon of soils in variant $N_{300}P_{210}K_{150}$, the content of HCO_3 is 60.0 mg/l, NO_3-12.0 mg/l, NH_4-7.9 mg/l, Ca 49.5 mg/l, Mg-37.4 mg/l, Na- 35.8 mg/l. Down the profile, their number decreases.

As a result of an increase in biological activity, a high concentration of soil solution is observed in conditions of irrigated agriculture. The development of virgin lands intensifies the nitrification process and soil solution is enriched with nitrates. Simultaneously with nitrates, an increase in the content of calcium, magnesium and sodium is observed.

Influence of different agricultural backgrounds on the protein content in seeds. The results obtained in the study of the dynamics of the protein content in the formed and ripening cotton seeds are presented in Table 2.

Table 2

Influence of the soil solution concentration on the amount of protein in cotton seeds (mg per 100 seeds)

Variants	Seed age, in days				
	30	40	50	60	70
1. The control	1234±26	1587±32	1903±41	1976±43	2027±49

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2. N_{200} P_{140} K_{100}	1618±36	1971 ±42	2287±53	2360±55	2483±61
3. N_{250} P_{175} K_{125}	1687±39	2040±50	2356±56	2420±62	2476±63
4. N_{300} P_{210} K_{150}	1746±40	2093±52	2395±57	2453±63	2508±66

According to the results obtained, the accumulation of protein in seeds from the period of their formation to ripening occurs very quickly in the check and fertilized variants. In the unfertilized check variant, the protein content in cotton seeds was 30-40% less than in the fertilized variants which led to a low concentration of soil solution. With an increase in the soil solution concentration in the growing medium, the amount of protein in seeds also increased. This means that the accumulation of proteins in cotton seeds occurs rather quickly and depends on the soil solution concentration.

IV. Discussion

Influence of the soil solution concentration on the oil content of seeds. Seeds are not only planting material but also occupy a special place in the oil and fat industry. The data obtained on the accumulation of fats (lipids) in cotton seeds are presented in Table 3.

Table 3

Influence of the growing medium on the amount of lipids in cotton seeds

(mg per 100 seeds)

Variants	, in days				
	30	40	50	60	70
1. The control	368±9	1038±27	1817±46	2007±54	2123±56
1. N_{200} P_{140} K_{100}	451±10	1319±32	2213±58	2481±60	2601±67
2. N_{250} P_{175} K_{125}	476±11	1403±36	2298±60	2549±66	2673±71
3. N_{300} P_{210} K_{150}	492±12	1468±39	2363±61	2619±68	2735±73

In terms of the amount of proteins, the concentration of lipids is much lower in cotton seeds grown without mineral fertilizers than in fertilized versions.

When applying mineral fertilizers, the amount of fat in cotton seeds was 20-25% higher than in the check variant. The effect of mineral fertilizers is already manifested in their relatively small quantities. For example, in variant $N_{200}P_{140}K_{100}$, the lipid content in ripe cotton seeds is 2601 ± 67 mg per 100 seeds, and in

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variants $N_{250}P_{175}K_{125}$ and $N_{300}P_{210}K_{150}$, it is 2673 ± 71 and 2735 ± 73 mg, respectively. A similar situation was observed for seeds of different ages. This state lasts from seed formation to ripening.

Influence of different agricultural backgrounds on the amount of phytin in seeds. Our research work was focused on the effect of different fertilizer rates on the amount of phosphorus compounds in seeds, especially phytin. It is known from the literature sources that phytin in cotton seeds accumulates mainly in the form of Ca, Mg, K salts of myoinositexaphosphate acid. Consequently, the biosynthesis of phytin and its accumulation in the outer testa are directly related to the amount of potassium and phosphorus fertilizers in the growing medium.

According to the results of field experiments, the amount of phytin in seeds during ripening is 25-30% less than in the check variant (Table 4). The use of fertilizers in the norm $N_{200}P_{140}K_{100}$ has a dramatic effect on the amount of phytin in seeds. A further increase in the application rate of mineral fertilizers to the growing medium also leads to an increase in the amount of phytin in seeds, but this change is not so noticeable.

Table 4

Influence of the growing medium on the amount of phytin in cotton seeds

(µg per 100 seeds)

Variants	Seed age, in days				
	30	40	50	60	70
1. The control	2793±66	9817±241	18077±483	28943±769	29187±795
2. N_{200} P_{140} K_{100}	3087±83	12095±314	21343±519	32951±826	34187±885
3. N_{250} P_{175} K_{125}	3549±92	12839±329	22743±532	33945±831	34961±911
4. N_{300} P_{210} K_{150}	3864±97	13679±342	23719±541	35646±839	36017±936

In variant $N_{250}P_{175}K_{125}$, the positive effect of the amount of phosphorus and potassium fertilizers on the amount of phytin in seeds is clearly seen. For example, during the ripening period of cotton seeds in variant $N_{250}P_{175}K_{125}$ the amount of phytin in seeds was 34961±911 µg per 100 seeds. In a field experiment with the introduction of mineral fertilizers in variant $N_{300}P_{210}K_{150}$, this figure was 36017±936 µg.

In our previous studies, it was noticed that phosphate fertilizers increase the amount of phosphorus compounds in seeds by 20-25%.

V. Conclusion

Based on the above data and literature sources, it can be stated that the optimal proportions of mineral fertilizers have a positive effect on the biosynthesis of the basic reserve constituents (proteins, lipids, phytin) in ripe seeds and on their amount. This, in turn, is one of the key factors in ensuring a heavy and high-quality cotton harvest.

The results obtained during the field experiment can be used in the development of norms and ratios

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of mineral fertilizers for extra nutrition of industrial cotton varieties growing on soils of certain types and characteristics.

1. Optimal ratios of mineral fertilizers have a positive effect on the biosynthesis and the amount of basic reserve constituents (proteins, lipids, phytin) in ripe cotton seeds.

2. With an increase in mineral fertilizers in the growing medium, the amount of protein (2508-2483 mg of 100 seeds) in cotton seeds also increases.

3. The positive effect of mineral fertilizers on the amount of fat (lipids) in seeds can be traced even at relatively small amounts.

4. Phosphate fertilizers increase the content of phosphorus compounds in seeds by 20-25%.

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