## АГРОХИМИЯ

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# MATHEMATICAL FORECAST OF THE EFFECT OF MINERAL FERTILIZERS ON COTTON PRODUCTIVITY ON THE GRAY SOILS OF DIFFERENT SALINITY IN CONDITIONS OF TURKESTAN REGION

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*Abstract.* Soil salinization remains a critical constraint for cotton cultivation in the southern regions of Kazakhstan, particularly in the Turkestan region. This study aimed to develop a model quantifying the combined influence of soil salinity levels and mineral fertilizer doses on cotton yield and fiber quality. Field trials were conducted on light gray soils with varying degrees of salinity on the production fields of the "Sabyr" farm, Maktaaral district. Standard agrochemical methods assessed soil properties, crop yield, and fiber quality. Results demonstrated that mineral fertilizers enhanced cotton productivity across all salinity levels, with the most significant yield response observed on slightly saline soils. The highest yield (6.49 t/ha) was recorded with N150P100K80 on slightly saline soils, while medium saline soils produced 5.41 t/ha under the same treatment. Phosphorus-potassium application without nitrogen (P100K80) resulted in the lowest yield gains. Regression modeling revealed a negative relationship between excessive nitrogen and potassium application and yield (Y), although their combined interaction partially offset this effect. Notably, the interaction between nitrogen and salt content (NtS) also negatively affected yield. The regression model demonstrated high reliability (R = 0.940), confirming its predictive accuracy. Correlation analysis indicated a moderate to strong relationship between potassium nutrition and key fiber quality indicators. Increasing potassium doses improved tensile strength (r = 0.61), maturity factor (r = 0.48), and fiber length (r = 0.62), while negatively affecting micronaire (r = -0.38), fiber fineness (r = -0.60), and water column resistance (r = -0.60). Fiber quality also correlated positively with total salt content in the arable layer (r = 0.37–0.61). Economic analysis showed that N150P100K80 was most profitable on slightly saline soils (1352.5 thousand KZT/ha), whereas N100P150K80 was optimal on medium saline soils (1035.8 thousand KZT/ha). These findings underline the importance of site-specific nutrient management under saline conditions.

*Keywords:* soil salinity; cotton yield; economic efficiency; fiber quality.

## INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is one of the world's most economically significant crops, serving as a primary source of natural fiber, edible oil, and raw materials for industrial applications. Its cultivation efficiency is highly dependent on soil health, salinity levels, and the strategic implementation of agronomic practices, particularly mineral fertilization. Soil salinization poses a major challenge to cotton productivity, especially in arid and semi-arid regions such as southern Kazakhstan, where high salinity negatively impacts both yield and fiber quality. Soil salinization is a critical concern in arid and semi-arid regions where high evapotranspiration rates, improper irrigation practices, and insufficient drainage contribute to salt accumulation in the root zone. Consequently, optimizing nutrient management strategies under saline conditions is critical for sustainable production [1, 2].

To combat the detrimental effects of salinity on cotton, mineral fertilization has emerged as a pivotal agronomic strategy.

Balanced and site-specific fertilization not only promotes plant resilience to saline stress but also ensures optimal nutrient availability, contributing to better yield and improved fiber parameters [3]. Among the essential macronutrients, nitrogen (N), phosphorus (P), and potassium (K) play key roles in the physiological development of cotton. Research has demonstrated that rational fertilization enhances productivity, with nitrogen promoting vegetative growth, phosphorus supporting root development and early-stage resilience, and potassium improving fiber strength and uniformity [4, 5]. However, excessive or imbalanced fertilizer application can lead to nutrient leaching, environmental degradation, and diminished economic returns. Thus, developing precision-based fertilization models is imperative to maximize efficiency while minimizing ecological harm [6].

Recent studies have explored innovative approaches to improve nutrient uptake under adverse conditions. For instance, foliar application of potassium has been shown to mitigate salinity stress, enhancing fiber characteristics even in suboptimal soils [7]. Similarly, phosphorus management is crucial in saline environments, as it aids root elongation and early crop establishment. Screening for phosphorus-efficient cotton cultivars has further been identified as a viable strategy for cultivation in low-fertility regions [8, 9]. These findings underscore the need for targeted fertilization protocols tailored to specific soil and climatic conditions.

Beyond fertilization, seed quality plays a pivotal role in determining cotton productivity. Conventional methods such as seed priming and scarification remain effective in improving germination rates, while emerging technologies - including plasma treatment and nanotechnology-based seed coatings - show promise in enhancing stress tolerance and crop uniformity [10, 11]. Such advancements complement optimized fertilization regimes, offering a holistic approach to yield improvement.

The complexity of interactions between soil salinity, fertilization, seed quality, and environmental factors underscores the need for integrated, data-driven decision-making tools. Traditional empirical approaches often fall short in capturing these nonlinear relationships. In response, predictive modeling using artificial intelligence (AI) and machine learning (ML) is increasingly being employed in modern agronomy. Techniques such as artificial neural networks (ANNs), support vector machines (SVM), and random forests are capable of analyzing large datasets to identify key yield determinants and generate accurate predictions [12, 13]. These tools allow for dynamic decision-making that accounts for seasonal variability, soil heterogeneity, and changing climatic conditions.

The current research understanding emphasizes the importance of integrated nutrient and salinity management to ensure cotton productivity in saline-affected regions. Despite extensive studies on fertilization and salinity tolerance, there remains a lack of comprehensive, region-specific models that account for the unique agroecological conditions of southern Kazakhstan. The development of such models is essential for bridging the gap between experimental knowledge and practical field application.

This study is highly relevant due to the increasing degradation of irrigated lands and expansion of salinized soils in Central Asia. There is a growing demand for sustainable, cost-effective, and science-based solutions that ensure cotton yield stability without compromising environmental integrity.

The aim of the research is to develop mathematical models for predicting the yield and quality of raw cotton depending on the level of soil salinity and doses of applied fertilizers. The results are expected to provide practical recommendations for optimizing fertilizer use and improving the efficiency of cotton production in salinity-stressed environments.

The novelty of this research lies in the creation of a robust mathematical model that integrates salinity levels, fertilizer doses, and environmental variables for the prediction of both yield and fiber quality under local conditions. Unlike traditional empirical approaches, this model leverages predictive analytics to offer a decision-support tool tailored for precision farming in Kazakhstan's saline-affected regions.

MATERIALS AND METHODS

To conduct field experiments to study the effect of mineral fertilizers on cotton productivity in conditions of serozems saline to different degrees, plots were selected in the farm "Sabyr", Maktaaral district, Turkestan region, at coordinates: 40085'76.52 "N, 68049'10.40 "E (figure 1)

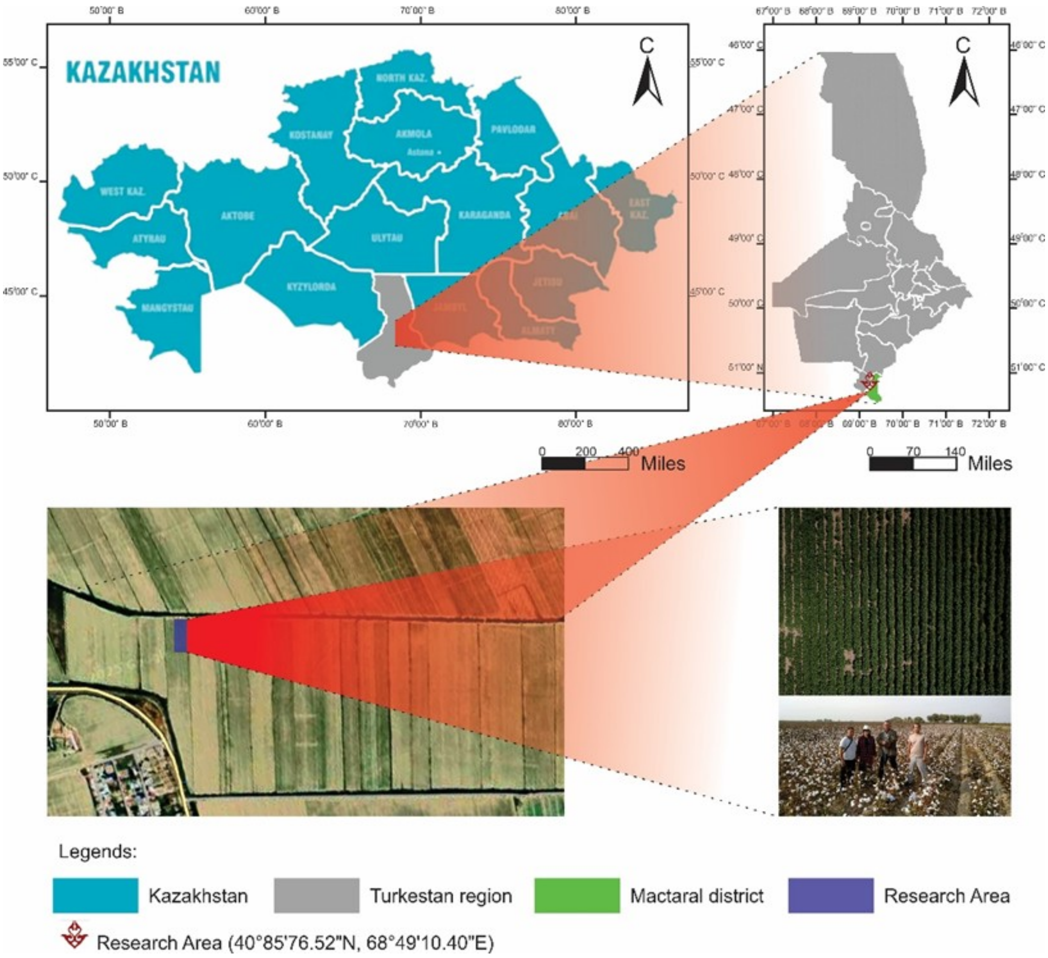


Figure 1 - Study area map, Atakent settlement, 2022

The soils have low humus content and high carbonation, the use of mineral fertilizers on which plays a key role in increasing the yield and quality of cotton [14].

In spring before the experiments and in the main phases of cotton vegetation, soil samples were taken and basic agrochemical analyses were carried out for the content of basic nutrients and salt content in the arable and subsoil horizons.

Table 1 presents the main agrochemical parameters - humus content, mobile forms of nitrogen, phosphorus and potassium, as well as pH and sum of salts. According to results of water extract analysis, the selected soil plots were classified as weakly and medium saline with salt sum content of 0.14-0.15 and 0.45-0.51%, respectively.

Table 1 - Agrochemical parameters of soil under cotton, Atakent, spring 2022

| Sample depth, cm | Humus, % | Mobile forms, mg/kg | | | pH | Amount of salts, % |
|---|---|---|---|---|---|---|
| | | nitrogen | phosphoru s | potassium | | |
| Lightly saline background | | | | | | |
| 0-25 | 0.78 | 61.6 | 78 | 350 | 8.8 | 0.140 |
| 25-50 | 0.70 | 47.6 | 70 | 280 | 8.8 | 0.150 |
| Medium saline background | | | | | | |
| 0-25 | 0.78 | 53.2 | 78 | 380 | 8.5 | 0.450 |
| 25-50 | 0.63 | 39.2 | 75 | 360 | 8.6 | 0.510 |

The scheme of field experiments on both salinity backgrounds included the same 9 variants with different doses and ratios of fertilizers: 1. Control (without fertilizers); 2. N100P100; 3. N100K80; 4. P100K80; 5. N100P100K80; 6. N50P100K80; 7. N150P100K80; 8. N100P150K80; 9. N100P100K120; Ammonium nitrate (34%), double superphosphate (45%) and potassium sulfate (51%) were used as fertilizers, which were applied once before sowing the crops by deep soil loosening.

Yields were counted on a unit-by-unit basis with data processing using the method of analysis of variance according to Dospekhov [15].

Analytical studies of selected samples were carried out according to generally accepted methods [16]. The humus content in soil samples was determined by the Tyurin method, total nitrogen - by the Kjeldahl method, hydrolyzable nitrogen - by the Tyurin-Kononova method, and mobile phosphorus and potassium - by the Machigin method.

Regression analysis with stepwise exclusion of insignificant variables (P>0.05) was used to model the effect of soil nutrients, fertilizers and salinity on cotton yield, and the consistency of the model was assessed by multiple correlation coefficient ($R_2$).

A half regression model was used to capture the influence and interaction of factors [17]:

$$Y = a_0 + a_1N_t^{0,5} + a_2N_t + a_3P_t^{0,5} + a_4P_t + a_5K_t^{0,5} + a_6K_t + a_7S^{0,5} + a_8S + a_9(N_tP_t)^{0,5} + a_{10}(N_tK_t)^{0,5} + a_{11}(N_tS)^{0,5} + a_{12}(P_tK_t)^{0,5} + a_{13}(P_tS)^{0,5} + a_{14}(K_tS)^{0,5}; \quad (1)$$

here:

Y – is the resulting (dependent) factor;

$a_0$ – free term reflecting the value of the resulting factor without mineral fertilizers; $a_1$, $a_2$, $a_3$, ... an - regression coefficients reflecting the effect and interaction of factors;

$N_t$, $P_t$, $K_t$ and S - independent factors studied in the experiment ($N_t$ - total stock of nitrogen and nitrogen fertilizers, $P_t$ – total stock of phosphorus and phosphorus fertilizers,, $K_t$ – total stock of potassium and potassium fertilizers, S - sum of salts, %).

## RESULTS AND DISCUSSION

Gross yield varies depending on fertilizers and soil salinity level. On slightly saline background the average yield is 5.68 t/ha, and on medium saline background - 4.68 t/ha. This indicates a decrease in yield with increasing soil salinity.

The average yield increase from fertilizers compared to the control (without fertilizers) on a slightly saline background is on average 32.4%, and on a medium saline background - 37.6%. This shows that fertilizers are effective on both backgrounds, but their effect is more pronounced on medium saline soils.

In slightly saline background, the maximum yield (6.49 t/ha) was achieved with application of N150P100K80, which gave an increase of 51.4% to the control. The lowest increment (17.5%) was observed at application of P100K80, which demonstrates the relatively low efficiency of phosphorus and potassium without nitrogen. The complex fertilizer N100P100K80 gave a gain of 39.0%. On average, fertilizers increased yield by 32.4% compared to the control (figure 2).

In medium saline background the maximum yield (5.41 t/ha) was at N150P100K80, providing 59.1% growth. The lowest growth (13.8%) was observed at P100K80, which shows the weak influence of phosphorus-potassium nutrition without nitrogen. The full combination of fertilizer N100P100K80 gave an increase of 51.2%, with a decrease in yield from salinity by 13.8%.

On average, fertilizer increased yield by 37.6%, but the yield reduction due to salinity was 23.2% (figure 2).

Reduction of gross yield on medium saline background in comparison with weakly saline background is on average 17.6%.

The regression analysis allowed us to obtain the following mathematical model:

$$Y = 58,22 - 3,81N_t^{0,5} - 1,63\,K_t^{0,5} + 0,12\,(N_tK_t)^{0,5} - 0,26NS^{0,5};\ R=0,940 \qquad (2)$$

As can be seen from equation (2), an increase in total soil N (Nt) and potassium (Kt) reduces the resulting factor - (Y-yield), with their combined action partially compensating for this effect, but the interaction of total soil N and fertilizer with salt (S) also reduces (Y), and the high accuracy of the model (R = 0.940) confirms its reliability.

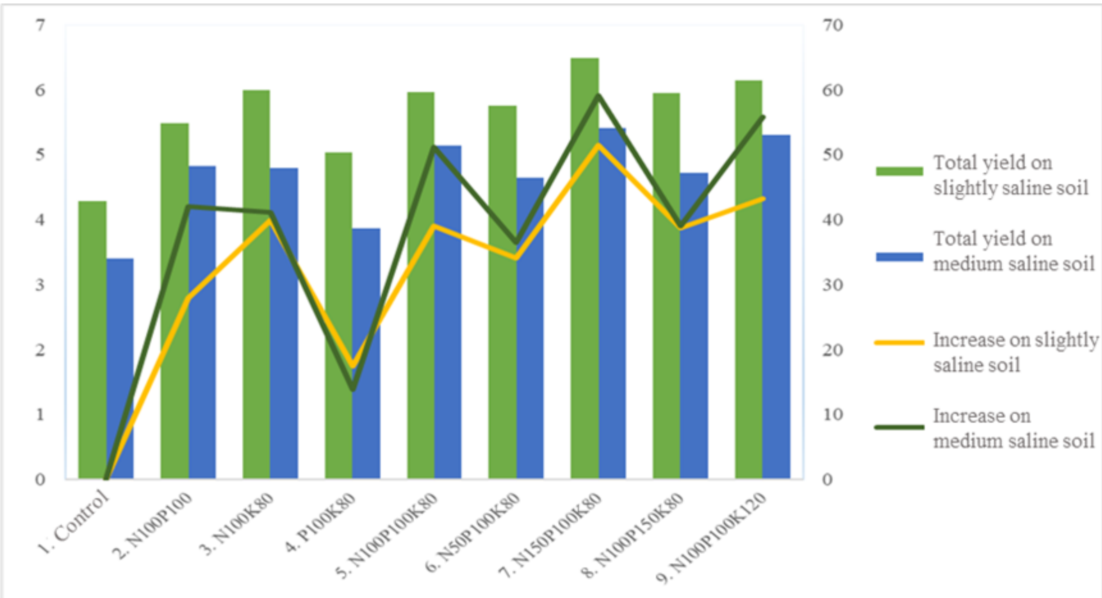


Figure 2 - Gross cotton yield on soil of different salinity levels depending on fertilizer application, 2022.

On slightly saline background, at the maximum dose of fertilizers (N150P100K80) costs amounted to 919.6 thousand tenge/ha, which allowed to obtain a gross income of 2272.2 thousand tenge/ha (table 2). In the control variant without additional fertilizer application, these indicators were 502.0 and 1501.0 thousand tenge/ha, respectively. The highest conditional net income in the amount of 1352.5 thousand tenge/ha was obtained with the application of fertilizer dose N150P100K80. However, the highest profitability (199%) was recorded in the control variant without fertilizer application. This is due to the absence of fertilizer costs in the control variant. At the same time, the cost of production in the variant with the maximum dose of fertilizers was 148.9 tg/kg, which is 26.9% higher than in the control. The highest economic efficiency was achieved when applying the dose of fertilizers (N150P100K80), which increased income by 353.5 thousand tenge/ha compared to the control. In the medium saline background the maximum economic efficiency was achieved at the applying of fertilizers N100P150K80. Gross income in this case amounted to 1892.1 thousand tenge/ha, which is 702.6 thousand tenge/ha more than in the control variant.

Table 2 - Economic indicators of cotton production on different salinity backgrounds depending on fertilizers, Atakent settlement, 2022.

| Fertilizer options | Total costs, thousand tenge/ha | Gross income from marketable yield, thousand tenge/ha | Net income, thousand tenge/ha | Cost price, thousand tenge/ha | Profitability, % | Economic efficiency to control, thousand tenge/ha |
|---|---|---|---|---|---|---|
| Lightly saline soil profile | | | | | | |
| 1. Control | 502.0 | 1501.0 | 999.0 | 117.0 | 199.0 | - |
| 2. N100P100 | 729.0 | 1920.4 | 1191.4 | 132.9 | 163.4 | 192.3 |
| 3. N100K80 | 778.0 | 2099.7 | 1321.7 | 129.7 | 169.9 | 322.6 |
| 4. P100K80 | 718.4 | 1763.6 | 1045.2 | 142.6 | 145.5 | 46.1 |
| 5. N100P100K80 | 849.8 | 2085.9 | 1236.1 | 142.6 | 145.5 | 237.1 |
| 6. N50P100K80 | 798.8 | 2012.8 | 1214.1 | 138.9 | 152.0 | 215.0 |
| 7. N150P100K80 | 919.6 | 2272.2 | 1352.5 | 141.7 | 147.1 | 353.5 |
| 8. N100P150K80 | 886.4 | 2083.3 | 1197.0 | 148.9 | 135.0 | 197.9 |
| 9. N100P100K120 | 907.1 | 2150.2 | 1243.2 | 147.6 | 137.1 | 244.1 |
| Medium saline soil profile | | | | | | |
| 1. Control | 450.1 | 1189.5 | 739.4 | 132.4 | 164.3 | - |
| 2. N100P100 | 686.1 | 1689.4 | 1003.2 | 142.2 | 146.2 | 263.8 |
| 3. N100K80 | 708.1 | 1679.8 | 971.7 | 147.5 | 137.2 | 232.3 |
| 4. P100K80 | 650.1 | 1353.2 | 703.1 | 168.1 | 108.2 | -36.3 |
| 5. N100P100K80 | 801.8 | 1798.0 | 996.2 | 156.1 | 124.2 | 256.8 |
| 6. N50P100K80 | 733.9 | 1623.5 | 889.6 | 158.2 | 121.2 | 150.1 |
| 7. N150P100K80 | 856.3 | 1892.1 | 1035.8 | 158.4 | 121.0 | 296.4 |
| 8. N100P150K80 | 814.8 | 1653.5 | 838.8 | 172.5 | 102.9 | 99.3 |
| 9. N100P100K120 | 857.7 | 1853.6 | 995.9 | 162.0 | 116.1 | 256.5 |

This heatmap represents the correlation matrix of various parameters (figure 3). The color scale indicates the strength and direction of correlations, with blue shades representing positive correlations and red shades representing negative correlations. NPK shows a strong positive correlation with N (0.63), P (0.73) and K (0.66), indicating these nutrients are often applied together. Yield has a positive correlation with NPK (0.55) but a negative correlation with S.S (-0.65), suggesting soil salinity negatively impacts yield. Dev negatively correlates with Yield (-0.71) and K (-0.60), implying higher salinity hinders development.

Strong positive correlations exist between Str, on the one side and Mat and Length (Len) (above 0.9) - on the other side, indicating that these traits are closely linked.

Mic has moderate to strong negative correlations with Str (-0.77), and Mat (-0.76), meaning higher Mic values are associated with lower values in these traits.

Extremely strong negative correlation between M.N and Str (-0.99) indicate that these traits are almost perfectly inversely related.

Overall, the data suggests that nutrient management and soil salinity significantly influence yield and development, while structural and maturity traits are closely related.

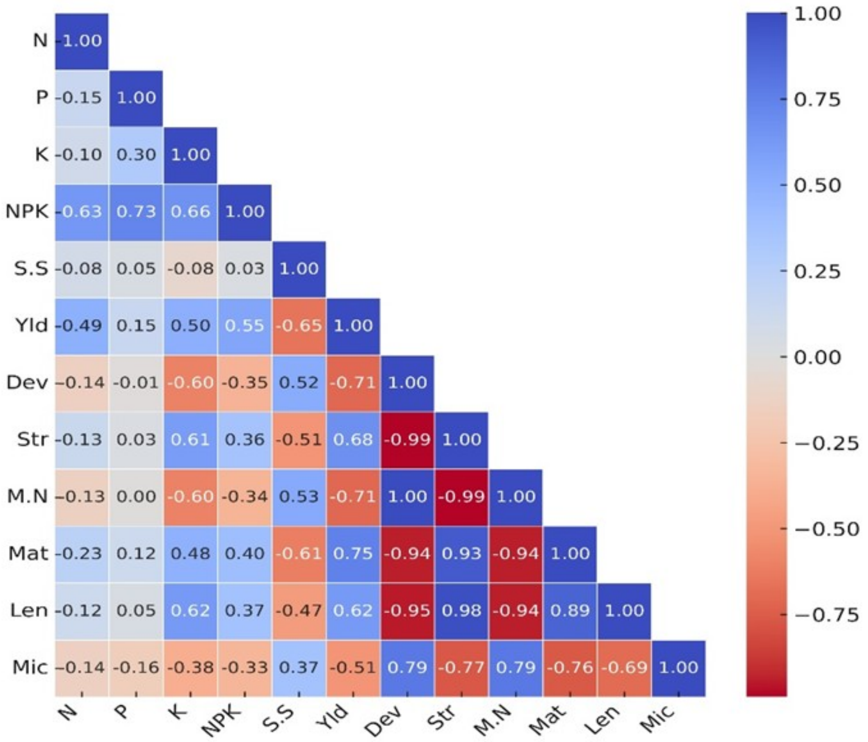


Figure 3 - Correlation matrix of pairwise dependencies of qualitative indicators of cotton fiber from the studied factors, Atakent settlement, 2022.

| | N | P | K | NPK | S.S | Yld | Dev | Str | M.N | Mat | Len | Mic |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | 1.00 | | | | | | | | | | | |
| P | -0.15 | 1.00 | | | | | | | | | | |
| K | -0.10 | 0.30 | 1.00 | | | | | | | | | |
| NPK | 0.63 | 0.73 | 0.66 | 1.00 | | | | | | | | |
| S.S | -0.08 | 0.05 | -0.08 | 0.03 | 1.00 | | | | | | | |
| Yld | 0.49 | 0.15 | 0.50 | 0.55 | -0.65 | 1.00 | | | | | | |
| Dev | -0.14 | -0.01 | -0.60 | -0.35 | 0.52 | -0.71 | 1.00 | | | | | |
| Str | -0.13 | 0.03 | 0.61 | 0.36 | -0.51 | 0.68 | -0.99 | 1.00 | | | | |
| M.N | -0.13 | 0.00 | -0.60 | -0.34 | 0.53 | -0.71 | 1.00 | -0.99 | 1.00 | | | |
| Mat | -0.23 | 0.12 | 0.48 | 0.40 | -0.61 | 0.75 | -0.94 | 0.93 | -0.94 | 1.00 | | |
| Len | -0.12 | 0.05 | 0.62 | 0.37 | -0.47 | 0.62 | -0.95 | 0.98 | -0.94 | 0.89 | 1.00 | |
| Mic | -0.14 | -0.16 | -0.38 | -0.33 | 0.37 | -0.51 | 0.79 | -0.77 | 0.79 | -0.76 | -0.69 | 1.00 |

Nitrogen-N; Phosphorus-P; Potassium-K; Salt sum, - S.S; gross yield, - Yld; instrument reading in mm of water column, - Dev; fiber breaking load, - Str; fiber metric number, - M.N; fiber maturity factor, - Mat; fiber breaking length, - Len; microneur, Mic.

CONCLUSION

The results of the study showed that cotton gross yield depends on the type of fertilizers and soil salinity level. The average yield on slightly saline background was 5.88 t/ha, while on medium saline background it decreased to 4.80 t/ha, which confirms the negative effect of salinity on plant productivity.

Fertilizer application increased yield at both salinity levels. On average, the yield increase compared to the control was 37.05% on slightly saline background and 41.15% on medium saline background, which indicates high efficiency of fertilizers. The highest yield was obtained when fertilizer N150P100K80 was applied on both backgrounds, and the lowest yield increase was observed when only phosphorus-potassium fertilizers were used.

Regression analysis showed that increasing nitrogen (Nt) and potassium (Kt) stocks decreased yield (Y), partially offset by their interaction, while nitrogen combined with salts (S) also decreased (Y), with high model accuracy (R = 0.940).

Economic efficiency of fertilizers also varied depending on their composition. On a slightly saline background, the maximum net income (1352.5 thousand tenge/ha) was achieved with the application of N150P100K80. In conditions of medium saline background, the most profitable option was the application of N100P150K80, which provided gross income of 1892.1 thousand tenge/ha and conditionally net income of 1035.8 thousand tenge/ha. Variant N100P100K80 on medium saline background was economically inexpedient, demonstrating negative economic efficiency (-36.32 thousand tenge/ha to control).

Correlation analysis revealed a positive effect of nitrogen and potassium on yield, while phosphorus had a less pronounced effect. Soil salinity was negatively correlated with yield as well as with the strength characteristics of cotton fiber, reducing its breaking load and metric number.

Thus, the results of the study confirm that the use of complex fertilizers with increased content of nitrogen and potassium is the most effective way to increase the yield and economic profitability of cotton cultivation in saline soils.

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## ТҮРКІСТАН ОБЛЫСЫНЫҢ ӘРТҮРЛІ ТҰЗДАНУ ДЕҢГЕЙІНДЕГІ СҰР ТОПЫРАҚТАРЫНДА МИНЕРАЛДЫ ТЫҢАЙТҚЫШТАРДЫҢ МАҚТА ӨНІМДІЛІГІНЕ ӘСЕРІН МАТЕМАТИКАЛЫҚ БОЛЖАУ

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Қазақстанның оңтүстік өңірлерінде топырақтың тұздану мәселесі мақта өндірісі үшін негізгі шектеуші факторлардың бірі болып табылады. Зерттеулерге сәйкес, құрамында азот, фосфор және калий бар минералды тыңайтқыштарды ұтымды пайдалану мақта-талшық өнімділігін арттырып, оның сапалық көрсеткіштерін жақсартады. Зерттеудің мақсаты - топырақтың тұздану деңгейі мен енгізілген тыңайтқыштардың мөлшеріне байланысты мақта-талшық өнімділігі мен сапасын болжау үшін математикалық модельдер әзірлеу. Минералды тыңайтқыштардың әртүрлі тұздану дәрежесіндегі сұр топырақтарда мақта өнімділігіне әсерін зерттеу мақсатында жүргізілген далалық тәжірибелер үшін Түркістан облысы, Мақтаарал ауданы, «Сабыр» шаруа қожалығының жер телімдері таңдап алынды. Биомассаның жинақталу динамикасын зерттеу мақсатында биометриялық зерттеулер жүргізіліп, өсімдік үлгілері алынды. Таңдап алынған үлгілерге аналитикалық зерттеулер жалпы қабылданған әдістемелерге сәйкес жүргізілді. Мақалада Түркістан облысының тұзданған сұр топырақтарында суармалы жағдайда жүргізілген минералды тыңайтқыштардың мақта өнімділігіне әсерін зерттеу бойынша далалық тәжірибелердің нәтижелері келтірілген. Зерттеу нәтижелері тыңайтқыштардың топырақтың тұздану деңгейіне қарамастан өсімдіктердің өнімділігін арттыратынын көрсетті, алайда олардың тиімділігі әлсіз тұзданған топырақта айқынырақ байқалды. Ең жоғары өнім (6,49 т/га) әлсіз тұзданған сұр топырақта N150P100K80 енгізілгенде алынды, ал орташа тұзданған топырақта (5,41 т/га) – осы тыңайтқыш құрамын қолданғанда байқалды. Ең төменгі өнімділік өсімі екі түрлі тұздану деңгейінде де фосфор-калий тыңайтқыштарын (P100K80) қолданғанда анықталды. Корреляциялық талдау калиймен қоректену мен талшық сапасы арасында тығыз байланыс бар екенін көрсетті (r = 0,38-0,62). Алайда калий мөлшерінің артуы талшықтың миллиметрлік су бағанында өлшенетін көрсеткішіне (r = -0,60), метрлік нөміріне (r = -0,60) және микронейріне (r = -0,38) теріс әсер етті, бірақ үзілу жүктемесін (r = 0,61), пісу коэффициентін (r = 0,48) және талшықтың үзілу ұзындығын (r = 0,62) жақсартты. Талшық сапасының өзгерістері топырақтың жырту қабатындағы тұздардың жалпы мөлшерімен де оң байланысқа ие болды (r = 0,37-0,61). Зерттеу нәтижелері минералды тыңайтқыштарды қолдану топырақтың тұздану деңгейіне қарамастан мақта өнімділігін арттыратынын көрсетті, бірақ олардың тиімділігі әлсіз тұзданған сұр топырақтарда жоғары болды. Ең жоғары өнімділік (6,49 т/га) N150P100K80 тыңайтқышын енгізу кезінде тіркелді, ал орташа тұзданған топырақта дәл осы нұсқа 5,41 т/га өнім берді. Экономикалық жағынан ең тиімді нұсқа азот пен калий мөлшері жоғары тыңайтқыштарды қолдану болып табылды, бұл олардың тұзданған топырақтарда мақта өнімділігін арттырудағы маңызды рөлін растайды.

*Түйінді сөздер*: топырақтың тұздануы, мақта, өнімділік, экономикалық тиімділік, талшық сапасы.

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МАТЕМАТИЧЕСКИЙ ПРОГНОЗ ВЛИЯНИЯ МИНЕРАЛЬНЫХ УДОБРЕНИЙ НА ПРОДУКТИВНОСТЬ ХЛОПЧАТНИКА НА СЕРОЗЕМАХ РАЗНОЙ СТЕПЕНИ ЗАСОЛЕНИЯ В УСЛОВИЯХ ТУРКЕСТАНСКОЙ ОБЛАСТИ

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Проблема засоления почв в южных регионах Казахстана является одной из основных лимитирующих факторов для производства хлопка, при этом рациональное использование удобрений способствует повышению урожайности и улучшению качественных показателей хлопка-сырца. Целью работы является разработка моделирования влияния уровня засоления почвы и доз внесенных удобрений на урожайность и качество хлопка-сырца. Полевые опыты с хлопчатником проведены на сероземах, засоленных в разной степени, на производственных полях крестьянского хозяйства «Сабыр», Мактааральского района, Туркестанской области. Математическая обработка урожайных данных и анализ почвенных образцов проведены согласно общепринятым методикам. Экспериментально установлено, что удобрения повышают продуктивность хлопчатника независимо от уровня засоления почвы, однако их эффективность более выражена на слабозасоленной почве. Максимальный урожай (6,49 т/га) на слабозасоленном сероземе достигнут при внесении N150P100K80, а на среднезасоленной почве (5,41 т/га) – при тех же дозах удобрений. Наименьший прирост урожайности на обоих фонах засоленности почвы наблюдался при применении фосфорно-калийных удобрений - P100K80. Регрессионный анализ выявил, что увеличение суммарных запасов азота ($N_t$) и калия ($K_t$) снижает результирующий фактор (Y), однако их совместное действие частично компенсирует этот эффект, в то время как взаимодействие азота с солями ($N_tS$) также уменьшает Y, а высокая точность модели (R = 0,940) подтверждает ее надежность. Корреляционный анализ показал достаточно тесную зависимость между калийным питанием и качеством волокна (r = 0,38-0,62), при этом увеличение калия ухудшило показание прибора в миллиметрах водного столба (r = -0,60), номер метрический волокна (r = -0,60) и микронейр (r = -0,38), но улучшило разрывную нагрузку (r = 0,61), коэффициент зрелости (r = 0,48) и разрывную длину волокна (r = 0,62). Изменения показателей качества волокна также имели достаточно положительную крепкую связь с суммой солей с пахотного слоя почвы (r = 0,37-0,61). Результаты исследования показали, что на высокообеспеченном подвижным фосфором сероземе азот и калий играют ключевую роль в повышении урожайности хлопчатника, обеспечивая его величину на слабозасоленных сероземах до 6,49 т/га (N150P100K80), а на среднезасоленных – до 5,41 т/га. Экономическая эффективность удобрений варьировалась: на слабозасоленном фоне максимальный условно-чистый доход составил 1352,5 тыс. тенге/га при внесении N150P100K80, а в условиях среднезасоленного фона наиболее эффективным оказалось применение N100P150K80, обеспечившее условно-чистый доход в 1035,8 тыс. тенге/га.

*Ключевые слова:* засоленность почвы, урожайность хлопчатника, экономическая эффективность, качество волокна.

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