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IMPACT OF FOLIAR NUTRITION ON PHENOLOGICAL, MORPHOLOGICAL AND YIELD ATTRIBUTING CHARACTERS IN LENTIL

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ABSTRACT

A field experiment was conducted at the C-Block farm, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia during the *rabi* season of 2024–2025 to evaluate the effect of foliar nutrition on lentil. Lentil is one of the India's most important pulse crops, grown after the harvest of *kharif* paddy. However, delayed paddy harvesting often pushes lentil sowing beyond the optimum time, exposing the crop to moisture stress and higher temperatures during reproductive stages, which restricts yield. To address these constraints, the experiment included three genotypes—'BL-16' (G_1), 'L-4717' (G_2) and 'IPL-220' (G_3)—and four foliar treatments (Nano urea @ 4 ml/l (T_1), salicylic acid @ 100 ppm (T_2), a combination of both (T_3) and a control (water spray) (T_4)). The study followed a factorial RBD with genotypes as the first factor and treatments as the second. Results showed that nano urea combined with salicylic acid (T_3) significantly enhanced 50% flowering, 50% podding, number of pods per plant, seeds per pod and seed yield. Among genotypes, 'IPL -220' G_3 performed best under T_3, indicating its suitability for cultivation with combined foliar application of nano urea and salicylic acid may enhance lentil productivity in Gangetic West Bengal condition.
***Keywords* :** Lentil, nano urea, salicylic acid, foliar application, phenology, yield.

Introduction

Lentil (*Lens culinaris*) is an important cool season *rabi* crop and second most important pulse crop (Singh *et al*., 2014) with high protein and essential amino acids (Tripathi *et al*., 2019). India is among the world's leading producers of lentils, accounting for about 28.6% of global annual production. The crop is cultivated over 1.5 million hectares, yielding a total annual output of 1.56 million tonnes with an average productivity of 1032 kg per hectare (Ministry of Agriculture and Farmer Welfare, 2022). According to the Food and Agriculture Organization, India also ranks as the largest producer (25% of global output), consumer (27% of global consumption), and importer (19.5%) of pulses worldwide (Kumar *et al*., 2023). The majority of lentil cultivation, takes place in Madhya Pradesh, Uttar Pradesh, and West Bengal, which together account for more than 71% of national production. In West Bengal, lentils are grown on about 0.57 lakh hectares, producing 0.47 lakh tonnes with an average productivity of 9.11 q/ha (Hazra and Basu, 2023). Lentil contains protein twice that of cereals and provides a high source of protein for humans (Salaria *et al*., 2022). It adapts well to a wide range of climatic conditions, from temperate to tropical and humid to arid regions. It has highest capacity for nitrogen fixation, deep root systems, and efficient utilization of rainfall and for enhancing the stability and sustainability of agricultural production systems (Erskine *et al*., 2009). Although lentil is typically cultivated in rice fallow areas by utilizing residual soil moisture under rainfed conditions within the rice–lentil cropping system (Malik, 2016), several factors such as delayed sowing due to late rice harvest, rapid soil moisture loss, declining water levels, rising temperatures, and mid- to terminal-stage droughts during flowering and pod filling can significantly reduce lentil productivity (Baidya *et al*., 2021; Venugopalan *et al*., 2021) and adversely affects reproductive biology, yield components, and overall productivity (Kumari *et al.*, 2018; Maji *et al.*, 2022). Foliar nutrition has proven to be highly effective, especially in regions where soil-based fertilizer application results in nutrient loss or fixation. It serves as an efficient alternative when the rapid supply of nutrients is restricted or when soil conditions hinder nutrient uptake (Salisbury and Ross, 1985). Through foliar spraying, nutrients are delivered directly to the site of photosynthesis, ensuring minimal wastage, quicker nutrient availability, and reduced fertilizer requirements. This method can also promote rapid crop growth within a short period. Since, nodulation activity generally ceases 45 to 50 days after sowing, supplying plants with additional nitrogen through foliar feeding has been found to enhance growth and increase seed yield by providing a quick nitrogen source (Ashour and Thalooth, 1983; Attia and El-Dsouky, 2001; El-Karmany *et al.*, 2003; El-Kramany and Gobarah, 2005). Foliar application of urea at 50% flowering significantly improved yield and seed protein content. In legumes, early onset of leaf senescence before crop maturity disrupts the source-sink relationship, leading to yield reduction. Foliar nitrogen sprays have been shown to delay senescence and consequently improve yield. (Zhou and Yang, 2023). Keeping in mind the addressed problem, the present research work was conducted to assess the impact of foliar nutrition on phenological and morphological characters in lentil under gangetic West Bengal condition.

Materials and Methods

The experimental study was conducted during *rabi* season 2024-2025 at Bidhan Chandra Krishi Viswavidyalaya, C-Block farm, Nadia, West Bengal situated at $22^0$59' 13" N latitude and $88^0$27' 17" E longitude with an altitude of 9.75 m above the mean sea level under new alluvial zone. Experimental field was fairly levelled medium land with good drainage facilities. Seeds of lentil variety *viz*, 'BL-16' (G_1), 'L-4717' (G_2) and 'IPL-220' (G_3) were collected from MULLaRP project, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal. The experiment was laid out in a factorial RBD design with three genotypes as first factor and four treatments as second factor. The genotypes were 'BL-16'(G_1), 'L-4717' (G_2) and 'IPL-220' (G_3) and the treatments were spraying of Nano Urea @ 4ml/l of water (T_1); Spraying of salicylic acid @ 100ppm (T_2); combination of T_1 and T_2 (T_3); Control (water spray) (T_4). Spraying was done at the time of 50% flowering stage. Seeds were sown in replicated plot (thrice) with the spacing of 22.5cm row to row and 10cm between plant to plant. Chemical fertilizers, N: P_2O_5: K_2O were applied @ 20:40:40 kg/ha during final land preparation. First and second weeding was done at 20 and 40 DAS.

Data on phenological characters *viz.* first flowering (days), 50% flowering (days), 50% podding (days), days to maturity, morphological characters *viz.* plant height, number of primary branches, number of pods plant^{-1}, number of seeds pod^{-1}, 100 seed weight (g), seed yield (kg/ha) were recorded. Data from field experiments were subjected to statistical analysis following the principle and procedure by Panse and Sukhatme (1978).

Results and Discussion

Phenological and morphological characters

Days to first flowering: It was observed from Table 1 that, days to first flowering were significantly influenced by genotypes, with the earliest duration recorded in genotype G_3 (43.58 days). However, treatments are statistically non-significant, though the earliest flowering was noted in T_2 (48.74 days). Among the treatment combinations, G_3T_3 exhibited the earliest flowering (43.00 days). G_2 took maximum days to first flowering (56.44 days), T_1 recorded maximum days to first flowering (49.22 days) and incase of combinations G_3T_1 recorded the maximum days to first flowering (56.89 days).

Days to 50% flowering: A similar pattern as like days to first flowering was observed for days to 50% flowering (Table 1). There was significant difference among the genotypes, treatments and the interaction between genotypes and treatments. Genotype G_3 exhibited earliest days for 50% flowering (49.39 days). Among the treatments, T_1 recorded the minimum values (57.00 days) and among the genotype-treatment combinations, G_3T_3 exhibited the shortest duration for 50% flowering (43.00 days).

Days to 50% podding

There was significant difference among the genotypes, treatments and the interaction between genotypes and treatments. Minimum number of days to 50% podding was observed in genotype G_3 (59.71 days), T_3 (67.23 days) and in interaction between genotypes and treatments G_3T_3 (57.64 days) (Table 1). Maximum days to 50% podding was observed in genotype G_2 (80.52 days), T_4 (72.42 days) and in treatment combinations G_2T_4 (82.38 days).

Days to maturity: In the case of days to maturity, significant variation was observed among genotypes and treatments. Among the interaction between genotypes and treatments, there was non-significant variation (Table 1). Genotype G_2 recorded the minimum duration for maturity (128.61 days), while among the treatments, T_3 showed the shortest maturity period (124.59 days). The combination G_1T_3 exhibited the least days to maturity (125.33 days). The improvement in these phenological traits can be attributed to the foliar application of nano urea and salicylic acid, which had a pronounced effect, particularly evident in the days to maturity. Similar results were reported by Fatema (2010). The reduction in the number of days to maturity observed under these treatments may be attributed to the improved physiological efficiency and nutrient utilization brought about by the foliar application of nano urea and salicylic acid. Nano urea, owing to its high surface area and superior nutrient absorption capacity, provides a consistent and balanced nitrogen supply during critical growth stages. This facilitates enhanced photosynthetic activity, accelerates reproductive development, and ultimately shortens the overall crop duration (Chaudhary *et al*., 2025). Similarly, salicylic acid functions as a signaling compound that strengthens plant tolerance to abiotic stress, promotes chlorophyll stability, and modulates enzyme activities associated with flowering and maturity (Song *et al*., 2023).

Several researchers have reported the beneficial role of foliar applications in influencing crop phenology. Fatema (2010) observed that foliar feeding of nutrients and growth regulators, particularly salicylic acid, significantly advanced flowering and maturity in legumes, ensuring better synchronization of reproductive stages. Correspondingly, Singh *et al.* (2013) demonstrated that foliar application of nano urea improved nitrogen use efficiency and promoted early maturity in both pulses and cereals. These findings corroborate the present results, emphasizing that the combined use of nano urea and salicylic acid through foliar spraying enhances nutrient metabolism, accelerates developmental transitions, and leads to earlier physiological maturity.

Plant height (cm): Growth attributes such as plant height were significantly influenced by different genotypes and treatments (Table 1). The maximum plant height was observed in genotype G_2 (27.47 cm) and treatment T_2 (25.56 cm), with the combinations G_2T_2 (28.44 cm) and G_2T_3 (28.11cm) showing statistically similar values. The lowest plant height was recorded in genotype G_3 (20.06 cm), treatment T_4 (21.96cm), and combinations G_3T_4 (18.11 cm) and G_3T_3 (18.44 cm). Similar findings were reported by Singh *et al.* (2012) and Samanta *et al.* (2024) while working on lentil and brassica.

No of primary branches: Maximum number of primary branches was also obtained from genotype G_2 (3.65), treatment T_2 (3.67), and combinations G_2T_2 (4.04) and G_2T_3 (4.04), following a trend similar to that of plant height (Table 1). Foliar nutrition of the lentil crop with nano urea and salicylic acid enhanced both plant height and the number of primary branches. This improvement can be attributed to better nourishment, which promotes cell division, photosynthetic efficiency, and vegetative growth (Singh *et al*., 2013). Hence, the early maturity recorded in G_2, T_3, and G_1T_3 treatment combinations underscores the synergistic influence of genotype potential and foliar nutrient management in improving physiological efficiency and expediting crop maturity.

Seed yield and attributing characters

Number of pods per plant: The maximum number of pods per plant was recorded in genotype G_3 (62.67), treatment T_3 (74.74), and the combination G_3T_3 (77.22). In contrast, the minimum number of pods per plant was observed in G_2 (61.50), T_1 (61.33), and the combination G_1T_4 (45.00) (Table 2). Similar findings were reported by Mohammed *et al.* (2016). The number of pods per plant is a key yield-contributing trait, as it directly influences the overall yield potential of the crop. In the present study, the higher pod number recorded in T_3 and the combination G_1T_3 reflects the synergistic effect of nano urea and salicylic acid in improving nutrient efficiency and reproductive vigor. The results clearly indicate that the number of pods per plant, being a major yield determinant, responds positively to foliar nutrient management, leading to enhanced productivity and better crop performance.

Number of seeds per pod: The number of seeds per pod showed significant variation among the different genotypes and treatments (Table 2). Maximum number of seeds per pod was observed in G_2 (1.42), G_3 (1.43), T_3 (1.64), and the combination G_3T_3 (1.69), while the lowest values were recorded in G_1 (1.37), T4 (1.18), and the combination G_1T_4 (1.17). These results are consistent with the observations of Mohammed *et al.* (2016) and Kumar *et al.* (2019), who reported that the number of seeds per pod is primarily influenced by the genotype and can be further improved through proper nutrient management and favorable environmental conditions. The superior performance observed under treatment T_3 could be attributed to enhanced nutrient uptake and utilization, which may have promoted better flower retention and successful fertilization. Therefore, the interaction between genotype and treatment is vital in enhancing reproductive efficiency and maximizing yield potential.

100 seed weight (g): The 100-seed weight exhibited significant variation among the genotypes and treatments but it exhibited the non-significant difference between the interactions (Table 2). The highest seed weight was recorded in G_3 (1.47g), T_3 (1.52g), and in their interaction between genotypes and treatments G_3T_3 (1.54g), while the lowest 100 seed weight was observed in G_1 (1.43g), T_4 (1.46g), and in the combination G_1T_4 (1.35g). These results are consistent with the findings of Rani *et al.* (2018) and Kumar *et al.* (2020), who reported significant differences in seed weight among genotypes, attributing them to variations in genetic potential and nutrient use efficiency. The higher seed weight observed under treatment T_3 may be due to improved nutrient absorption, enhanced photosynthetic performance, and efficient translocation of assimilates to the developing seeds. Therefore, the interaction between genotype and treatment plays a crucial role in promoting better seed development and enhancing overall yield quality.

Seed yield (kg/ha): Seed yield per hectare increased with the foliar application of nano urea and salicylic acid compared to the control (T_4). A significant variation in seed yield was observed among the different genotypes and treatment combinations (Table 2). The highest seed yield was recorded in genotype G_3 (1238 kg/ha) followed by G_2 (1144 kg/ha), treatment T_3 (1534 kg/ha), and the combination G_3T_3 (1630 kg/ha), whereas the lowest yield was obtained from genotype G_2 (1144 kg/ha), treatment T_4 (940 kg/ha), and the combination G_1T_4 (837 kg/ha). These results are consistent with the findings of Patel *et al.* (2021) and Sharma *et al.* (2022), who reported that foliar application of nano urea and salicylic acid significantly enhanced seed yield in legumes by improving photosynthetic activity, nutrient utilization efficiency, and stress resilience. The superior performance observed under treatment T_3 indicates that timely foliar application ensures an adequate nutrient supply during critical growth stages, thereby promoting better reproductive growth and higher yield. Thus, the interaction between genotype and foliar nutrient management is crucial for achieving maximum yield potential in lentil production.

Conclusion

The study demonstrated that both genotypes and foliar nutrient treatments had a significant impact on the growth, phenological, and yield characteristics of lentil. Genotype G_2 exhibited superior vegetative growth, whereas G_3 excelled in reproductive performance and yield potential. Among the treatments, foliar application of nano urea and salicylic acid (T_3) proved most effective, enhancing plant height, branching, and promoting early flowering and maturity, which collectively contributed to higher seed yield and yield components. The combined application of nano urea and salicylic acid improved nutrient absorption, photosynthetic efficiency, and stress resilience, indicating that timely foliar feeding is a key strategy for improving growth, advancing physiological maturity, and achieving higher productivity in lentil cultivation. Foliar application of nano urea and salicylic acid (T_3) can be recommended for enhancing growth, early maturity, and yield in lentil. Considering both genotypes and treatments it can be concluded that genotype G_3 with timely foliar nutrition can further improve productivity and resource use efficiency.

Table 1: Phenological characters as influenced by foliar nutrition

	First flowering (days)	50% flowering (days)	50% podding (days)	Days to maturity	Plant height (cm)	No. of primary branches
G_1	46.75	55.08	68.08	131.36	22.42	3.12
G_2	56.44	65.83	80.52	128.61	27.47	3.65
G_3	43.58	49.39	59.71	130.39	20.06	3.27
SEm (±)	**0.157**	**0.308**	**0.533**	**0.689**	**0.592**	**0.041**
CD (p=0.05)	**0.472**	**0.924**	**1.598**	**2.066**	**1.775**	**0.124**
T_1	49.22	57.00	69.57	131.22	23.07	3.27
T_2	48.74	57.11	68.54	128.11	25.56	3.67
T_3	48.82	55.37	67.23	124.59	22.67	3.27
T_4	48.93	57.59	72.42	136.56	21.96	3.17
SEm (±)	**0.233**	**0.106**	**0.241**	**0.535**	**0.443**	**0.046**
CD (p=0.05)	**NS**	**0.302**	**0.684**	**1.518**	**1.257**	**0.130**
G_1T_1	45.89	55.56	67.56	132.33	21.44	3.00
G_1T_2	46.78	55.33	66.44	130.00	25.44	3.20
G_1T_3	46.89	53.67	65.22	125.33	21.00	3.20
G_1T_4	47.44	55.78	73.11	137.78	21.78	3.06

G_2T_1	56.89	65.89	80.76	130.00	26.89	3.93
G_2T_2	56.22	66.44	80.13	126.45	28.44	4.04
G_2T_3	56.56	64.11	78.82	123.00	28.11	4.04
G_2T_4	56.11	66.89	82.38	135.00	26.44	2.59
G_3T_1	44.89	49.56	60.40	131.33	20.89	2.87
G_3T_2	43.22	49.56	59.04	127.89	22.78	3.78
G_3T_3	43.00	48.33	57.64	125.44	18.44	3.73
G_3T_4	43.22	50.11	61.76	136.89	18.11	2.69
Interaction	**G x T**	**G x T**	**G x T**	**G x T**	**G x T**	**G x T**
SEm (±)	**0.404**	**0.184**	**0.418**	**0.927**	**0.443**	**0.079**
CD (p=0.05)	**1.145**	**0.523**	**1.185**	**NS**	**1.257**	**0.225**
CD: Critical Difference, SE: Standard Error of Mean (±), NS: Non-significant						

Table 2: Seed yield attributing characters as influenced by foliar nutrition

	No. of pods plant^{-1}	No. of seeds pod^{-1}	100 Seed weight (g)	Seed yield (kg/ha)
G_1	62.64	1.37	1.43	1196
G_2	61.50	1.42	1.45	1144
G_3	62.67	1.43	1.47	1238
SEm (±)	**0.130**	**0.005**	**0.003**	**5.259**
CD (p=0.05)	**0.510**	**0.014**	**0.008**	**15.769**
T_1	61.33	1.37	1.44	1089
T_2	67.22	1.42	1.50	1207
T_3	74.74	1.64	1.52	1534
T_4	45.78	1.18	1.36	940
SEm (±)	**0.289**	**0.006**	**0.004**	**8.625**
CD (p=0.05)	**0.820**	**0.017**	**0.010**	**24.461**
G_1T_1	60.00	1.34	1.43	1113
G_1T_2	68.33	1.39	1.45	1209
G_1T_3	73.67	1.57	1.49	1468
G_1T_4	45.00	1.17	1.35	837
G_2T_1	63.00	1.38	1.44	1060
G_2T_2	67.33	1.44	1.47	1174
G_2T_3	73.33	1.67	1.52	1504
G_2T_4	47.00	1.20	1.36	995
G_3T_1	61.00	1.39	1.46	1094
G_3T_2	66.00	1.45	1.49	1239
G_3T_3	77.22	1.69	1.54	1630
G_3T_4	45.33	1.18	1.37	989
Interaction	**G x T**	**G x T**	**G x T**	**G x T**
SEm (±)	**0.501**	**0.011**	**0.006**	**14.939**
CD (p=0.05)	**1.420**	**0.030**	**NS**	**42.367**
CD: Critical Difference, SE: Standard Error of Mean (±), NS: Non-significant				

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