Volatiles & Essent. Oils, 2021; 8(5):11825-11836

NVEO
Natural Volatiles & Essential Oils

# Influence of Chemical Composition and Concentration of Soil Solution on Physiological Indicators, Cotton Yield, and the Ways of their Optimization

Sidikov Saidjon[1], Ergasheva Olimaxon[2], Zakirova Salomat[3], Abdushukurova Zamira[4], Yunusova Sayyorahon[5]

[1,2,3,4,5] Department of Soil Science, National University of Uzbekistan, Uzbekistan

**Abstract**

In conditions of a typical serozem, the influence of the chemical composition and concentration of soil solution on physiological parameters, in particular, on the formation of the leaf surface of the cotton plant, the productivity of photosynthesis and crop yield was studied. Recommendations for the effective use of fertilizers were given. Scientifically grounded fertilizer rates were developed to optimize the concentration of soil solution for plant nutrition.

It is known that the productivity of plants is directly related to the intensity and productivity of physiological and biochemical processes in them. In addition, plant physiology provides a theoretical basis for obtaining high-quality crop yields. The creation of the optimal composition and concentration of soil solution for the mineral nutrition of plants, especially when applying agrotechnical measures, is one of the urgent tasks of great theoretical and practical importance.

The optimum concentration is the most favorable medium for plant development, which helps accelerate the absorption of nutrients by the plants and ensures high crop yields. The regulation of the composition and concentration of the soil solution in the practice of agriculture is carried out by the application of fertilizers, soil cultivation, and land reclamation.

The results obtained are of great theoretical and practical importance in understanding the exchange reactions in the soil-absorbing complex between absorbed ions and ions in the composition of solution; in the effect of fertilizers, irrigation and processing technology on the physiological parameters of plants; in the scientifically grounded application of fertilizers, and in the educational process of higher educational institutions.

**Keywords**: soil, soil solution, anions, cations, concentration, agrotechnical measures, mineral fertilizers, physiological indicators, leaf surface, productivity of photosynthesis, phytin, yield

## Introduction

**Relevance of the topic**. The soil is the main mean of modernization and rapid development of agriculture, of further strengthening food security, expanding the production of environmentally friendly products. Improving soil properties, increasing yields are the keys to rich and high-quality yields. The improvement of soil fertility and crop productivity is closely related to the use of fertilizers. However, the use of fertilizers without considering the soil properties, especially the composition of the soil solution, will not lead to the desired results, on the contrary, the composition changes and contamination of soil could be observed.

Soil solution can be defined as the liquid phase of soil, including soil water containing dissolved gases, organomineral and organic compounds, gases and the finest colloidal sols. Soil solutions are one of the most important categories of natural waters, "the main substrate of life", "the main element of the biosphere mechanism." The importance of studying soil solutions under natural and anthropogenic factors is that the soil solution can be optimized for plant nutrition.

Currently, one of the main tasks of agriculture is to maintain the condition of the soil solution for optimal plant nutrition. In this regard, the study of the composition and concentration of the soil solution, the creation of its favorable state for plant nutrition is an urgent task in agriculture.

**Object and subjects of research.** Studies to determine the influence of the nutrient medium on physiological indicators and cotton yield were carried out at the experimental site of the Department of Soil

Science, located on the territory of the Botanical Educational and Scientific Center of the National University of Uzbekistan. This region belongs to the Tashkent oasis and consists of the valleys of the Keles, Angren and Chirchik rivers. The climate is typical for the foothills of Central Asia and is characterized as a moderate continental one. Research subjects are cotton, old-irrigated typical sierozem, agrotechnical measures, mineral fertilizers, soil solution.

**Purpose, research objectives and main options.** The main aim of the research is to study the concentration and chemical composition of the soil solution in irrigated lands in various agro-backgrounds and to determine the influence of the nutrient medium on the physiological parameters of cotton, including the formation of the leaf surface of cotton, the productivity of photosynthesis and crop yield. To achieve this aim, the following tasks were completed: a field experiment was conducted on a typical gray soil, determining the chemical composition and concentration of the soil solution, identifying the influence of the nutrient medium on the physiological parameters and yield of cotton.

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

When studying a soil solution, one should not limit oneself to studying only 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, one should know all, without exception, the properties of a soil solution, such as concentration, chemical composition, osmotic pressure and their changes. The vital activity of plants and microorganisms is also impossible without a soil solution, which performs a protective and regulatory function and is a source of nutrition.

**Scientific novelty of the topic**. For the first time in Uzbekistan, the most complex component of irrigated soils, the soil solution, was identified: its chemical composition, concentration, patterns of parameter changes under the influence of natural and anthropogenic factors, the effect of the concentration of soil solution on physiological parameters and optimal conditions for plant nutrition.

**Research methodology**. Laboratory and field studies on the isolation, composition, and concentration of soil solutions and their effect on the physiological parameters of cotton were determined by generally accepted methods in agrochemistry. To isolate and study soil solutions, the Ishcherekov-Komarova method of soil solution displacing was used; ethyl alcohol was used as a displacer. The Ishcherekov-Komarova method turned out to be very convenient to use, including in the expeditionary version, which led to its widespread use. Using this method, the authors have created a device (Fig. 1) to displace the soil solution.

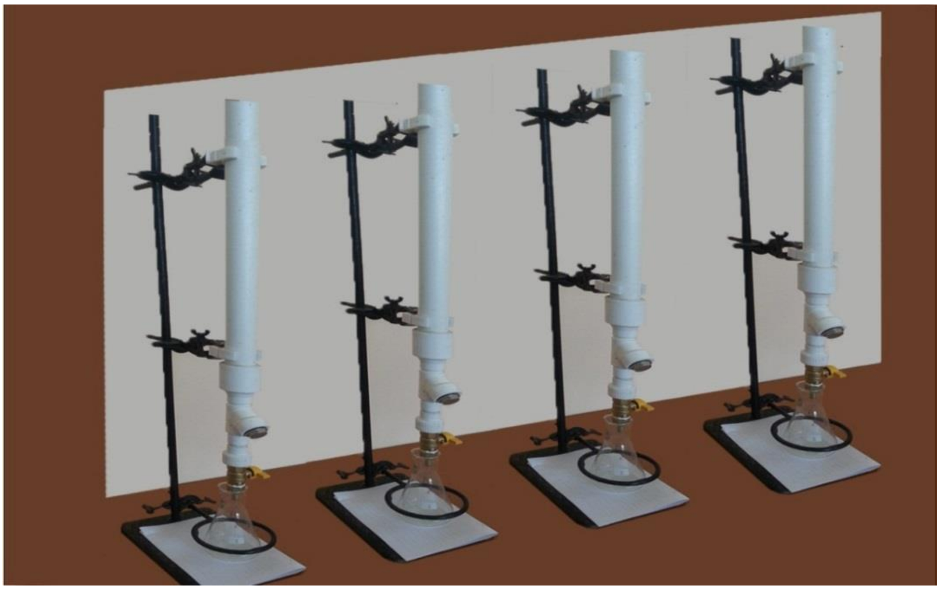

Fig. 1. Device for displacing soil solution

When performing laboratory analysis, literary sources by domestic and foreign researchers were used [1, 2, 3, 4]. Nitrogen in proteins was determined by the Pleshkov calorimetric method, fats - by the Soxhlet method, phytin - by the Kursanov method. The field experiment was conducted in 3 repetitions on 4 options (Table 1).

Table 1: Field experiment scheme

| Option | Annual fertilizer rate, kg/ha | Distribution of the annual fertilizer rate, kg/ha | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Under the chill | | Before sowing | | | 3-4 true leaves | Budding | | FFlow ering |
| | | P 70% | K 50% | N 30% | P 30% | K 20% | N 20% | N 20% | K 30% | N 30% |
| 1 | Control | - | - | - | - | - | - | - | - | - |
| 2 | $N_{200}$ $P_{140}$ $K_{100}$ | 98 | 50 | 60 | 42 | 20 | 40 | 40 | 30 | 60 |
| 3 | $N_{250}$ $P_{l75}$ $K_{125}$ | 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 |

## Literature review

Analysis of literature sources shows that the study of the soil solution at the proper level was carried out at the Dokuchaev Soil Institute (Russia) by P.I.Shavrigin (1958-1963), A.A. Kizilova (1955-1967-1970) and at the University of California. (United States of America) N.J. Barrow (1972), T.N.Choo (1982). They obtained valuable information on the soil solution in their region.

A number of foreign scientists studied trace elements in soil-pore water (D.M. Bonito, 2005), chemistry of soil and water (M.E. Essington, 2004), lysimetric methods for controlling the electrical conductivity of soil solution and the concentration of nutrients in greenhouse tomato crops (Francisco Javier Cabrera Corral, Santiago Bonachela Castagno, Maria Dolores Fernandez Fernandez, Maria Rosa Granados Garcia, Juan

Carlos Lopez Hernandez, 2016), quantification of pyrophosphate in soil solution by hydrolysis of pyrophosphatase (Casper Reizel, Benjamin L. Turner, 2014) precipitation on the chemical composition of forest soils (Arne Verstraten, Johan Neirink, Gerrit Jenow, Natalie Kools, Peter Roskams, Maarten Hens, 2012), the chemical properties of the soil solution, the reaction of rice and the efficiency of water use in various flood management methods (Jose Bernardo Moraes Borin, Felipe de Campos Carmona, Ibanor Anginoni, Amanda Posselt Martins, Isadora Rodriguez Jaeger, Elio Marcolin, Gustavo Cantori Hernandez, Estefania Silva Camargo, 2016), Leaching of ions and acidification of soil solution in the vadose zone under soil treated with sewage sludge for agriculture (Ricardo Perobelli Borba, Victor Sanchez Ribeirinho, Otavio Antoniode Camardenera, Crisodetiano Albert Kira, Aline Rene Cossione, 2018).

According to Asgeir Rosseb Almas, Hilmar Thor Svarsson, Tore Krogstad (2017), the distribution of phosphorus in soil determines the fluxes and supplies of labile phosphorus in the soil solution.

The data obtained by Yusuke Unno, Hirofumi Tsukada, Akira Takeda, Yuichi Takaku, Shunichi Hisamatsu indicate that the distribution coefficient of soil organic matter solution in soil is a key factor for radioactive iodization in surface and underground soils (2017).

According to Smagin (2004), individual states and processes of interaction between phases and components of soil systems can be described using the categories of equilibrium thermodynamics.

In soil chemistry, there is still uncertainty in the interpretation of the term "soil solution", which is often understood to mean different forms of soil moisture in composition and properties. A.E. Vozbutskaya considers the terms “liquid phase of soil” and “soil solution” to be analogous.

The Explanatory Dictionary of Soil Science (edited by Rode, 1975) defines a soil solution as "water found in soil and containing organic and mineral substances and gases in a dissolved state."

The dictionary reference "Chemical contamination of soils and their protection" (1991) adds to this "the soil solution is a homogeneous liquid phase of a variable composition."

R.W. Pearson (cited after Orlov, 1985) calls a soil solution "a quasi-equilibrium solution of electrolytes that exists in soil under the condition of its incomplete saturation with moisture."

A similar interpretation is given in the dictionary "Biosphere: pollution, degradation, protection" (2003): "a soil solution is a solution of chemicals in water, which is in quasi-equilibrium with the solid and gaseous phases of soil and partially or completely fills its pore space."

D.S. Orlov (1985) complements the concept of "soil solution", rightly defining it as a liquid part of soil in natural conditions. All these definitions reflect some features of such a system as a soil solution, but they cannot be considered strict. For example, it is not clear whether all forms of water in soil can be attributed to the soil solution. In particular, are strongly bound (hygroscopic) and free gravitational moisture related to the soil solution? This question is not idle.

Terminological discrepancies, on the one hand, and the variety of methods used to isolate solutions that make it possible to obtain different fractions of soil moisture, on the other hand, lead to the fact that researchers in each individual case obtain and study systems with significantly different properties.

Considering that the capillary and gravitational moisture is in the same soil, and that the capillary moisture is one of the sources of gravitational flow formation, their composition, on the whole, is close. However, there are differences. Since gravity water quickly filters through the soil without reaching a state of equilibrium with solids, its composition is less clear concerning the properties and genetic characteristics of a given soil. In addition, it strongly depends on the amount and mode of precipitation and can bear the imprint of the composition of snow, rain or irrigation water, as well as interactions with above-ground parts of plants (washout), leaf fall, and an atmosphere different in composition from soil air (Snakin, 1989).

Strongly bound moisture, in contrast to gravitational moisture, is stable, immobile, and inaccessible to plants and has special physical properties: in particular, it does not dissolve substances that are soluble in free water. These features make it less informative for soil studies. At the same time, the main part of the liquid phase in most soils is capillary (pore) moisture. This fraction of soil moisture is more stable than gravitational, is close to the state of quasi-equilibrium, is most accessible to plants, and is mainly studied in in-situ measurements.

The soil itself is a heterogeneous, porous colloidal-capillary system (Smagin, 2003), in which the distribution of ions is regulated by inter-phase adsorption interactions that create a concentration gradient of substances near a solid surface, and the retention force of the solution decreases with distance.

Several forms of varying degrees of mobility represent soil moisture, and its distribution in soil is directly related to the nature of the pore space. A solution of small pores, or non-free water, or film moisture (according to the terminology of different authors) has specific properties and composition. Anomalous features of non-free, bound water were established for such characteristics as density, viscosity, dielectric constant, thermal conductivity, and dissolving ability.

Numerous data indicate that the liquid phase of soil is not homogeneous, and this circumstance explains the differences in the chemical composition of soil solutions obtained with the application of pressure of different magnitudes.

Moisture obtained from soil by centrifugation, and, thus, more strongly bound with soil (by osmotic, sorption, capillary forces), has higher concentrations of most of the studied chemical components in comparison with solutions extracted by gravity lysimeters.

Many researchers cite similar data. For example, studies by Marques et al. (1996) show that soil solutions obtained by vacuum lysimeters ($p$ = 600 kPa) contain more Si, $NH_4^+$ , $NO_3^-$ , $Cl^-$ , $Mg^{2+}$ , $Al^{3+}$ compared to solutions obtained by gravity lysimeters. Differences between different fractions of soil solutions depend on the soil texture.

De Vries, Reinds, Deelstra (1999) showed that, in sandy soils, the differences in soil solutions obtained by different methods are not significant. At the same time, in soils heavier in texture, the concentration of solutions increases.

The interaction between solute particles and solvent molecules is a prerequisite for the existence of real solutions. This position underlies the chemical theory of solutions proposed by D.I. Mendeleev (1887), who established that in real solutions there are individual particles of a substance and of a solvent, and the products of their interaction.

Natural soil solutions are characterized by ionic strength from several mmol/l to hundreds of mmol/l (in saline soils). So, in the soil solution of the salt marsh, I = 20-350 mmol/l, and in solutions from the plant litter of peaty-podzolic soil - from 0.7 to 8.7 mmol/l. On average, the soil solutions in a temperate climate are characterized by ionic strength of about 10 mmol/l (and higher), while for strongly weathered soils of the tropics (oxysol), a weakly concentrated soil solution with ionic strength of less than 5 mmol/l (up to 0.2 mmol/l) is most typical (Harter, Naidu, 2001).

In saline soils, as well as in the lower mineral horizons, where the content of anions of weak organic acids is insignificant, electrostatic interactions are dominant, and therefore the use of activity coefficients can be sufficient for calculating real activities, especially with the use of mathematical models that take into account the ion association.

However, in most cases in soil solutions, in addition to electrostatic interactions of ions, numerous reactions of chemical interaction occur - competing reactions (complexation, protonation, etc.). Under these conditions, one element can be present in several different ionic forms, can be represented by a free ion, or be a part of various complex ions.

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

T. Schloesing was the first who proposed the method of displacing soil solutions with distilled water in 1866, and then alcohol was used as a displacer. Later, a method was developed for squeezing out or pressing out soil solutions at high pressures and its modification - the centrifugation method.

The lysimetric method is widely used in the study of migration processes of substances in undisturbed soils. Despite the fact that lysimetric waters can only approximate soil solutions, the method was of great importance for obtaining primary information on the composition and properties of natural waters in various soils and modern processes of migration and accumulation of soil products in them.

Historically, one of the first methods was the method of water extracts, used by researchers; nowadays it is the standard method for soil analysis.

Of the available studies, M. Schnitzer et al. made the most significant contribution to the experimental study of the interaction of polyvalent cations with fulvic acids. However, despite the importance and depth of research, it was not focused on practical use in calculations; therefore, when setting problems, the results in the form of conditional stability constants of complexes cannot be directly used as input thermodynamic data.

Considering the significant content and importance of metal-fulvate complexes in soil solutions, let us dwell in more detail on the method of their experimental study and methods of processing analytical information that provide the necessary thermodynamic constants.

There are very few direct experimental studies of the interaction of fulvic acids with metals, in which equilibrium concentrations of fulvic acids and metal ions are presented. Among those studies is the work by D.S. Gamble, in which the reactions of interaction of bivalent copper with fulvic acids were studied, and the equilibrium constants were calculated.

Experimental studies of the equilibria of fulvic acids with cations are based on the study of the distribution of the metal between the cation-exchange resin and the solution in the absence and presence of a complexing agent - fulvic acid. For this purpose, the Schubert ion exchange method is used.

Thorough studies of the ratio of salts extracted by water extracts and present in soil solutions were conducted by P.I.Shavrygin. It follows that the total amount of water-soluble substances in aqueous extracts is higher than in soil solutions; the higher the differences, the lower the salt solubility. The differences are more related to calcium salts and, to a lesser extent, to chloride ions.

The method of water extracts, while remaining the main one for controlling the salt state of soils, makes it possible to obtain data on the soil solution concentration that characterize the true conditions for the existence of plants in a given soil (N.G. Minashina, 1970).

Karavanova, Malinina (2007) came to the conclusion that the level of fluctuations of different chemical elements (and their compounds) in soil solutions from leaf litters and horizons Eih of peaty-podzolic soils differ significantly. The concentrations of Al, Si, $C_{org}$ vary insignificantly.

Geographic zoning affects the ratio of precipitation and evaporation, water balance, the nature of vegetation, the intensity of weathering, the nature of soils and the type of migration of substances, which is inevitably reflected in the composition of soil solutions. According to G.A. Maksimovich (1955), 9 latitudinal zones are distinguished, where certain hydrochemical facies of soil solutions prevail. A facies is an area of soil cover, the aqueous solutions of which are characterized throughout its entire length by the same hydrochemical properties.

Summarizing the literary review given above, we can say that the soil solution is the liquid phase of soil, which contains mineral, organic and organomineral substances, and dissolved gases in ionic, molecular, colloidal forms.

From the analysis of the cited literary sources, it is seen that at present it is impossible to obtain a rich and high-quality harvest without saturating the plant with mineral fertilizers. This applies to all crops on irrigated lands in Uzbekistan. If during the growing season the process of plant feeding is disrupted, the yield will spontaneously decrease. To ensure the effective impact of fertilizers, it is necessary to create special conditions, that is, the correct implementation of agrotechnical measures. If the soil is poorly prepared for planting in autumn and spring, the crops are poorly looked after, the rows are not processed in a timely manner and efficiently, not watered properly, the positive effect of mineral fertilizers on the plant will be minimal. All types of nutrients are needed at a certain stage of plant development and in certain quantities. Therefore, it is necessary to know exactly the rates and timing of fertilization.

## Research Results

As a result of the analysis of literary sources and the research conducted by the authors, data on the sources, the formation process and the chemical composition of the soil solution in irrigated soils of the serozem zone were obtained. According to these data, the mineralization of the soil solution ranges from several tens of mg/l to several g/l, depending on the type of soil and geographic location. Below are the results of the study of the chemical composition, concentration of irrigated serozem soils.

**Influence of the concentration of soil solution on the formation of the leaf surface of cotton plant**

It is known that the water regime of plants, the photosynthesis and the amount of yield largely depend on the level of the leaf. It should also be noted that leaf formation consists of four stages. These are the formation of leaf primordia, the formation of a leaf strip, the formation of a leaf blade due to lateral meristems and an increase in this blade due to elongation. All of these processes depend on how well the plant is supplied with nutrients. Plant nutrients are absorbed from the soil solution.

Based on the above, within the framework of our study, we studied the effect of soil solution of various concentrations on the size of the leaf surface of cotton variety Namangan-77.

The experiments were conducted on four options with different concentrations of the soil solution: nutrient media without fertilizers (control), $N_{200}P_{140}K_{100}$, $N_{250}P_{175}K_{125}$ and $N_{300}P_{210}K_{150}$. The results of the study are presented in Table 2. It can be seen from the data in the table that at the phase of 3-4 true cotton leaves appearance, the least leaf surface was observed in the control option. Although the leaf surface of the plant at this stage of plant development was relatively increased in the options with fertilizers, no significant difference was observed between the options.

In the experiment, the area of the leaf surface of one plant during the budding period does not differ sharply from the options with fertilizers.

Table 2: Influence of the soil solution concentration on the formation of leaf surface of cotton plant

| Phases of cotton plant development | Options | Leaf surface of cotton plant, $cm^2$ |
|---|---|---|
| Phase of 4-5 true leaves | 1. Control | 123.4±3.6 |
| | 2. $N_{200}$ $P_{140}$ $K_{100}$ | 166.8±4.8 |
| | 3. $N_{250}$ $P_{175}K_{125}$ | 165.4±4.7 |
| | 4. $N_{300}$ $P_{210}$ $K_{150}$ | 166.6±4.5 |
| Budding | 1. Control | 368.4±10.8 |
| | 2. $N_{200}$ $P_{I40}$ $K_{IOO}$ | 485.5±14.1 |
| | 3. $N_{250}$ $P_{175}$ $K_{125}$ | 468.7±13.8 |
| | 4. $N_{300}$ $P_{210}$ $K_{150}$ | 488.9±11.8 |
| Flowering | 1. Control | 1208.0±36.1 |
| | 2. $N_{200}$ $P_{140}$ $K_{100}$ | 1410.7±42.4 |
| | 3. $N_{250}$ $P_{I75}$ $K_{125}$ | 1480.8±43.4 |
| | 4. $N_{300}$ $P_{210}$ $K_{150}$ | 1495.7±33.8 |
| Boll formation | 1. Control | 2135.4±63.1 |
| | 2. $N_{200}$ $P_{140}$ $K_{100}$ | 3319.3±90.2 |
| | 3. $N_{250}$ $P_{175}$ $K_{125}$ | 3468.4±91.2 |
| | 4. $N_{300}$ $P_{210}$ $K_{150}$ | 3488.9±81.3 |

At the next phase of plant development (flowering), a sharp increase in the area of the leaf surface of the cotton plant was observed. In one plant, the size of the leaf surface was 1208.0 ± 36.1 cm in the control option with a low concentration of soil solution and 1410.7 ± 42.4-1495.7 ± 33.8 cm in the options with a high concentration under the influence of fertilizers. For example, in the $N_{200}P_{140}K_{100}$ option, the leaf area of one plant was 1410.7 ± 42.4 $cm^2$, in the $N_{250}P_{175}K_{125}$ option - 1480.8 ± 43.4 $cm^2$, and in the $N_{300}$ $P_{210}$ $K_{150}$ option - 1495.7 ± 33.8. $cm^2$.

The greatest increase in the leaf surface was observed in the phase of the cotton bolls formation. At this stage of plant development, the efficiency of the soil solution concentration using mineral fertilizers becomes even more noticeable. For example, it was observed that the leaf surface in all options of the experiment almost doubled during the period of boll formation compared to the period of flowering of the cotton plant.

From the above, it can be concluded that the mineral nutrition of the cotton plant to create the optimal concentration of the soil solution and the application of phosphorus fertilizers in combination with a large amount of nitrogen and potassium fertilizers lead to an expansion of the leaf surface of plants, which leads to an increase in the productivity of photosynthesis. This, in turn, is one of the key factors in ensuring a plentiful and quality cotton harvest.

In general, the experimental options for efficiency relative to the leaf surface of one cotton plant can be arranged as follows: $N_{200}P_{140}K_{100}$> $N_{250}P_{175}K_{125}$> $N_{300}P_{210}K_{150}$> Control. Consequently, the use of mineral fertilizers has a positive effect on the leaf surface and, ultimately, on the cotton yield.

**Influence of different agricultural backgrounds on photosynthetic productivity of the cotton plant**

In the research conducted, the effect of the soil solution concentration on the photosynthetic productivity of cotton leaves was studied. The results obtained during the experiments are given in Table 3.

Table 3: Influence of the soil solution concentration on the photosynthetic productivity of the cotton plant, (g/m$^2$)

| Options | Cotton development phases | | | | |
|---|---|---|---|---|---|
| | Phase of 4-5 true leaves | Budding | Flowering | Boll formation | Ripening |
| 1. Control | 0.14±0.01<br>5.06±0.14 | 0.21±0.01<br>5.26±0.15 | 1.43±0.03<br>5.84±0.17 | 1.35±0.03<br>4.92±0.13 | 1.21±0.02 4.11±<br>0.12 |
| 2. $N_{200}$ $P_{I40}$ $K_{100}$ | 0.20±0.01<br>7.44±0.21 | 0.34±0.01<br>7.64±0.21 | 2.74±0.07<br>8.16±0.24 | 3.30±0.10<br>7.05±0.20 | 3.19±0.09<br>6.02±0.18 |
| 3. $N_{250}$ $P_{175}$ $K_{125}$ | 0.28±0.02<br>8.07±0.23 | 0.47±0.06<br>8.27±0.23 | 3.73±0.11<br>8.85±0.27 | 4.67±0.13<br>7.93±0.23 | 4.34±0.12<br>6.94+0.19 |
| 4. $N_{300}$ $P_{2I0}$ $K_{I50}$ | 0.39±0.03<br>8.29±0.24 | 0.67±0.05<br>8.63±0.25 | 5.46±0.14<br>9.13±0.27 | 5.88±0.13<br>8.51±0.25 | 5.14±0.12<br>7.16±0.22 |

Note. In the numerator: the amount of organic matter formed during photosynthesis in 1 plant per 1 day, in grams; in the denominator: the amount of organic matter formed during photosynthesis per 1 m$^2$ of leaf surface, in grams.

From the data in Table 3, it is seen that the productivity of photosynthesis in cotton leaves increases depending on the concentration of the soil solution. For example, in the phase of the formation of 3-4 true leaves, the photosynthetic productivity of one cotton leaf in the control option is 0.14 ± 0.01 g, and in option 2 - 0.20 ± 0.01 g. With an increase in the concentration of the soil solution, the productivity of photosynthesis increases to 0.28 ± 0.02 g and 0.39 ± 0.03 g. It should be noted that the photosynthetic productivity of cotton increases until the flowering phase of plants. Then, there is a slight decrease. However, the productivity of photosynthesis remains high until the end of cotton ontogenesis.

Thus, the optimization of the soil solution concentration due to the introduction of mineral fertilizers has a significant positive effect on the growth and development of the cotton plants, the photosynthetic productivity of cotton increases almost twice. Consequently, the highest photosynthetic productivity of cotton falls on the budding and flowering phases of plants. This, in turn, is directly related to the fact that cotton forms a strong root system, and the plant is optimally supplied with mineral elements.

**Influence of different agricultural backgrounds on the yield of cotton**

It is known that cotton fiber is one of the main raw materials in agriculture. Therefore, most research institutes focus on increasing the quantity and quality of cotton fiber. In particular, the Department of Soil

Science of the National University of Uzbekistan has been conducting research on various varieties of cotton for several decades, concerning the effect of various agricultural backgrounds on the yield of cotton. The results of the field experiment on the yield of cotton are presented in Table 4.

Table 4: Influence of the soil solution concentration on yield of cotton, c/ha

| Options | Fertilizer Ratio (N : P : K) | Yield |
|---|---|---|
| Control | - | 16.39±0.52 |
| $N_{200}$ $P_{140}$ $K_{100}$ | 1:0.70:0.5 | 39.77±1.24 |
| $N_{250}$ $P_{175}$ $K_{125}$ | 1:0.70:0.5 | 42.42±1.31 |
| $N_{300}$ $P_{210}$ $K_{150}$ | 1:0.70:0.5 | 42.98±1.33 |

From the data in Table 4, it is seen that the concentration of the soil solution created when applying mineral fertilizers at different rates and ratios has a different effect on the yield of cotton. For example, in the control option, i.e. without the use of fertilizers, the yield of cotton is low (16.39 ± 0.52).

In the options with fertilizers, the highest yield was obtained in the $N_{300}P_{210}K_{150}$ option, and the lowest yield - in the $N_{200}$ $P_{140}$ $K_{100}$ option. In these options of the experiment, the yield of cotton is 42.98 ± 1.33 and 39.77 ± 1.24 centners per hectare, respectively.

Thus, the results of field experiments show that high yields of cotton are observed against the background of the introduction of nutrients with a large amount of mineral fertilizers, i.e. the greater the amount of mineral fertilizers in the nutrient medium, the higher the crop yield. However, this is not always the case, in some cases, the amount of mobile forms of mineral elements in soil can be large, but cannot significantly affect the yield of cotton. This may indicate the presence of a certain genetic normative response to mineral elements in cotton plants.

## Conclusions

For the mineral nutrition of the cotton plant, the application of phosphorus fertilizers in combination with a large amount of nitrogen and potassium fertilizers leads to an expansion of the leaf surface of plants and, ultimately, increases the productivity of photosynthesis. This, in turn, is one of the key factors in ensuring a plentiful and high quality cotton crop.

At present, it is impossible to obtain a rich high-quality crop without saturating the cotton plants with mineral fertilizers. The effectiveness of mineral fertilizers largely depends on their timely application. The use of nitrogen, phosphorus and potash fertilizers on a scientific basis makes it possible to increase the fertility of irrigated lands and obtain a rich cotton crop.

Violation of the rules for the use of mineral fertilizers can lead to unexpected deterioration of the ecological situation in cotton growing.

To optimize the composition and concentration of irrigated serozem soils for plant nutrition, it is recommended to use fertilizers at the rate of $N_{250}$ $P_{175}$ $K_{125}$ and irrigation rates, which provide 70-80% of soil moisture.

## REFERENCES

Arne Verstraeten, Johan Neirynck, Gerrit Genouw, Nathalie Cools, Peter Roskams, Maarten Hens. Impact of declining atmospheric deposition on forest soil solution chemistry in Flanders, Belgium. Atmospheric Environment Volume 62, December 2012, Pages 50-63.

Asgeir Rosseb Almas, Hilmar Thor Sævarsson, Tore Krogstad. The partitioning of P in soil determines the fluxes and deliveries of labile P in soil solution. Geoderma Volume 306, 15 November 2017, Pages 135-143.

Bonito D. M. Trace Elements in Soil Pore Water: A Comparison of Sampling Methods. PhD thesis, University of Nottingham. 2005. 299 p.

Essington M.E. Soil and water Chemistry. An integrative approach. CRC press. Boca Raton.London. NY. Washington. 2004. 534 p.

Francisco Javier Cabrera Corral, Santiago Bonachela Castaño, María Dolores Fernández Fernández, María Rosa Granados García, Juan Carlos López Hernández. Lysimetry methods for monitoring soil solution electrical conductivity and nutrient concentration in greenhouse tomato crops. Agricultural Water Management.Volume 178, December 2016, Pages 171-179.

Francisco Javier Cabrera Corral, Santiago Bonachela Castaño, María Dolores Fernández Fernández, María Rosa Granados García, Juan Carlos López Hernández. Lysimetry methods for monitoring soil solution electrical conductivity and nutrient concentration in greenhouse tomato crops. Agricultural Water Management. Volume 178, December 2016, Pages 171-179.

Jose Bernardo Moraes Borin, Felipe de Campos Carmona, Ibanor Anghinoni, Amanda Posselt Martins, Isadora Rodrigues Jaeger, Elio Marcolin, Gustavo Cantori Hernandes, Estefânia Silva Camargo. Soil solution chemical attributes, rice response and water use efficiency under different flood irrigation management methods. Agricultural Water Management. Volume 176, October 2016, Pages 9-17.

Kasper Reitzel, Benjamin L.Turner. Quantification of pyrophosphate in soil solution by pyrophosphatase hydrolysis. Soil Biology and Biochemistry. Volume 74, July 2014, Pages 95-97.

Ricardo Perobelli Borba, Victor Sanches Ribeirinho, Otávio Antoniode Camargo, Cristiano Albertode Andrade, Carmen Silvia Kira, Aline Reneé Coscione. Ion leaching and soil solution acidification in a vadose zone under soil treated with sewage sludge for agriculture. Chemosphere. Volume 192, February 2018, Pages 81-89.

Sidikov Saidjon, Ermatova Munojat, Abdushukurova Zamira. Method For Optimization of Composition And Concentration of Soil Solution of Irrigated Soils For Nutrition of Plants. Solid State Technology (Volume: 63 Issue: 4 Publication Year: 2020).

Sidikov Saidjon, Ermatova Munojat, Tashmetova Nigora. Optimization of the chemical composition and concentration of soil solution of soils of desert zone for nutrition of plants. Scopus-PalArch's Journal of Archaeology of Egypt/ Egyptology.

Sidiqov Saidjon, Ermatova Munojat, Abdushukurova Zamira, Ergasheva Olimaxon, Mahkamova Dilafruz, Tashmetova Nigora. Degree of humification of cotton, alfalfa and ephemers organs, their effect on the content and composition of soil organic matter. Plant Cell Biotechnology and Molecular Biology. Paje: 94-102.

Yao Yu Yanan Wan, Aboubacar Younoussa Camara, Huafen Li. Effects of the addition and aging of humic acid-based amendments on the solubility of Cd in soil solution and its accumulation in rice. Chemosphere Volume 196, April 2018, Pages 303-310.

Yusuke Unno, Hirofumi Tsukada, Akira Takeda, Yuichi Takaku, Shun'ichi Hisamatsu. Soil-soil solution distribution coefficient of soil organic matter is a key factor for that of radioiodide in surface and subsurface soils. Journal of Environmental Radioactivity. Volumes 169–170, April 2017, Pages 131-136.

Malinina M.S., Motuzova T.V. Metodi polucheniya pochvennix rastvorov pri pochvenno-ximicheskom monitoringe. V sb: fizicheskie i ximicheskie metodi issledovaniya pochv. M. MGU, 1991. –S. 101-130.

Rukovodstvo k provedeniyu ximicheskix i agrofizicheskix analizov pochv pri monitoringe zemel`. Tashkent, 2004. 260 str.

Skrinnikova I.N. Metodi issledovaniya ximicheskogo sostava jidkoy fazi pochv. V sb: Metodi statsionarnogo izucheniya pochv. M., "Nauka", 2011. 211 str.