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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

**THE EFFECT OF PLANT DENSITY AND MINERAL
FERTILIZERS ON THE PRODUCTIVITY AND QUALITY
OF SUMMER CROPS OF THE COTTON PLANT**

Specialty: **3103.07-Plant growing**
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Applicant: **Nurlana Akif Guliyeva**

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The dissertation work was performed at the Agrochemistry Laboratory of the Research Institute of Plant Protection and Technical Plants.

Scientific supervisor: - doctor of agrarian sciences, professor
Hasanali Asad Aslanov

Official opponents: - Correspondent member of ANAS, doctor of agrarian sciences, professor

Magsud Rustam Gurbanov

- doctor of philosophy in agrarian sciences, associate professor

Khuraman Tofiq Abbasova

- doctor of philosophy in agrarian sciences

Parvana Mahmud Mammadova

Dissertation Council FD 1.29 of the Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at the Research Institute of Crop Husbandry of the Ministry of Agriculture of the Republic of Azerbaijan.

Chairman of the Dissertation Council: doctor of agrarian sciences, professor

_____ **Jalal Shamil Mammadov**

Scientific secretary of the Dissertation Council: doctor of philosophy in agrarian sciences, associate professor

 **Sevda Kamal Hajiyeva**

Chairman of the scientific seminar: doctor of agrarian sciences, associate professor

 **Islam Akif Bayahmadov**

GENERAL DESCRIPTION OF THE RESEARCH

Relevance and degree of completion of the topic. "The State Program for 2017-2022 on development of cotton growing in the Republic of Azerbaijan" approved by the order of the President of the Republic of Azerbaijan I.H.Aliyev dated July 13, 2017, was aimed at strengthening state support for cotton growing and solving problems in this area. As a result of the implementation of the State Program, the production of raw cotton in 2022 will reach 500,000 tons¹.

Cotton growing is one of the areas of great importance in providing permanent employment to the rural population and strengthening the fodder base of livestock. Fiber, the main product of cotton, is an invaluable raw material for the textile industry, so this plant is of strategic importance, as it is always in great demand in the world market. Regular comparison of the purchase price of cotton in the world market with grain and fuel shows that this product is important as a valuable, wide-ranging universal technical plant. Lack of use of quality seed material and fast-growing local varieties, water, organic-mineral fertilizers, and non-compliance with agro-technical measures are the main factors that lead to a decrease in productivity.

Based on numerous studies, it has been determined that due to the soil and climatic conditions of our republic, it is possible to get two products from one field in a year. The average annual indicators of the useful temperature, which is a key factor in the climatic conditions of the regions, are considered sufficient to harvest twice from one field in a year. The scientific study of harvesting two crops a year from a single area is very relevant in the context of global climate change and the lack of arable land in our country.

So, replanting of cotton after barley harvest, determination of the effective plant density, and mineral fertilizer norms ensuring high-quality products from the fields are topical and is one of the

¹ "State Program for the development of cotton cultivation in the Republic of Azerbaijan for 2017-2022" July 13, 2017 (in Azerbaijani).

problems of great scientific and practical importance².

The purpose and tasks of the research. The main purpose of the research was to determine the effective plant density (planting scheme) and mineral fertilizer norms that ensure high-quality production from cotton planted after barley harvest on gray-brown (chestnut) soils in the Ganja-Gazakh region.

To achieve the goal of the research, the following tasks have been set:

- study of soil and ecological conditions of the research area;
- study of agrochemical properties of the experimental lands;
- study of the effect of plant density and mineral fertilizer norms on the growth and development of cotton by phases;
- study of the effect of plant density and mineral fertilizer norms on cotton productivity and quality;
- study of the effect of plant density and mineral fertilizer norms on changes in nitrogen, phosphorus, and potassium in aboveground parts of cotton throughout developmental phases;
- study of the effect of plant density and mineral fertilizer norms on the above-ground mass, fiber, and grain yield of cotton and the uptaking nutrients from the soil;
- study of the effect of plant density and mineral fertilizer norms on the uptaking nutrients from fertilizers;
- determination of economic efficiency.

Research methods. In soil samples taken: in pH meter, total humus was determined by the I.V. Tyurin's method, absorbed ammonia by the D.P.Konev's method, nitrate nitrogen by the Grandval-Lyaju's method, total nitrogen, total phosphorus by the K.E. Ginzburg's and the G.M. Sheglova's methods, mobile phosphorus by the B.P. Machigin's method, total potassium by the Smith's method, exchangeable potassium was determined in the flame photometer by the P.B. Protasov's method.

² Guliyeva, N.A., Gahramanova, R.F. Cotton growing is one of the most profitable sectors of the Azerbaijani economy // International Scientific Conference "Actual Problems of Modern Natural and Economic Sciences" at Ganja State University-Ganja: GSU, - 04-05 May 2018, - pp.314-316 (in Azerbaijani).

Analysis of technological properties of cotton fiber was carried out in accordance with generally accepted methodological indicators in dynamometer DSH-3M and MSHU-1, MPRSH-1, MPV-1, PVS-1 devices.

Processing of the results of the field experiments, determination of the total leaf surface area, calculation of the productivity, accuracy of the experiment, mathematical analysis of the correlation relations, and economic efficiency were performed by B.A. Dospekhov, V.N. Peregudov, P.N. Konstantinov and N.N. Baranov methods.

Main points presented to the defense of the dissertation:

- providing the research area with nutrients;
- growth and development of the cotton plant throughout phases depending on plant density and mineral fertilizer norms;
 - cotton productivity depending on plant density and mineral fertilizer norms;
 - economic value indicators of the cotton plant and technological quality of fiber depending on plant density and mineral fertilizer norms;
 - changes in total nitrogen, phosphorus, and potassium depending on plant density and mineral fertilizer norms throughout plant developmental phases;
 - uptaking nutrients from soil depending on plant density and mineral fertilizer norms;
 - economic efficiency.

Scientific novelty of the research. For the first time in the research, the effective plant density, mineral fertilizer norms, which increase the productivity and quality indicators of the Ganja-110 variety of cotton planted after barley harvest on irrigated gray-brown (chestnut) soils of the Ganja-Gazakh region, were determined.

Theoretical and practical significance of the research. In summer plantings of cotton, plant density and mineral fertilizer norms have a significant impact on productivity and quality of the production. The highest net profit was 899.9 AZN/ ha at a density of 111,000 plants, mineral fertilizers at the rate of N₉₀P₁₂₀K₉₀, and profitability ratio was 97.0%.

Approbation and application of the work. The results of the research were presented at the Scientific and Technical Council of the Agrotechnical Department of the Azerbaijan Plant Protection and Technical Plants Research Institute and the Scientific Council of the Institute (2017-2020), at the International Scientific Conference "Actual Problems of Modern Natural and Economic Sciences" at Ganja State University (04- 05 May, 2018, Ganja), at the Republican Scientific Conference "Development of ecologically clean agriculture in Azerbaijan" at the Azerbaijan State Agrarian University (October 29, 2019, Ganja), At the XXXIII International Scientific-Practical Conference "Eurasia Science" in the Russian Federation (November 15, 2020, Moscow), at the at the International Scientific-Practical Conference "Key Problems of Quality Assurance in University-Industrial Relations" at the Azerbaijan Technological University (December 25-26, 2020), at the scientific-methodical seminar of the Agricultural Research Institute of Ministry of Agriculture (2021).

The results of field experiments were applied in 2020 on an area of 5 hectares in the Alpout village of the Goranboy region. As a result of the application, the raw cotton yield at a density of 111,000 plants and in the rate of mineral fertilizers N₉₀ P₁₂₀ K₉₀ was 26.5 cwt/ ha, and the net profit was 817.4 AZN/ ha.

Name of the organization where the dissertation was performed. The dissertation work was carried out at the former Azerbaijan Research Institute of Cotton Growing of the Ministry of Agriculture of the Republic of Azerbaijan (now Research Institute of Plant Protection and Technical Plants).

Total volume of the dissertation in characters with an indication of the separate volumes of the structural units. The dissertation consists of an introduction, five chapters, results, recommendations for producers, a list of 175 references, and appendices. There are 7 figures, 12 tables, and appendices in the dissertation. The introduction consists of 4 pages with 8259 characters, the first chapter- 23 pages with 51,831 characters, the second chapter- 40 pages with 90424 characters, the third chapter-17 pages with 32,777 characters, the fourth chapter-31 pages with

42,109 characters, the fifth chapter-32 pages with 46654 characters, results-2 pages with 2578 characters, recommendations for producers-1 page with 884 characters and a list of 175 references -20 pages with 36,021 characters. The volume of the dissertation consists of 178 pages of computer typing, the total volume consists of 312,153 characters (228,862 characters excluding figures, tables, graphs, appendices, and a list of references).

CONTENT OF THE WORK

The introduction presents the actuality of the topic, its importance for science and practice.

Chapter I - "Literature Summary" presents the impact of plant density, mineral and organic fertilizers, irrigation, and other agrotechnical measures on soil fertility, cotton productivity, valuable economic indicators, technological quality of fiber, etc. in research conducted in our country and abroad by many authors. Therefore, there is a need to conduct research on the development of effective plant density and mineral fertilizer norms that ensure high-quality production from cotton planted after barley harvest on gray-brown (chestnut) soils.

Chapter II-"The importance of cotton in the national economy, its botanical description, and agrotechnics" includes various products from cotton (*Gossypium hirsutum* L.), its strategic importance, botanical description, and biological characteristics, demand for soil, water, and nutrients, and so on.

Chapter III describes "Soil and climatic conditions of the research area, research object, methodology and agrochemical properties of the soils of the experimental area". In order to determine the plant density and mineral fertilizer norms of cotton after barley harvest, the research was conducted with the Ganja-110 cotton variety in 2017-2020 at the Ganja Regional Agrarian Science and Innovation Center of the Ministry of Agriculture of the Republic

of Azerbaijan.³

Field experiments with 2 factors were set in the following scheme after the autumn barley harvest in June:

Factor A -planting scheme: 1. density of 166,000 plants (60x10x1 cm); 2. 111,000 plants (60x15x1 cm); 3. 83,000 plants (60x20x1 cm).

Factor B- mineral fertilizer norms: 1. Control (fertilizer-free); 2. P₁₂₀K₉₀ (Background) 3. Background + N₆₀; 4. Background + N₉₀; 5. Background + N₁₂₀.

Field experiments were performed in 3 repetitions, with a total area of 120 m² (40x3 m) of each variant, 60 kg of seeds per hectare with 3 plant densities (166,000 plants (60x10x1 cm); 111,000 (60x15x1 cm) and 83,000 (60x20x1 cm)) were sowed using row-sowing and then dispersed according to the scheme. Mineral fertilizers in the form of nitrogen-ammonium nitrate (34.7%), phosphorus-simple superphosphate (18.7%), and potassium-potassium sulfate (46%), 70% of phosphorus and potassium fertilizers were applied to the soil before sowing, and cultivation was carried out at a depth of 10-12 cm, the remaining 30% was given in the feeding, and nitrogen was given twice in the form of feeding (before budding and flowering). Phenological observations were carried out on 25 plants in 2 repetitions, the height of the stem and the number of reproductive organs were determined. The economic efficiency of the application of mineral fertilizers was calculated based on the cost of additional raw cotton products.

Thus, our agrochemical analysis shows that due to the gradation accepted in our republic (Gulahmedov A.N., Akhundov F.H., Ibrahimov S.Z., 1980) these lands are poorly provided with the appropriated forms of nutrients.⁴

³ Guliyeva, N.A. Establishment of sowing schemes and fertilization norms for summer plantings of cotton// Collection of articles of EURASIASCIENCE XXXIII international scientific and practical conference. - Moscow: Aktualnost. RF, - 15 November 2020, - pp.12-14 (in Russian)

⁴ Guliyeva, N.A. Formation of the main soil types in the western part of Azerbaijan depending on soil and ecological conditions // Bulletin of Science and Practice. Scientific

Chapter IV is devoted to "The effect of plant density and mineral fertilizer norms on the growth, development, productivity, quality and economic efficiency of cotton."

In the planting scheme of 60x10 cm, the highest area of the leaf surface was observed in the N₉₀ + Background variant. Thus, it was 321.3-326.4 cm² in the budding phase, 1160.5-1176.7 cm² in the flowering phase, and 2180.5-2205.2 cm² in the full ripeness phase. The leaf surface area at the rate of 120 kg/ha of nitrogen fertilizer with the Background amounted to 291.5-295.7; 1055.4-1064.7 and 1988.2-1995.1 cm², respectively.

At a density of 111,000 plants, in the planting scheme of 60x15 cm, the highest leaf surface area was observed in the N₉₀ + Background variant, 350.3-375.1 cm² in the budding phase, 1310.5-1337.0 cm² in the flowering phase, and 2460.0-2490.6 cm² in the full ripeness phase.

At the rate of 120 kg/ha of nitrogen fertilizer together with the Background, the leaf surface area amounted to 325.7-338.2, 1170.7-1185.4, and 2210.3-2240.5 cm², respectively.

At a plant density of 83,000 plants, in the planting scheme of 60x20 cm, the total leaf surface area increased significantly compared to both plant densities, depending on the nutrient area. The highest leaf surface area was observed in N₉₀+Background variant, 366.6-383.8 cm² in the budding phase, 1330.7-1345.5 cm² in the flowering phase, and 2501.2-2523.6 cm² in the full ripeness phase. The leaf surface area at the rate of 120 kg/ha of nitrogen fertilizer with the Background was 333.5-344.6; 1188.3-1196.2, and 2238.4-2248.0 cm², respectively⁵.

We have also studied the effect of plant density and mineral fertilizer norms on the height and development of cotton plants during growth phases. At a density of 166000 plants, growth and development indicators of cotton increased due to the effect of

electronic journal, ISSN 2414-2948, - 2020. V.6. No12 (61st edition), - pp.46-58 (in Russian)

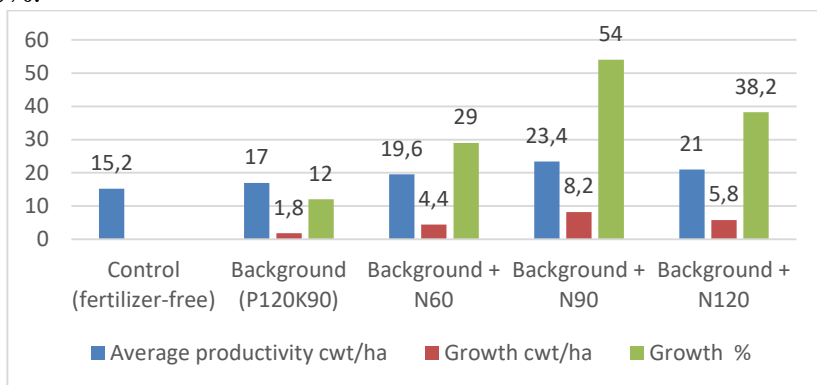
⁵ Guliyeva, N.A. The effect of plant density and mineral fertilizer norms on the total leaf surface of cotton in multiple cropping // - Ganja: Azerbaijan Technological University, "Scientific News" bulletin, - 2021, No1/34, - pp.139-143 (in Azerbaijani)

mineral fertilizers. Thus, in the Background ($P_{120}K_{90}$) variant, the plant height was 69.2-73.6 cm in the full ripeness phase, sympodial branches per plant-5.4-6.0, cotton bolls -5.3-5.7, open cotton bolls - 3.0-3.4, surface and root mass of a plant (dry mass in the air) was 63.4-65.6 and 31.5-33.7 g.

At a density of 111,000 plants with a planting scheme of 60x15 cm, growth and development indicators of cotton increased due to the effect of mineral fertilizers. Thus, in the budding phase of the Background variant ($P_{120}K_{90}$), the height of the plant was 28.8-30.5 cm, sympodial branches -4.2-4.5, buds -3.5-3.8, in the flowering phase the height was 43.8-46.3 cm, sympodial branches per plant - 5.3-5.8, buds -5.0-5.4, cotton bolls -3.8-4.1, in the full ripeness phase, the height was 76.4-79.6 cm, sympodial branches -6.2-6.4, cotton bolls - 5.7-6.1, open cotton bolls -3.8-4.1, the mass of above-ground parts and roots (dry mass in the air)- 68.6-71.7 and 33.8-36.3 g.

Similar results were obtained at a density of 83,000 plants, in the planting scheme of 60x20 cm. Plant density and mineral fertilizers have a significant impact on the height and development of the cotton plant, which ultimately increases the raw cotton yield. At the end of the vegetation, in the density of 166,000 plants, in the planting scheme of 60x10 cm, due to the effect of fertilizers, the height of one plant was 3.1-13.7 cm, sympodial branches - 0.5-3.2, cotton bolls-0.4-3.0, the number of open cotton bolls- 0.4-1.6, the mass of above-ground parts -5.3-25.3 g, root mass -3.1-11.9 g, at a density of 111,000 plants, in the planting scheme of 60x15 cm, the height was 3.8-14.0, sympodial branches- 0.6-3.3, cotton bolls- 0.5-3.2, open cotton bolls -0.6-1.7, the mass of above-ground parts - 6.4-25.1 g, the root mass -3.5-13.2 g, in 83,000 plants density, in the planting scheme of 60x20 cm, the height was 4.2-15.2 cm, sympodial branches -0.7-3.4, cotton bolls -0.6-3.4, open cotton bolls- 0.8-1.9, the mass of above-ground parts - 7.4-26.2 g, the root mass -3.44,4-15.5g. The highest indicators of all three plant densities were observed in the Background + N_{90} variant. At a density of 83,000 plants, in the planting scheme of 60x20 cm, more height and development indicators were formed per plant.

While the three-year average productivity of cotton at a density of 166,000 plants (Figure 1) was 15.2 cwt/ha in the control (fertilizer-free) variant, it was 17.0 cwt/ha (1.8 cwt/ha or 12.0% more than the control) in the Background (P₁₂₀K₉₀) variant, thus, the increase compared to the control was 1.8 cwt/ha or 12.0%. These indicators were 19.6 cwt/ha in the Background+ N₆₀, the increase compared to the control was 4.4 cwt/ha or 29.0%. The highest raw cotton product 23.4 cwt/ha was observed in the Background + N₉₀ variant, the increase compared to the control was 8.2 cwt/ha or 54.0%.



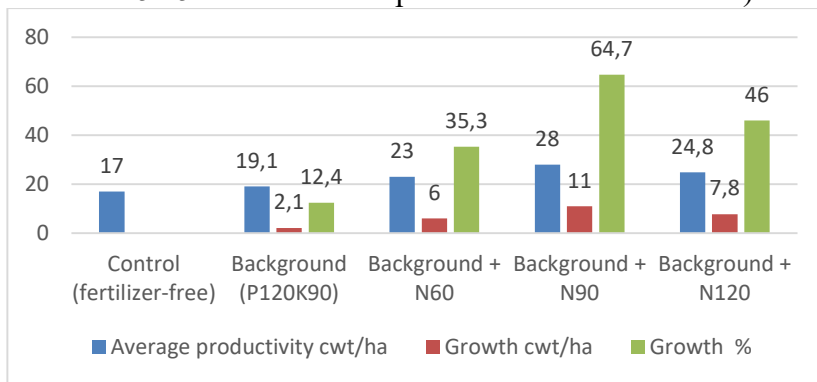
E = 0.32-0.41 cwt/ha, P = 1.60-2.28%

Figure 1. The effect of plant density and mineral fertilizers on cotton productivity (166,000 plants/ha, three-year average):

1. Control (fertilizer-free);
2. Background (P₁₂₀K₉₀);
3. Background+N₆₀; 4. Background+N₉₀; 5. Background+N₁₂₀.

While the 3-year average productivity of raw cotton at a density of 111,000 plants (Figure 2) was 17.0 cwt/ha in the control variant, it was 19.1 cwt/ha (2.1 cwt/ha or 12.4% more than the control) in the Background (P₁₂₀K₉₀), the increase was 2.1 cwt/ha or 12.4% compared to the control. These indicators were 23.0 cwt/ha in Background+N₆₀, the increase compared to the control was 6.0 cwt/ha or 35.3%. The highest raw cotton product was 28.0 cwt/ha in Background+ N₉₀, the increase compared to the control was 11.0 cwt/ha or 64.7%.

While the 3-year average productivity of cotton was 14.3 cwt/ha at a density of 83,000 plants (Figure 3) in the control variant (fertilizer-free), it was 16.0 cwt/ha in the Background (P₁₂₀K₉₀) variant, the increase compared to the control was 1.7 cwt/ha or 12.0%. The raw cotton yield was 18.3 cwt/ha (4.0 cwt/ha or 28.0% increase compared to the control) in the Background+N₆₀ variant. The highest raw cotton yield in Background+N₉₀ was 21.8 cwt/ha (7.5 cwt/ha or 52.5% increase compared to the control variant).



E = 0.36-0.73 cwt/ha, P = 1.57-3.0%

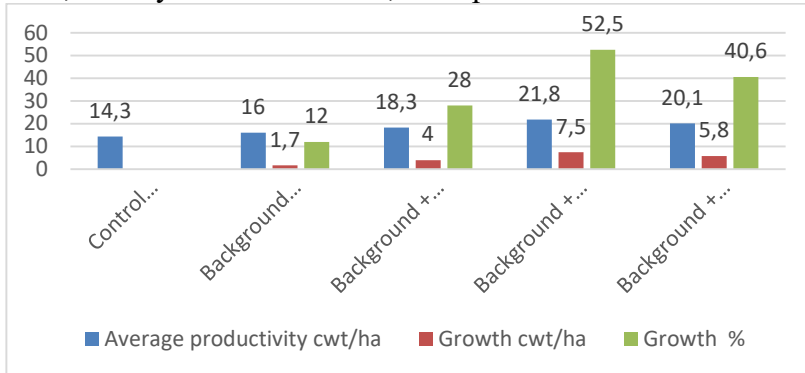
Figure 2. The effect of plant density and mineral fertilizers on cotton productivity (111,000 plants/ha, three-year average):

1. Control (fertilizer-free);
2. Background (P₁₂₀K₉₀);
3. Background+N₆₀;
4. Background+N₉₀;
5. Background+N₁₂₀.

In the irrigated gray-brown soils, more raw cotton yield was obtained than in the control variant at all three plant densities and mineral fertilizer norms. The highest raw cotton yield at a density of 166,000 plants (60x10 cm) was 23.4 cwt/ha in the Background + N₉₀ variant, the increase was 8.2 cwt/ha or 54.0% compared to the control-without fertilizer variant; 28.0 cwt/ha at a density of 111,000 plants (60x15 cm) in the Background + N₉₀ variant, the increase was 11.0 cwt/ ha or 64.7%; 21.8 cwt/ha at a density of 83,000 plants (60x20 cm) in the Background + N₉₀ variant, the increase was 7.5 cwt/ha or 52.5%. The highest raw cotton yield was obtained at a

density of 111,000 (60x15 cm) plants per hectare⁶.

In the control (fertilizer-free) variant with a plant density of 166,000 plants, the mass of 1000 seeds was 103.5-106.5 grams, the mass of raw cotton in one cotton boll - 4.8-5.1 g, fiber length- 34.8-35.0 mm, fiber yield -33.5-33.8%, fiber product - 4.70-5.31 cwt/ha.



E = 0.36-0.46 cwt/ha, P = 1.0-2.56%

Figure 3. The effect of plant density and mineral fertilizers on cotton productivity (83000 plants/ha, three-year average):

1. Control (fertilizer-free);
2. Background (P₁₂₀K₉₀);
3. Background+N₆₀;
4. Background+N₉₀;
5. Background+N₁₂₀.

The highest indicators were observed in the N₉₀ + Background variant, the mass of 1000 grains was 113.6-116.3 grams, the mass of raw cotton in one cotton boll - 5.6-5.7 grams, the fiber length - 35.6-35.7 mm, the fiber yield- 35.8-36.0%, the fiber product - 8.13-8.40 cwt/ha, increase in fiber product- 3.09-3.43 cwt/ha or 58.0-72.0%. The indicators studied in the norm of 120 kg/ha of nitrogen fertilizer together with the Background amounted to 110.2-114.8 g, 5.5-5.6 g; 35.4-35.5 mm; 35.1-35.5%; 8.13-8.40 cwt/ha; 2.19-2.32 cwt/ha or 41.0-49.0%, respectively.

⁶ Aslanov G.A., Guliyeva, N.A. The effect of plant density and inorganic fertilizers on cotton in summer plantings// Bulletin of Science and Practice. Scientific electronic journal ISSN, 2414-2948, - 2021. V.7. No3 (64th edition) - pp.58-63 (in Russian).

In the variant with a plant density of 111,000 plants, the highest indicators were in the N₉₀+Background variant. The mass of 1000 grains was 119.6-121.5 g, the mass of raw cotton in a cotton boll-5.8-6.0 g, fiber length-35.8-36.1 mm, fiber yield-36.8-37.0%, fiber product-9.31-10.62 cwt/ha, increase in fiber product-3.94-4.62 cwt/ha or 73.0-77.0%. The indicators studied at the norm of 120 kg/ha of nitrogen fertilizer together with the background amounted to 117.6-119.2 grams, 5.6-5.7 grams; 35.5-35.8 mm; 36.0-36.5%; 8.17-9.40 cwt/ha; 2.80-3.40 cwt/ha or 52.0-56.0%, respectively.

In the control (fertilizer-free) variant with the density of 83,000 plants, the mass of 1000 grains was 110.3-115.6 g, the mass of raw cotton in a cotton boll- 5.1-5.2 g, fiber length- 35.4-35.5 mm, fiber yield- 34.5-35.0%, fiber product- 4.60-5.01 cwt/ha. The highest indicators were observed in N₉₀+Background: the mass of 1000 grains was 121.8-128.7 g, the mass of raw cotton in a cotton boll - 6.0-6.2 g, fiber length- 36.1-36.2 mm, fiber yield- 37.6-38.0%, fiber product- 7.63-8.25 cwt/ha, increase in fiber product- 3.03-3.24 cwt/ha or 64.0-65.0%. The indicators studied at the rate of 120 kg/ha of nitrogen fertilizer together with the Background decreased compared to the Background + N₉₀ variant and amounted to 119.5-125.8 g, 5.8-6.0 g; 35.8-36.0 mm; 36.4-37.0%; 6.92-7.51 cwt/ha; 2.32-2.50 cwt/ha or 49.0-50.0%, respectively.

Plant density and mineral fertilizers, along with productivity, also have a significant impact on the economic performance of raw cotton^{7,8}.

At a density of 166,000 plants, due to the effect of mineral fertilizers, the mass of 1000 grains was 1.7-10.1 g, the mass of raw cotton in a cotton boll- 0.2-0.8 g, fiber length – 0.2-0.8 mm, fiber

⁷ Guliyeva, N.A. The effect of planting scheme and mineral fertilizers on the mass of 1000 grains in summer plantings// Republican Scientific Conference "Development of ecologically clean agriculture in Azerbaijan" of Azerbaijan State Agrarian University, - Ganja: ASAU, - 29 October 2019, -pp.48-53 (in Azerbaijani).

⁸ Guliyeva, N.A. The effect of plant density and fertilizers on the mass of raw cotton in a cotton boll in summer plantings // - Ganja: News Bulletin of Ganja branch of ANAS, - 2019, No.4(78), - pp.130-136 (in Azerbaijani).

yield- 0.4-2.3%, fiber product -0.50-3.43 cwt/ha, at the density of 111,000 plants, due to the effect of mineral fertilizers, the mass of 1000 grains was 4.2-11.3 g, the mass of raw cotton in a cotton boll – 0.2-0.9 g, fiber length- 0.1-0.8 mm, fiber yield- 0.6-2.7%, fiber product- 0.65-4.62 cwt/ha, at the density of 83,000 plants, due to the effect of mineral fertilizers, the mass of 1000 grains was 4.7-13.1 g, the mass of raw cotton in a cotton boll -0.2-1.0 g, fiber length- 0.1-0.7 mm, fiber yield- 0.6-3.1%, fiber product- 0.57-3.24 cwt/ha, increased compared to the control (fertilizer-free) variant. The highest fiber yield of raw cotton in the fon+N₉₀ variant was observed at a density of 111,000 plants.

The effect of plant density and mineral fertilizer norms on the technological quality, breaking load, linear density, tensile strength, and staple length of cotton fiber were also studied in our research.

While at a density of 166,000 plants, in the control variant (fertilizer-free) breaking load of raw cotton was 4.0-4.2 gg, linear density- 5280-5300 m.tex, tensile strength -21.1-22.3 gg/tex, staple length- 29/31 mm, these indicators significantly increased in Background (P₁₂₀K₉₀) and amounted to 4.1-4.3 gg, 5300-5350 m.tex, 21,7-23,0 gg/tex, and 30/32 mm, respectively. The indicators studied in the increasing norms of nitrogen fertilizers with the Background, significantly increased compared to the control (fertilizer-free), and Background variants.

The highest indicators were observed in the Background+ N₉₀: breaking load was 4.4-4.5 gg, linear density 5340-5450 m.tex, tensile strength -23.5-24.5 gg/tex, and staple length-32/34 mm. Together with the Background, at the rate of 120 kg/ha of nitrogen fertilizer, these indicators decreased compared to the Background + N₉₀ variant.

At a density of 111,000 plants, in the control variant (fertilizer-free), breaking load of raw cotton was 4.2-4.3 gg, linear density - 5430-5450 m.tex, tensile strength – 22.8-23.4 gg/tex, and staple length- 30/32 mm, in the Background (P₁₂₀K₉₀) variant, these values were 4.3-4.4 gg, 5460-5510 m.tex, 23.5-24.2 gg/tex and 31/33 mm, the indicators studied in the increasing norms of nitrogen fertilizers with the Background significantly increased compared to the control

(without fertilizers), and Background. The highest indicators were observed in the Background+N₉₀, thus, breaking load was 4.5-4.6 gg, linear density -5620-5670 m.tex, tensile strength - 25.3-26.1 gg/tex, and the staple length- 33/35 mm. At the rate of 120 kg/ha of nitrogen fertilizer together with the Background, these indicators decreased compared to the Background + N₉₀ variant and amounted to 4.4-4.5 gg, 5520-5580 m.tex; 24.3-25.1 gg / tex, and 32-34 mm, respectively.

The studied values at a density of 83,000 plants with more nutrient areas were higher in each of the variants than in both plant densities. Thus, while in the control variant, breaking load of raw cotton was 4.3-4.4 gg, linear density- 5450-5470 m.tex, tensile strength -23.4-24.1 gg/tex, and staple length- 31/33 mm, in the Background (P₁₂₀K₉₀) variant these parameters were, respectively, 4.4-4.5 gg, 5510-5550 m.teks, 24.2-25.0 gg/tex and 32/34 mm. The indicators studied in the increasing norms of nitrogen fertilizers with the Background significantly increased compared to the control (fertilizer-free) and Background variants. The highest indicators were observed in Background+N₉₀ as in other plant densities, breaking load was 4.6-4.8 gg, linear density -5640-5680 m.tex, tensile strength -26.0-27.2 gg/tex, and staple length- 34/36 mm. At the rate of 120 kg/ha of nitrogen fertilizer together with the Background, these indicators decreased compared to the Background+N₉₀ variant and amounted to 4.5-4.6 gg, 5550-5600 m.tex; 25.0-25.8 gg/ tex, and 33-35 mm, respectively⁹.

Chapter V is dedicated to "Effects of plant density and mineral fertilizer norms on total nitrogen, phosphorus and potassium in the aboveground parts of the cotton plant, the uptake of nutrients from the soil through aboveground parts, fiber and seed production, as well as nutrient absorption and economic efficiency".

It was found that plant density and mineral fertilizers cause changes in the total nitrogen, phosphorus, and potassium in dry

⁹ Guliyeva, N.A. The effect of plant density and mineral fertilizers on fiber length and fiber yield in summer plantings of cotton/ Azerbaijan Agrarian Science, - 2019, No.4, - pp.146-150 (in Azerbaijani).

matter of the aboveground mass throughout the developmental phases of the cotton plant. The highest amounts of total nitrogen, phosphorus, and potassium were observed in the budding phase, at the beginning of vegetation for all three plant densities, and decreased at the end of vegetation, at the full ripeness phase. This indicator increased compared to the control (fertilizer-free) variant at a density of 166,000 plants/ha. The highest amount of total nitrogen, phosphorus and potassium was observed in the N₉₀+Background variant. Thus, total nitrogen was 2.90-2.96%, total phosphorus - 0.71-0.76%, total potassium 2.45-2.51% in the budding phase, and 0.53-0.88, 0.28-0.33%, and 0.73-0.80%, in the full ripeness phase, respectively¹⁰.

At a density of 166,000 plants (aboveground mass, fiber, and grain yield), the highest amount of nutrients uptaken from the soil was observed in the N₉₀+Background variant: nitrogen 95.5-105.9 kg/ha, phosphorus 53.6-61.4 kg /ha, and potassium 116.2-130.2 kg/ha, the absorption coefficient was 45.0-49.6% for nitrogen, 21.4-24.8% for phosphorus, and 54.2-59.1% for potassium.

At a density of 111,000 plants/ha, the highest amount of nutrients uptaken from the soil was observed in the N₉₀+background variant: nitrogen 90.2-103.0 kg/ha, phosphorus 52.7-61.8 kg/ha and potassium 105.5-119.0 kg/ha. The absorption coefficient was 47.3-53.1% for nitrogen, 22.3-27.5% for phosphorus, and 53.0-60.0% for potassium.

At a plant density of 83,000, the highest amount of nutrients uptaken from the soil was observed in the N₉₀+Background variant: nitrogen 79.7-90.2 kg/ha, phosphorus 44.9-53.0 kg/ha, and potassium 89.3-98.7 kg/ha, absorption coefficient was 42.3-46.6% for nitrogen, 19.4-27.5% for phosphorus, and 44.1-46.8% for potassium.

The effect of plant density and mineral fertilizer norms on economic efficiency in summer plantings of cotton was also studied.

¹⁰ Guliyeva, N.A. The effect of plant density and mineral fertilizer norms on changes in total nitrogen, phosphorus, and potassium in the above-ground mass, in air dry matter of cotton plants throughout the development phases // - Ganja: Azerbaijan Technological University,, "Scientific News" bulletin, - 2022, No2/39, - pp.5-12 (in Azerbaijani).

All costs incurred in the production of mineral fertilizers and additional products were taken into account when calculating the economic efficiency. When calculating the results of the study, prices from 2020 were used (Figure 4).

Net profit was determined based on all costs incurred in the additional product and the market selling price of that product. Expenditures on mineral fertilizers at all three plant densities were 186.2-254.7 AZN/ha, depending on the variants. In the 60x10 cm planting scheme with a density of 166,000 plants, the cost of agrotechnical measures and cotton harvesting was 548.5-630.5 AZN / ha, and the combined cost of mineral fertilizers and agrotechnical measures - 548.5-874.1 AZN / ha, net profit from gross output-439.5-646.9 AZN / ha, profitability ranged from 46.0 to 80.0%. The highest net profit 646.9 AZN/ha was obtained at a density of 166,000 plants in the N₉₀P₁₂₀K₉₀ variant, the level of profitability was 74.0%.

Expenditures on agrotechnical measures and cotton harvesting at a density of 111,000 plants were 566.5-676.5 AZN/ ha, expenditures on mineral fertilizers and agrotechnical measures together - 566.5-920.1 AZN/ ha, net profit from gross product - 538.5- 899.9 AZN/ ha, the level of profitability varied between 60.0-97.0%. The highest net profit 899.9 AZN/ha was obtained at a density of 111,000 plants in the N₉₀P₁₂₀K₉₀ variant, the profitability was 97.0%. Expenditures on agrotechnical measures and cotton harvesting at a density of 83,000 plants were 539.5-614.5 AZN/ha, expenditures on mineral fertilizers and agrotechnical measures together -539.5-846.9 AZN/ha, net profit from gross output-390.0-570.1 AZN/ha, profitability level varied between 40.0-72.0%. At a density of 83,000 plants as in other plant densities, the highest net profit was 570.1 AZN/ha in the N₉₀P₁₂₀K₉₀ variant, profitability level was 67.0%.

The highest economic efficiency from cotton planted after barley harvest was obtained in the norm of N₉₀P₁₂₀K₉₀ of mineral fertilizers with a density of 111,000 plants. Contrary to dense and sparse plantings, net profit was 899.9 AZN/ha, the profitability level was 97.0%.

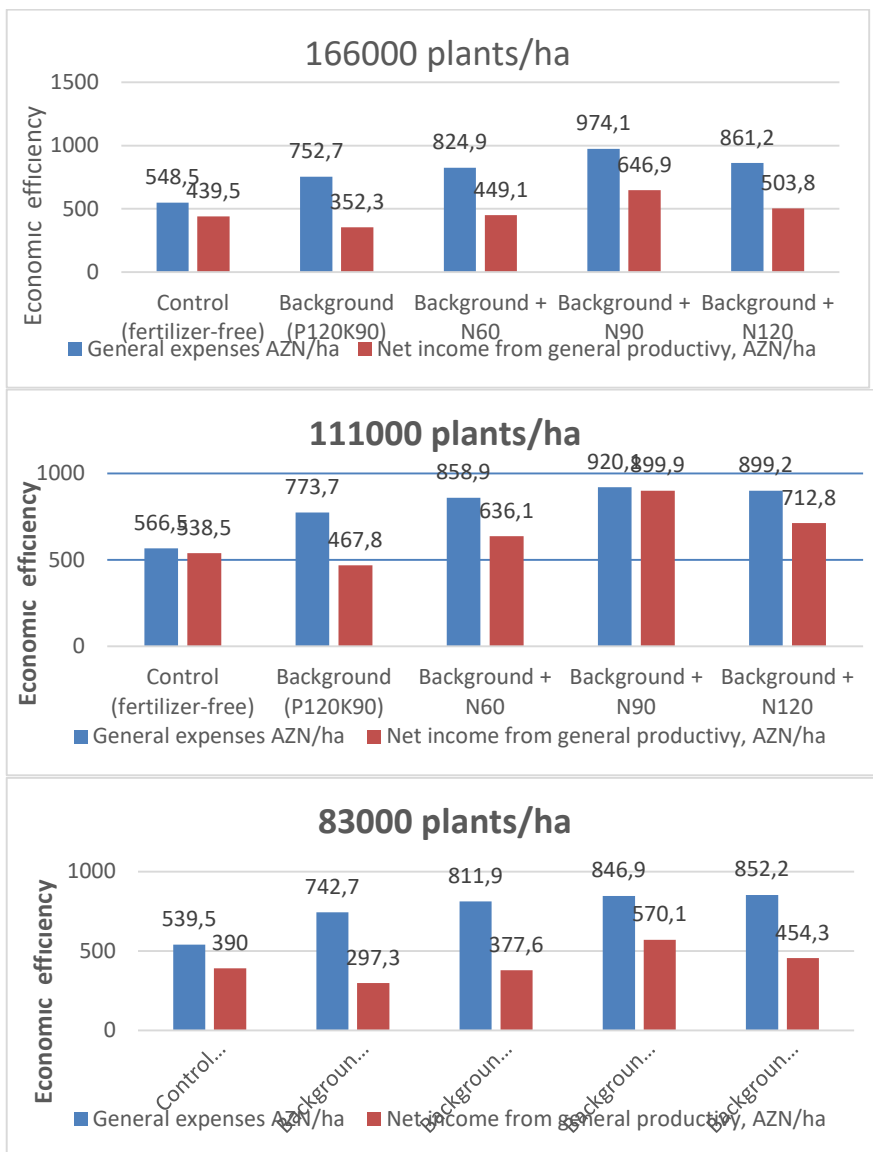


Figure 4. Effect of plant density and mineral fertilizer norms on the economic efficiency of the cotton plant (2017-2019):

1. Control (fertilizer-free);
2. Background (P₁₂₀K₉₀);
3. Background+N₆₀; 4. Background +N₉₀; 5. Background +N₁₂₀.

Conclusions

1. In a situation where arable land is in short supply, it is possible to harvest twice from a single area in a year by using soil and climatic conditions, fast-growing and productive varieties, soil resources, mineral fertilizers that ensure the dynamic development of cotton growing which play a key role in the economy of our republic.

2. In order to get high-quality raw cotton from cotton plantings after barley harvest in gray-brown (chestnut) soils of the Ganja-Gazakh region, the sowing period was determined to be on June 1-10, at a density of 111,000 plants, in the sowing scheme of 60x15 cm and $N_{90}P_{120}K_{90}$ norm of mineral fertilizers.

3. Optimal plant density, planting scheme, and mineral fertilizer norms significantly affect the length of cotton, the number of sympodial branches, buds, cotton bolls, the formation of surface and root mass, and the formation of the leaf surface. In all three plant densities and planting schemes, the reduced and increased norms of nitrogen fertilizer in the background of $P_{120}K_{90}$ did not have much effect on height and development.

4. The mass of 1000 grains, the mass of raw cotton in one boll, the length of the fiber, and the yield of fiber were more in dense plantings, at a density of 83000 plants/ha. The highest indicators were observed in the $N_{90}P_{120}K_{90}$ norm of mineral fertilizers.

5. At a density of 111,000 plants, in the planting scheme of 60x15 cm, more raw cotton yield was obtained in all variants compared to the dense and sparse plantings. The highest raw cotton yield for 3-year average was 28.0 cwt/ha in the norm of $N_{90}P_{120}K_{90}$ mineral fertilizers, the increase compared to the non-fertilized variant was 11.0 cwt/ha or 64.7%. Compared to the control (fertilizer-free) variant, the raw cotton product per kilogram of NPK was 1.00, 2.22; 3.67; 2.66 kg, respectively.

6. It was found that plant density and mineral fertilizer norms, along with productivity, also have a significant effect on the technological quality of cotton fiber. The highest indicators were observed at a density of 111,000 plants, and in the $N_{90}P_{120}K_{90}$ norm of mineral fertilizers, increased compared to the control variant

(fertilizer-free). Thus, the breaking load of cotton fiber was 0.1-0.4 gg, linear density- 50-140 m.tex, tensile strength - 0.7-2.7 gg/tex, and staple length- 1/3 mm.

7. Plant density and mineral fertilizer norms enhance the amount of total nitrogen, phosphorus, and potassium in the aboveground mass of cotton plants throughout developmental phases. During the full ripeness phase, at the end of vegetation, the effect of mineral fertilizers leads to a 0.03-0.10% increase in total nitrogen, 0.03-0.11%, phosphorus, and 0.03-0.13% in potassium at a density of 166,000 plants/ha. At a density of 111,000 plants, the increase were 0.10-0.17% in total nitrogen, 0.06-0.17% in phosphorus, and 0.13-0.22% in potassium. The highest amount was observed at a plant density of 83,000 plants/ha, which has more nutrient area. Thus, compared to the control (fertilizer-free) variant, total nitrogen increased by 0.13-0.23%, phosphorus by 0.09-0.20%, and potassium by 0.13-0.22% .

8. Plant density and mineral fertilizer norms enhance the amount of total nitrogen, phosphorus, and potassium uptaken from the soil by the cotton plant (aboveground mass, fiber, and grain yield) and the plant's absorption rate from fertilizers. Amounts of total nitrogen, phosphorus, and potassium uptaken from the soil increased compared to the control (fertilizer-free) variant. Thus, at a density of 166,000 plants/ha, the increase in nitrogen, phosphorus, and potassium were by 9.2-44.6 kg/ha, 6.8-29.8 kg/ha, and 10.6-53.2 kg/ha, respectively. At a density of 111,000 plants/ha, these parameters changed by 14.1-47.8 kg/ha, 8.7-33.0 kg/ha, and 17.5-53.8 kg/ha, while the smallest increase was observed at a density of 83,000 plants/ha, which was by 13.6-41.9 kg/ha, 8.4-27.5 kg/ha, and 14.3-42.1 kg/ha, respectively. The absorption coefficient was determined in all three plant densities in the N₉₀+Background variant, and the highest value was found at 111,000 plants/ha, at the optimal density compared to dense and sparse plantings. This coefficient changed in the range of 26.6-29.6% for nitrogen, 16.6-20.3% for phosphorus, and 39.0-46.2% for potassium.

9. Economic analysis of the study of summer crop cultivation technology of cotton shows that the highest economic efficiency was

obtained at a density of 111,000 plants, in the planting scheme of 60x15 cm, in the $N_{90}P_{120}K_{90}$ norm of mineral fertilizers, net profit was 899.9 AZN/ha, and profitability level was 97.0%.

Recommendations for producers

1. To get high raw cotton production from the local fast-growing Ganja-110 variety, it is recommended to sow 111,000 plants per hectare in a scheme of 60x15 cm with 60 kg/ha norm in gray-brown (chestnut) soils, after barley harvest in the 1st decade of June.

2. It is advisable to use mineral fertilizers in the form of nitrogen-ammonium nitrate (34.7%), phosphorus-simple superphosphate (18.7%), and potassium-potassium sulfate (46%). Cultivation should be performed at a depth of 10-12 cm by applying 70% of phosphorus and potassium fertilizers to the soil before sowing, and the remaining 30% with nitrogen in the form of feeding in 2 steps (before budding and flowering).

3. $N_{90}P_{120}K_{90}$ norm of mineral fertilizers is recommended to obtain a high-quality raw cotton yield from re-sowing after barley harvest in gray-brown (chestnut) soils and to maintain soil fertility.

List of published scientific works on the topic of the dissertation:

1. Guliyeva, N.A., Gahramanova, R.F. Cotton growing is one of the most profitable sectors of the Azerbaijani economy // International Scientific Conference "Actual Problems of Modern Natural and Economic Sciences" at Ganja State University-Ganja: GSU, - 04-05 May 2018, - pp.314-316 (in Azerbaijani)

2. Guliyeva, N.A. The effect of planting scheme and mineral fertilizers on the mass of 1000 grains in summer plantings// Republican Scientific Conference "Development of ecologically clean agriculture in Azerbaijan" of Azerbaijan State Agrarian University, - Ganja: ASAU, - 29 October 2019, -pp.48-53 (in Azerbaijani)

3. Guliyeva, N.A. The effect of plant density and fertilizers on the mass of raw cotton in a cotton boll in summer plantings // -

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Technological University,, “Scientific News” bulletin, - 2022,
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Address: Az1098; Baku, Pirshagi settlement; sovkhos No2; Research Institute of Crop Husbandry

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