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Effect of sulphur and nano urea on growth attributes of sunflower (*Helianthus annuus* L.)

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Abstract

A field experiment was conducted in the Rabi season of 2025–26 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, to study the effect of Nano Urea and Sulphur on the growth attributes of sunflower (*Helianthus annuus* L.), variety *N.S.F.H-1008*. The experiment was conducted in Randomized Block Design (RBD) which includes 10 treatment combinations, replicated three times, using three levels of Nano Urea (3, 4, and 5 ml/L applied as foliar spray at 20 and 45 DAS) combined with three levels of Sulphur (20, 25, and 30 kg/ha applied basally), against a control receiving NPK at 80:40:40 kg/ha. The soil of the experimental field was sandy loam, nearly neutral in reaction (pH 7.4), with low organic carbon (0.61%). Results revealed that treatment T₅ (Nano Urea 4 ml/L + Sulphur 25 kg/ha) recorded the significantly highest plant height (133.4 cm at 80 DAS) and the best relative growth rate during the 60–80 DAS grand growth phase. Treatment T₉ (Nano Urea 5 ml/L + Sulphur 30 kg/ha) recorded the highest plant dry weight (27.30 g/plant at 80 DAS) and the highest crop growth rate (0.5507 g/m²/day at 20–40 DAS and 0.4699 g/m²/day at 60–80 DAS). The control (NPK only) recorded the lowest values across all growth parameters. The result concludes that combination of basal dose of Nitrogen and foliar application of Nano urea paired with moderate amount of Sulphur level (25kg/ha) gives the good results in vegetative growth of Sunflower.

Keywords: Sunflower, nano urea, sulphur, plant height, oil seed

Introduction

Sunflower (*Helianthus annuus* L.) is one of the most important edible oilseed crops in India, valued for its short duration, wide adaptability, and high-quality oil rich in unsaturated fatty acids. National productivity, however, remains below its genetic potential, largely due to inadequate and imbalanced nutrient management. Nitrogen and Sulphur both plays vital role in vegetative production: nitrogen drives cell division, chlorophyll synthesis, and leaf area expansion, while Sulphur is a constituent of essential amino acids and coenzymes involved in protein synthesis and enzymatic activity. A deficiency of either element retards the speed of vegetative growth, which will affect the reproduction and yield of crop later.

Conventional soil-applied nitrogen fertilizer like urea were lost due to leaching, volatilization, and denitrification, often leaving half of nitrogen for crops. Nano Urea, a foliar-applied liquid formulation with nitrogen encapsulated at the nanoscale, is directly absorbed from stomata which were translocate in whole plant body, which bypasses soil based losses and increases the efficiency of fertilizer. Combining this nitrogen source with an adequate basal Sulphur supply can strengthen nitrogen metabolism and protein formation, since Sulphur is required for the enzymatic steps that convert absorbed nitrogen into amino acids and proteins.

Bhakher *et al.* (2023) ^[1] reported favorable growth responses to combined Nano Urea and Sulphur application in sunflower, though this work did not test a full factorial range of Nano Urea doses (3–5 ml/L) against multiple Sulphur levels (20–30 kg/ha) in a single trial, nor report growth-rate kinetics (CGR and RGR) across the full crop duration. Hocking *et al.* (1987) ^[6] established that Sulphur and Nitrogen supply interact to affect sunflower vegetative growth and yield components, but under conventional (non-nano) fertilizer sources and in a controlled glasshouse setting rather than a field trial. The present study tests nine Nano Urea × Sulphur combinations against a conventional NPK control in a single field trial, with growth parameters recorded at four growth

stages, to resolve growth-stage-specific and dose-specific responses more precisely than the existing literature allows. This study conducted evaluates the growth of Sunflower with different combinations of Sulphur and Nano Urea in Agro-climatic conditions of Prayagraj.

Materials and Methods

The field experiment was conducted during the Rabi season of 2025–26 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The texture of soil in experimental field is sandyloam in texture, nearly neutral in reaction (pH 7.4), and low in organic carbon (0.61%) and available nitrogen. Available phosphorus and potassium were 42.3 kg/ha and 245.6 kg/ha respectively, and electrical conductivity is 0.663 dS/m.

Ten treatment combinations were laid out in a Randomized Block Design, each replicated three times, giving a total of thirty plots. The treatments holds three levels of Nano Urea (3, 4, and 5 ml/L, applied as two foliar sprays at 20 and 45 DAS) combined factorial with three levels of Sulphur (20, 25, and 30 kg/ha, applied basally as Sulphur Bentonite 90%), along with a control receiving NPK at 80:40:40 kg/ha. Sunflower variety N.S.F.H-1008 was sown on 10 November 2025 at a spacing of 45 × 30 cm and harvested on 17 March 2026, which gives crop duration of 127 days.

Observations on plant height, plant dry weight, crop growth rate (CGR), and relative growth rate (RGR) were recorded at 20, 40, 60, and 80 days after sowing (DAS) from five randomly tagged plants per plot. Crop growth rate and relative growth rate were computed using the standard formulae of Fisher (1921) ^[4], as adapted by Donald (1962) ^[3] for field crop growth analysis. Data were statistically analyzed by analysis of variance (ANOVA) for Randomized Block with 10 treatments and 3 replications, the design gave 29 total degrees of freedom, partitioned into 2 for replications, 9 for treatments, and 18 for error. The F-test was applied at the 5% level of probability, and treatment means were compared using the critical difference (CD) at p-0.05 wherever the F-test indicated significance.

Results and Discussion

Plant height (cm)

Plant height increased progressively at each successive growth stage across all treatments (Table 1a). No significant differences were recorded at 20 DAS, when the applied treatments had not yet produced differential effects on seedling growth. From 40 DAS onwards, however, clear differences emerged as the foliar Nano Urea was absorbed and the basal Sulphur became mobilized in the root zone. Treatment T₅ (Nano Urea 4 ml/L + Sulphur 25 kg/ha) recorded the highest plant height at every subsequent stage, reaching 98.23 cm at 60 DAS and 133.4 cm at 80 DAS, significantly ahead of all other treatments. The control (T₁₀) consistently recorded the lowest plant height at every growth stage, at only 95.43 cm at 80 DAS. The superior height under T₅ can be attributed to enhanced nitrogen presence due to adequate nitrogen uptake, working together with adequate Sulphur to support protein synthesis and cell elongation. These findings agree with Prasad *et al.* (2020) ^[10], who reported improved vegetative growth and yield attributes in sunflower under Nano Urea application, and with Bhakher *et al.* (2023) ^[1], who observed a similar positive influence of combined Nano Urea and Sulphur on plant height. The plateau in height gain beyond T₅ at higher Nano Urea doses (T₇–T₉) suggests that nitrogen supply ceased to

be the limiting factor for elongation growth once a threshold level was reached.

Plant dry weight (g/plant)

Dry matter accumulation also has similar progressive trend, increasing steadily from 20 DAS to harvest across all treatments (Table 1b). Differences were non-significant at 20 DAS but became clearly significant from 40 DAS onward. Treatment T₉ (Nano Urea 5 ml/L + Sulphur 30 kg/ha) recorded the highest plant dry weight at every later stage, reaching 27.30 g/plant at 80 DAS, ahead of T₅ (24.63 g/plant), the second-best treatment. Treatment T₁ (Nano Urea 3 ml/L + Sulphur 20 kg/ha) recorded the lowest dry weight throughout, at 15.23 g/plant at 80 DAS, while the control (NPK alone) also performed poorly at 20.23 g/plant, underscoring the importance of adequate Sulphur and Nano Urea supply over basal NPK alone. The highest dry matter accumulation is due to high Sulphur and Nano urea application where carbon accumulation is high due to adequate amount of Sulphur and Nano Urea application. This pattern is broadly consistent with Kalaiyarasan *et al.* (2020) ^[9], who reported that optimum Sulphur nutrition maximized dry matter accumulation in hybrid sunflower, and with Hussain *et al.* (2025) ^[5], who found that Sulphur application increased sunflower dry weight by 28% and crop growth rate by 66% over the control. Notably, T₉ led in dry weight while T₅ led in height, indicating that the highest biomass accumulation is driven by the highest nutrient input rather than by linear elongation alone; a similar dissociation between vegetative bulk and height gain under high-Sulphur and high-nitrogen regimes was reported by Hussain *et al.* (2025) ^[5] in sunflower.

Crop growth rate (g/m²/day)

CGR values across the 20–40, 40–60, and 60–80 DAS intervals are presented in Table 2. Treatment T₉ recorded the highest CGR at 20–40 DAS (0.5507 g/m²/day), followed by T₅ (0.4914 g/m²/day). At 40–60 DAS, T₄ (Nano Urea 4 ml/L + Sulphur 20 kg/ha) recorded the highest CGR (0.3843 g/m²/day), followed by T₆ (0.3146 g/m²/day). At 60–80 DAS, T₉ again recorded the highest CGR (0.4699 g/m²/day), followed by T₅ (0.3753 g/m²/day). The control recorded consistently lower CGR values across all intervals. CGR was generally highest during the 20–40 DAS interval among the high-input treatments, showing active vegetative growth due to availability of nitrogen and Sulphur during early period of growth, and again it peaked during 60–80 DAS for the top treatments as the crop entered its grand growth phase.

Relative growth rate (g/g/day)

RGR shows the efficiency of adding biomass relative to existing weight of plant, and Table 2 shows a general decline in RGR across all treatments as the crop matured. During 20–40 DAS, T₉ recorded the highest RGR (0.10 g/g/day), usually treatment difference use to be nonsignificant in early stages. During 40–60 DAS, T₄ were recorded the highest RGR (0.03 g/g/day), closely followed by T₁ (0.02 g/g/day) and T₃ (0.02 g/g/day), with treatment differences significant. During 60–80 DAS, T₁, T₂, T₃ and T₉ were jointly highest (0.02 g/g/day), while treatments T₄–T₈ and the control declined further to 0.01 g/g/day. The declining RGR pattern from the 20–40 to 60–80 DAS interval reflects natural crop ontogeny, in which the ratio of new growth to existing biomass falls because plant matures and accumulates structural tissue. These results show a similar pattern to that reported by Shekhawat and Shivay (2009) ^[11].

Table 1a: Effect of Nano Urea and Sulphur on plant height (cm) of sunflower at 20, 40, 60 and 80 DAS

Treatment	20 DAS	40 DAS	60 DAS	80 DAS
T ₁ : NU 3 ml/L + S 20 kg/ha	11.47	54.97	84.83	107.37
T ₂ : NU 3 ml/L + S 25 kg/ha	12.13	56.63	84.37	115.40
T ₃ : NU 3 ml/L + S 30 kg/ha	11.47	42.50	82.23	102.97
T ₄ : NU 4 ml/L + S 20 kg/ha	11.27	64.27	91.67	118.37
T ₅ : NU 4 ml/L + S 25 kg/ha	12.13	75.97	98.23	133.40
T ₆ : NU 4 ml/L + S 30 kg/ha	11.77	68.07	95.10	124.40
T ₇ : NU 5 ml/L + S 20 kg/ha	11.70	52.30	81.27	113.40
T ₈ : NU 5 ml/L + S 25 kg/ha	10.93	63.93	90.20	123.23
T ₉ : NU 5 ml/L + S 30 kg/ha	11.73	68.03	97.70	131.80
T ₁₀ : Control (NPK 80:40:40)	10.27	44.90	70.00	95.43
F-test	NS	S	S	S
SEm±	0.41	3.02	4.62	3.70
CD (p=0.05)	-	8.98	13.73	11.00

Table 1b: Effect of Nano Urea and Sulphur on plant dry weight (g/plant) of sunflower at 20, 40, 60 and 80 DAS

Treatment	20 DAS	40 DAS	60 DAS	80 DAS
T ₁ : NU 3 ml/L + S 20 kg/ha	1.45	5.12	9.00	15.23
T ₂ : NU 3 ml/L + S 25 kg/ha	1.56	8.38	12.53	19.78
T ₃ : NU 3 ml/L + S 30 kg/ha	1.56	6.57	10.75	16.85
T ₄ : NU 4 ml/L + S 20 kg/ha	1.56	8.01	15.69	21.47
T ₅ : NU 4 ml/L + S 25 kg/ha	1.69	11.52	17.13	24.63
T ₆ : NU 4 ml/L + S 30 kg/ha	1.53	10.10	16.39	23.30
T ₇ : NU 5 ml/L + S 20 kg/ha	1.56	9.32	14.80	20.59
T ₈ : NU 5 ml/L + S 25 kg/ha	1.56	10.06	14.62	20.73
T ₉ : NU 5 ml/L + S 30 kg/ha	1.68	12.69	17.91	27.30
T ₁₀ : Control (NPK 80:40:40)	1.43	8.96	14.36	20.23
F-test	NS	S	S	S
SEm±	0.05	0.39	0.59	0.96
CD (p=0.05)	-	1.167	1.763	2.845

Table 2: Effect of Nano Urea and Sulphur on crop growth rate (CGR) and relative growth rate (RGR) of sunflower across growth intervals

Treatment	CGR 20-40 DAS	CGR 40-60 DAS	CGR 60-80 DAS	RGR 20-40 DAS	RGR 40-60 DAS	RGR 60-80 DAS
T ₁ : NU 3 ml/L + S 20 kg/ha	0.18	0.19	0.31	0.06	0.02	0.02
T ₂ : NU 3 ml/L + S 25 kg/ha	0.34	0.20	0.36	0.08	0.02	0.02
T ₃ : NU 3 ml/L + S 30 kg/ha	0.25	0.20	0.30	0.07	0.02	0.02
T ₄ : NU 4 ml/L + S 20 kg/ha	0.32	0.38	0.28	0.08	0.03	0.01
T ₅ : NU 4 ml/L + S 25 kg/ha	0.49	0.28	0.37	0.09	0.01	0.01
T ₆ : NU 4 ml/L + S 30 kg/ha	0.42	0.31	0.34	0.09	0.02	0.01
T ₇ : NU 5 ml/L + S 20 kg/ha	0.38	0.27	0.28	0.08	0.02	0.01
T ₈ : NU 5 ml/L + S 25 kg/ha	0.42	0.22	0.30	0.09	0.01	0.01
T ₉ : NU 5 ml/L + S 30 kg/ha	0.55	0.26	0.46	0.10	0.01	0.02
T ₁₀ : Control (NPK 80:40:40)	0.37	0.26	0.29	0.09	0.02	0.01
F-test	S	S	S	S	S	S
SEm±	0.019	0.011	0.019	0.004	0.0006	0.0006
CD (p=0.05)	0.056	0.032	0.057	0.008	0.0014	0.0013

Conclusion

This study concludes that combined foliar and basal nutrition, using Nano Urea alongside an adequate Sulphur dose, produces comparatively markable plant growth in sunflower than basal NPK fertilization alone. Treatment T₅ (Nano Urea 4 ml/L + Sulphur 25 kg/ha) gave the tallest plants and the best relative growth rate during the crop's grand growth phase, while Treatment T₉ (Nano Urea 5 ml/L + Sulphur 30 kg/ha) produced the higher dry matter accumulation and the highest crop growth rate. Both treatments substantially outperformed the NPK-only control across every growth parameter measured, indicating that a moderate-to-high Nano Urea paired with Sulphur is a good strategy for proper vegetative growth of sunflower in the agro-climatic conditions of Prayagraj. However, multi-season and multi-location evaluations focusing on final achene yield and oil quality are warranted to substantiate these findings under broader agro-ecological conditions.

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