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EFFECT OF PLANTING GEOMETRY, MINERAL FERTILIZATION AND
BIOSTIMULANT TREATMENTS ON MAIN STEM GROWTH OF GROUNDNUT
(ARACHIS HYPOGAEA L.) CV. SALOMAT

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Abstract. The present study evaluated the dynamics of main stem growth in groundnut (*Arachis hypogaea* L.) cv. Salomat under different planting geometries, mineral fertilizer rates and biostimulant treatment variants under irrigated conditions of the Andijan region, Uzbekistan. The field experiment included two planting patterns, 70×10 cm and 70×20 cm with one plant per hill, two mineral nutrition backgrounds ($N60P110K40$ and $N90P165K65$ kg ha⁻¹), and treatments with Oksigumat Ekstra and Rokogumin at 1, 2 and 3 L ha⁻¹. Main stem height was recorded on 1 July, 1 August and 1 September 2021. Since foliar biostimulant application was performed on 8 July, the July measurement represented the pretreatment status, whereas August and September measurements characterized subsequent growth dynamics. Across all 14 corresponding treatments, the mean stem height under the 70×20 cm pattern was 34.66, 45.67 and 61.21 cm on 1 July, 1 August and 1 September, respectively, compared with 29.14, 38.37 and 51.44 cm under the 70×10 cm pattern. The mean difference between the planting patterns increased from 5.53 cm in July to 9.78 cm in September. Under $N60P110K40$, the greatest September stem height in both planting patterns was recorded in the Oksigumat Ekstra 3 L ha⁻¹ treatment: 52.9 cm at 70×10 cm and 63.0 cm at 70×20 cm. However, because pretreatment differences were already present among experimental plots and no statistical significance parameters were available for the presented dataset, the observed treatment differences should be interpreted as descriptive trends rather than proven biostimulant effects. The results demonstrate that planting geometry was the most consistent factor associated with variation in main stem height.

Keywords: groundnut, *Arachis hypogaea* L., Salomat cultivar, planting geometry, plant spacing, mineral nutrition, Oksigumat Ekstra, Rokogumin, stem height, growth dynamics.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed and grain legume crop cultivated for food, feed and industrial purposes. In addition to its valuable seed yield, groundnut produces vegetative biomass that can be used as nutritious livestock feed. Plant residues also contribute considerable amounts of mineral elements, particularly phosphorus and potassium, to the agroecosystem [1].

Growth and development of groundnut depend on genotype, environmental conditions and crop management practices. Main stem height is one of the important morphological indicators reflecting vegetative growth and plant response to the available growth resources. Its development is affected by plant population density, individual feeding area, water supply, mineral nutrition and other environmental factors.

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Groundnut genotypes can generally be classified according to growth habit into erect, semi-erect and spreading types. Erect and semi-erect forms are predominantly cultivated in Central Asia, where stem height is commonly reported to range from approximately 35 to 55 cm. Spreading forms may have high productivity potential, but their long growing period and more complicated inter-row cultivation limit their practical use under regional production systems [1].

Planting geometry is an essential management factor because it determines the feeding area available to an individual plant and regulates competition for solar radiation, soil moisture and mineral nutrients. Increasing plant spacing may reduce intraspecific competition and modify canopy architecture, branching and stem elongation. Previous studies have demonstrated that plant density and mineral fertilizer rates can substantially affect growth and productivity of groundnut [2, 3].

Mineral nutrition is another major component of groundnut production technology. Adequate nitrogen, phosphorus and potassium availability supports the formation of vegetative and reproductive organs. However, the response of a crop to fertilizer depends on plant density, soil conditions, moisture availability and cultivar characteristics.

Biostimulants have also been increasingly incorporated into crop management systems with the objective of supporting plant growth and physiological activity. Their observed performance, however, may depend on application timing, dose and the initial condition of plants. Therefore, correct interpretation requires separation of measurements made before and after treatment.

The objective of this study was to evaluate the dynamics of main stem height of groundnut cv. Salomat under two planting geometries and mineral fertilizer backgrounds and to characterize the observed growth patterns in experimental variants assigned to different rates of Oksigumat Ekstra and Rokogumin.

Materials and Methods

The field experiment was conducted in 2021 under irrigated conditions of the Andijan region of Uzbekistan. The experimental soil was irrigated meadow-serozem, heavy loam in texture and slightly saline, with groundwater occurring at approximately 1.5–2.0 m depth.

Groundnut cultivar Salomat was used as the plant material. Two planting geometries were investigated: 70 × 10 cm and 70 × 20 cm, with one plant per hill. The corresponding calculated feeding area was approximately 0.07 and 0.14 m² per plant, respectively.

Two mineral fertilizer backgrounds were studied: N60P110K40 and N90P165K65 kg ha⁻¹. Within each fertilizer background, seven treatment variants were included: an untreated biostimulant control; Oksigumat Ekstra at 1, 2 and 3 L ha⁻¹; and Rokogumin at 1, 2 and 3 L ha⁻¹.

Fourteen treatments were therefore evaluated within each planting geometry, resulting in a total of 28 experimental variants. The field experiment was conducted in four replications. Each gross plot occupied 140 m², while the accounting area was 70 m².

Main stem height was measured on 1 July, 1 August and 1 September 2021. Biostimulant treatment was carried out as a foliar application on 8 July 2021. Consequently, the measurements taken on 1 July were obtained before the application of the biostimulants.

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The measurements taken on 1 August and 1 September were used to characterize subsequent plant growth.

The results presented in this paper were evaluated descriptively. Since analysis of variance and least significant difference values were not available for this dataset, numerical differences are discussed as observed tendencies rather than statistically significant effects.

Results and Discussion

Effect of planting geometry on stem height

A clear difference in main stem height was observed between the two planting geometries throughout the study period. Plants grown at 70×20 cm were consistently taller than their corresponding treatments at 70×10 cm.

The average stem height across all 14 treatments at the 70×10 cm spacing was 29.14 cm on 1 July, 38.37 cm on 1 August and 51.44 cm on 1 September. Under the wider 70×20 cm spacing, the corresponding averages were 34.66, 45.67 and 61.21 cm.

Thus, the mean advantage of the 70×20 cm planting geometry was 5.53 cm on 1 July, 7.30 cm on 1 August and 9.78 cm on 1 September. The increasing difference during the growing period indicates that the response associated with individual feeding area became more pronounced as plant biomass increased.

Table 1. Main stem height of groundnut cv. Salomat under the 70×10 cm planting geometry, 2021

No	Mineral fertilizer, kg ha ⁻¹	Treatment	1 July, cm	1 August, cm	1 September, cm
1	N60P110K 40	Control	25.7	34.5	48.7
2	N60P110K 40	Oksigumat Ekstra, 1 L ha ⁻¹	27.6	36.7	50.0
3	N60P110K 40	Oksigumat Ekstra, 2 L ha ⁻¹	28.5	37.9	51.0
4	N60P110K 40	Oksigumat Ekstra, 3 L ha ⁻¹	29.9	40.1	52.9
5	N60P110K 40	Rokogumin, 1 L ha ⁻¹	26.4	35.4	49.5
6	N60P110K 40	Rokogumin, 2 L ha ⁻¹	28.3	37.7	50.9
7	N60P110K 40	Rokogumin, 3 L ha ⁻¹	29.2	38.8	51.8
8	N90P165K 65	Control	28.7	38.2	51.0
9	N90P165K 65	Oksigumat Ekstra, 1 L ha ⁻¹	30.7	41.0	53.7
10	N90P165K 65	Oksigumat Ekstra, 2 L ha ⁻¹	29.6	39.3	51.9



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No	Mineral fertilizer, kg ha ⁻¹	Treatment	1 July, cm	1 August, cm	1 September, cm
11	N90P165K65	Oksigumat Ekstra, 3 L ha ⁻¹	31.1	41.5	53.8
12	N90P165K65	Rokogumin, 1 L ha ⁻¹	29.6	36.8	50.4
13	N90P165K65	Rokogumin, 2 L ha ⁻¹	30.6	39.1	51.8
14	N90P165K65	Rokogumin, 3 L ha ⁻¹	32.0	40.2	52.7

Under the 70 × 10 cm planting geometry and the N60P110K40 fertilizer background, the untreated control reached 48.7 cm by 1 September. The final stem height in the Oksigumat Ekstra treatments increased numerically from 50.0 cm at 1 L ha⁻¹ to 52.9 cm at 3 L ha⁻¹. The latter value was 4.2 cm, or approximately 8.6%, higher than the corresponding control.

The Rokogumin treatments under the same fertilizer background reached 49.5–51.8 cm by 1 September. The greatest value within this group was recorded at 3 L ha⁻¹, exceeding the untreated control by 3.1 cm.

On the N90P165K65 background, the control reached 51.0 cm by 1 September. Oksigumat Ekstra treatments produced values ranging from 51.9 to 53.8 cm, whereas Rokogumin treatments ranged from 50.4 to 52.7 cm.

A uniform dose-dependent response was not observed in all treatments. For example, Oksigumat Ekstra at 2 L ha⁻¹ resulted in a lower final value than 1 and 3 L ha⁻¹ under N90P165K65. This indicates that the relationship between treatment rate and stem elongation was not linear.

Table 2. Main stem height of groundnut cv. Salomat under the 70 × 20 cm planting geometry, 2021

No.	Mineral fertilizer, kg ha ⁻¹	Treatment	1 July, cm	1 August, cm	1 September, cm
1	N60P110K40	Control	30.6	41.1	58.0
2	N60P110K40	Oksigumat Ekstra, 1 L ha ⁻¹	32.8	43.7	59.5
3	N60P110K40	Oksigumat Ekstra, 2 L ha ⁻¹	33.9	45.1	60.7
4	N60P110K40	Oksigumat Ekstra, 3 L ha ⁻¹	35.6	47.7	63.0



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No.	Mineral fertilizer, kg ha ⁻¹	Treatment	1 July, cm	1 August, cm	1 September, cm
5	N60P110K40	Rokogumin, 1 L ha ⁻¹	31.4	42.1	58.9
6	N60P110K40	Rokogumin, 2 L ha ⁻¹	33.7	44.9	60.6
7	N60P110K40	Rokogumin, 3 L ha ⁻¹	34.7	46.2	61.6
8	N90P165K65	Control	36.5	48.8	63.9
9	N90P165K65	Oksigumat Ekstra, 1 L ha ⁻¹	34.2	45.5	60.7
10	N90P165K65	Oksigumat Ekstra, 2 L ha ⁻¹	35.2	46.8	61.8
11	N90P165K65	Oksigumat Ekstra, 3 L ha ⁻¹	37.0	49.4	64.0
12	N90P165K65	Rokogumin, 1 L ha ⁻¹	35.2	43.8	60.0
13	N90P165K65	Rokogumin, 2 L ha ⁻¹	36.4	46.5	61.6
14	N90P165K65	Rokogumin, 3 L ha ⁻¹	38.1	47.8	62.7

The wider planting geometry resulted in greater stem height throughout the observation period. Under N60P110K40, the untreated control reached 58.0 cm on 1 September. Oksigumat Ekstra treatments resulted in 59.5, 60.7 and 63.0 cm at 1, 2 and 3 L ha⁻¹, respectively. The 3 L ha⁻¹ treatment was 5.0 cm, or 8.6%, higher than the corresponding control.

Rokogumin treatments under the same fertilizer background reached 58.9–61.6 cm. The numerically greatest value was again obtained at 3 L ha⁻¹.

A different pattern was observed under the N90P165K65 fertilizer background. The control reached 63.9 cm by 1 September, while Oksigumat Ekstra at 3 L ha⁻¹ produced 64.0 cm. The other Oksigumat Ekstra treatments resulted in 60.7–61.8 cm, and Rokogumin treatments in 60.0–62.7 cm.

Therefore, under the higher fertilizer background and wider spacing, the biostimulant-labelled treatments did not consistently exceed the control. This finding is important because



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it demonstrates that the observed response depended on the combination of planting geometry, mineral nutrition and treatment variant rather than on biostimulant dose alone.

The difference associated with planting geometry was especially clear when corresponding treatments were directly compared. Depending on the treatment, plants at 70×20 cm exceeded those at 70×10 cm by 3.5–7.8 cm on 1 July, 4.5–10.6 cm on 1 August and 7.0–12.9 cm on 1 September.

These results indicate that individual feeding area was closely associated with the vegetative growth of cv. Salomat. Increasing the distance between plants from 10 to 20 cm doubled the theoretical feeding area per plant and likely reduced competition for light, moisture and mineral nutrients. This may have allowed more intensive development of individual plants.

When treatment means were calculated separately for the two fertilizer backgrounds, higher mean stem height was generally observed under N90P165K65.

At 70×10 cm, mean stem height under N60P110K40 was 27.94, 37.30 and 50.69 cm on 1 July, 1 August and 1 September, respectively. Under N90P165K65, the corresponding values were 30.33, 39.44 and 52.19 cm.

At 70×20 cm, the respective values were 33.24, 44.40 and 60.33 cm under N60P110K40 and 36.09, 46.94 and 62.10 cm under N90P165K65.

Thus, the higher fertilizer background was associated with an average September increase of approximately 1.50 cm at 70×10 cm and 1.77 cm at 70×20 cm. Nevertheless, these differences were considerably smaller than the mean difference of 9.78 cm between the two planting geometries.

This comparison suggests that, for main stem height in 2021, planting geometry was associated with a stronger numerical response than the increase in mineral fertilizer rate.

An important methodological consideration is that Oksigumat Ekstra and Rokogumin were applied on 8 July, whereas the first stem measurement was conducted on 1 July. Consequently, differences recorded on 1 July cannot have been caused by the subsequent foliar application.

This pretreatment variability must also be considered when interpreting the final September values. For example, under N60P110K40 and 70×10 cm, the Oksigumat Ekstra 3 L ha⁻¹ treatment was already 4.2 cm taller than the control before foliar treatment and remained 4.2 cm taller on 1 September. From 1 July to 1 September, both treatments increased by exactly 23.0 cm.

A similar pattern occurred at 70×20 cm. Under N60P110K40, the control increased from 30.6 to 58.0 cm, corresponding to 27.4 cm of growth, whereas Oksigumat Ekstra at 3 L ha⁻¹ increased from 35.6 to 63.0 cm, also corresponding to 27.4 cm.

These examples show that higher final stem height in some biostimulant-labelled treatments partly reflected differences already existing before application rather than additional stem elongation after treatment.

Under N90P165K65 and 70×20 cm, the control increased by 27.4 cm between 1 July and 1 September. The corresponding increments were 26.5–27.0 cm for Oksigumat Ekstra



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and 24.6–25.2 cm for Rokogumin. Therefore, the 2021 stem-height dataset does not demonstrate a uniform stimulation of stem elongation by the tested preparations.

Because no analysis of variance or least significant difference values were available for this parameter, the results should not be interpreted as evidence of statistically significant differences among biostimulant rates. The data support descriptive conclusions about growth dynamics and the consistent effect associated with planting geometry, whereas specific biostimulant responses require statistical confirmation over replicated years.

CONCLUSION

The 2021 field observations demonstrated clear differences in main stem growth of groundnut cv. Salomat under different planting geometries and nutritional backgrounds.

1. The 70 × 20 cm planting geometry consistently produced taller individual plants than the 70 × 10 cm geometry.

2. Mean stem height under the 70 × 20 cm spacing reached 34.66 cm on 1 July, 45.67 cm on 1 August and 61.21 cm on 1 September, compared with 29.14, 38.37 and 51.44 cm, respectively, under the 70 × 10 cm spacing.

3. The mean difference between planting geometries increased during the growing period from 5.53 cm on 1 July to 9.78 cm on 1 September.

4. The average increase in stem height from 1 July to 1 September was 26.55 cm under 70 × 20 cm and 22.30 cm under 70 × 10 cm.

5. The higher N90P165K65 fertilizer background generally resulted in somewhat greater mean stem height than N60P110K40; however, the magnitude of this difference was smaller than that associated with planting geometry.

6. Under N60P110K40, the highest September stem height among the tested variants was observed with Oksigumat Ekstra at 3 L ha⁻¹: 52.9 cm at 70 × 10 cm and 63.0 cm at 70 × 20 cm.

7. Under N90P165K65 and 70 × 20 cm, the untreated control reached 63.9 cm, while Oksigumat Ekstra at 3 L ha⁻¹ reached 64.0 cm; other biostimulant variants ranged from 60.0 to 62.7 cm.

8. Since the first measurement preceded biostimulant application, pretreatment differences among the experimental plots were already present. Therefore, final differences in stem height cannot be attributed exclusively to biostimulant action.

9. The data did not show a uniform dose-dependent response to either Oksigumat Ekstra or Rokogumin.

10. Overall, planting geometry was the most consistent agronomic factor associated with main stem height of groundnut cv. Salomat under the conditions of the 2021 experiment.

Further multi-year analysis incorporating replicated statistical evaluation, yield components and economic performance is required to determine whether changes in plant height are associated with agronomically meaningful improvements in productivity.



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