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COTTON PRODUCTION: EFFECT OF APPLICATION RATES AND TIMING OF NEW MICROELEMENT FERTILIZERS ON COTTON GROWTH AND DEVELOPMENT

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Abstract
The principles of soil science and agrochemistry are used to maintain and increase soil fertility and to provide cotton with mineral nutrition on a scientific basis. The main problems in cotton growing are: ecological problems and environmental protection, soil fertility, wind and water erosion, labor productivity and the efficiency of all agrotechnical measures in the field; increasing cotton yield; improving product quality are among the urgent issues.

Keywords: Cotton growing, micronutrients, microorganisms, cotton, physiologically active substances, combing, flowering. phenological observation, soil fertility, boll, plant height.

Introduction

It is well known that in cotton production it is crucial to develop varieties that are resistant to various external factors under any soil and climatic conditions, as well as tolerant to diseases and insect pests. Equally important is designing specific cultivation technologies to achieve early, high-yield, and high-quality harvests. Cotton agronomy—including soil tillage, crop rotation systems, inter-row cultivation, and irrigation—is carried out in accordance with the established principles of agriculture. Maintaining and improving soil fertility and providing cotton with scientifically balanced mineral nutrition rely on the principles of soil science and agrochemistry.

The main challenges in cotton production include: environmental protection and preservation of the ecosystem, maintaining soil fertility, preventing wind and water erosion, improving labor productivity, and increasing the efficiency of all agronomic practices; boosting cotton yields; and enhancing product quality.

Under our local conditions, to produce 1 ton of seed cotton the crop requires approximately 50 kg of nitrogen, 10 kg of phosphorus, and 50 kg of potassium. In addition, the following microelements are needed on average: 50 kg of calcium, 10 kg of sulfur, 10 kg of magnesium, an equal amount of sodium, up to 2 kg of iron, up to 0.2 kg of boron, less than 50 g of copper, and about 1.5 kg of chlorine.

Analysis of Literature and Methodology

During cotton seed germination, an excess of nitrogen in the soil slows seedling emergence and weakens root development. In this situation, the presence of phosphorus helps counteract the strong effect (high concentration) of nitrogen. Before the flowering (squaring) stage, especially in its early period, too much nitrogen in the soil causes fruiting branches to emerge higher on the plant and delays the onset of key growth phases.

During the squaring and flowering stages, an excess of nitrogen leads to excessive vegetative growth, reduced yield, and delayed maturity. Conversely, a shortage of nitrogen at this time results in weak plant growth, fewer fruiting branches, and consequently fewer and smaller bolls.

Potassium also plays a crucial role in cotton development. It supports the plant's transition to the reproductive phase (flowering, boll formation, seed maturation) and improves water retention within the plant, thereby reducing transpiration.

Other elements influence cotton growth as well. For example, certain calcium compounds (Ca_2SO_4, $CaHPO_4$) stimulate root growth and the formation of new roots. Micronutrients are equally important. Boron, which accumulates in the reproductive organs of cotton flowers, enhances pollen tube growth and fertilization. A nitrogen deficiency stunts plant growth, causes smaller leaves, and gives them a yellowish-green color, whereas excessive nitrogen leads to rank growth and dark green leaves. Phosphorus deficiency produces short plants with small leaves and may cause reddish veins to appear on the foliage.

Along with the primary nutrients absorbed in large amounts, plants also need trace elements known as micronutrients. Current research shows that boron, zinc, copper, molybdenum, and manganese are essential for normal plant development. A lack of these nutrients disrupts metabolism, reduces the formation of yield components, and can lead to partial fruit drop, ultimately lowering overall yield.

Foliar fertilization is a cost-effective and efficient method that significantly increases productivity. It plays an important role in preventing the decline of mineral content during late growth stages and in helping crops recover quickly after natural stress events. Determining the correct concentration of foliar sprays is crucial, as an overly strong solution can damage plant tissues and harm key nutrient elements.

Research Materials and Methods

Field experiments were conducted in 2025 at the Fergana Experimental Station of the Scientific Research Institute of Cotton Breeding, Seed Production, and Cultivation Agro-technologies. The study tested liquid microelement fertilizers Avangard (Start) and Avangard (Nitrogen + Micro) as

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standard treatments. The experiment consisted of 10 variants, arranged in 3 blocks (replications) and 3 repeats on small plots planted with the cotton variety S-8296.

For these field trials, we used the new biofertilizers Avangard-Start and Avangard Nitrogen + Micro, complex microelement fertilizers enriched with micro- and macroelements produced by SWISSAGRO LLC.

Table 1 Experiment Setup (2025) – Cotton Variety S-8296

№	Experiment Variants	Rate of treatment at the 2–3 true-leaf stage, kg or l/ha	Treatment rate during the budding and flowering stage, kg or l/ha	Application rate during the flowering and fruiting stage, kg or liters per hectare (kg or l/ha)
1	Control	-	-	
2	Standard (Universal)	1,0	1,0	1,0
3	Avangard (start)	1,0		
4	Avangard (start)	1,0	1,5	
5	Avangard (start)	1,0	1,5	2,0
6	Avangard (start)	1,5	2,5	3,0
7	Avangard (azot+mikro)	1,0		
8	Avangard (azot+mikro)	1,0	1,5	
9	Avangard (azot+mikro)	1,0	1,5	2,0
10	Avangard (azot+mikro)	1,5	2,5	3,0

For these field trials, we used new biofertilizers produced by SWISSAGRO LLC—complex microelement fertilizers enriched with both micro- and macroelements—under the names **Avangard-Start** and **Avangard Nitrogen+Micro**.

Avangard-Start, RK (N 100 g/l, P 70 g/l, K 20 g/l, Ca 10 g/l, Fe 10 g/l, Mn 5 g/l, B 5 g/l, Zn 5 g/l, Co 0.1 g/l, Mo 0.5 g/l, Cu 2 g/l) increases crop germination by 8–10 %, accelerates growth, and improves tolerance to adverse weather conditions and harmful organisms, thereby raising yield.

Avangard Nitrogen+Micro, RK (N 300 g/l, SO_3 26 g/l, MgO 10 g/l, B 0.5 g/l, Fe 0.3 g/l, Mn 4 g/l, Cu 1 g/l, Zn 0.3 g/l, Mo 0.1 g/l, Co 0.01 g/l) likewise enhances germination by 8–10 %, speeds development, and strengthens resistance to unfavorable weather and pests, which ultimately increases yield.

According to the research, when base mineral fertilizers were applied at rates of N 200, P_2O_5 140, and K_2O 100 kg/ha, the timing and dosage of additional foliar feeding with these microelement fertilizers were found to influence:

• plant growth and development,
• cotton leaf area, dry mass, and photosynthetic productivity,

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- formation and shedding of yield components.

These effects were analyzed using the data presented in the following tables.

Table 2 Analysis of Phenological Observations of Cotton in the 2025 Experimental Setup

Experiment Variants	Plant height				Number of true leaves 1.06	Fruiting branch	
	1.06	1.07	1.08	1.09		1.07	1.09
1-Variant	22,68	53,4	63,2	64,94	6,65	4,75	6,2
2-Variant	23,12	55,05	66,5	67,8	7	4,89	6,5
3-Variant	22,8	55,55	62,9	65,56	6,6	5,09	6,29
4-Variant	20,69	55,67	63,1	67,2	6,2	5,29	6,55
5-Variant	20,76	59,65	72,0	74,1	6,44	5,76	6,68
6-Variant	23,05	60,43	73,8	76,52	7	5,67	6,76
7-Variant	24,16	57,51	64,9	67,2	7,08	5,35	5,8
8-Variant	21,28	60,59	67,6	70,15	6,29	5,67	6,25
9-Variant	22,85	63,08	73,2	77,6	6,4	6,12	6,92
10-Variant	23,17	60,09	74,0	76,85	6,97	5,77	6,65

Analysis of Phenological Observations (2025)

The first experiment began on 24 May 2025 during the cotton's true-leaf stage, when the seedling thinning was carried out using the handheld Aftomaks device. Observations showed that squaring and flowering started between 13 and 18 June. In the second experiment, foliar spraying of the working solution of biostimulants was performed on 20 June 2024. For each experimental plot, the solution was prepared and applied at a rate of 500 liters of water per hectare according to the specified treatment schedule.

By 1 July, analysis of phenological data showed that plant growth and development were noticeably higher in variants 5, 6, 9, and 10 where biostimulants were applied at the recommended rates, compared with the control. These treatments resulted in slightly greater plant height, number of true leaves, and number of fruiting branches. Variants 5, 6, 9, and 10 demonstrated the best results for plant height and fruiting branch formation.

Conclusion

The findings indicate that the use of physiologically active substances, biostimulants, fertilizers, and nitrogen-micro additives is an effective method to improve cotton growth and yield. Plant height, number of fruiting branches, flowers, squares, and open bolls all increased significantly with the application of biostimulants and nitrogen microelements. In particular, the microelement fertilizers Avangard Start and Avangard (Nitrogen + Micro) accelerated plant growth processes and contributed to higher yields.

Such approaches, combined with genetic and agronomic strategies for developing drought-resistant cotton varieties, can produce excellent results in increasing productivity. Throughout the phenological observations, treatments with physiologically active substances and nitrogen microelements improved the overall condition of the plants, leading to more fruiting branches and squares. These biostimulants enhanced photosynthesis, stimulated development, and ultimately boosted yield, supporting greater agricultural efficiency and resilience against climate-related abiotic stress.

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