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Pratibha Goud
Department of Plant Physiology,
College of Agriculture, JNKVV,
Jabalpur, Madhya Pradesh, India

Gyanendra Tiwari
Department of Plant Physiology,
College of Agriculture, JNKVV,
Jabalpur, Madhya Pradesh, India

Vibha Pandey
Department of Plant Pathology,
College of Agriculture, JNKVV,
Jabalpur, Madhya Pradesh, India

R Shiv Rama Krishnan
Department of Plant Physiology,
College of Agriculture, JNKVV,
Jabalpur, Madhya Pradesh, India

Yogendra Singh
Department of Genetics & Plant
Breeding, College of Agriculture,
JNKVV, Jabalpur, Madhya
Pradesh, India

Sachin Nagre
Department of Plant Physiology,
College of Agriculture, JNKVV,
Jabalpur, Madhya Pradesh, India

Ankita Singh
Department of Plant Physiology,
College of Agriculture, JNKVV,
Jabalpur, Madhya Pradesh, India

Kumar Jai Anand
Department of Genetics & Plant
Breeding, College of Agriculture,
JNKVV, Jabalpur, Madhya
Pradesh, India

Corresponding Author:
Gyanendra Tiwari
Department of Plant Physiology,
College of Agriculture, JNKVV,
Jabalpur, Madhya Pradesh, India

Comparative performance of biological vs synthetic growth modulators on growth and reproductive development of Lentil (*Lens culinaris* Medik.) varieties

Pratibha Goud, Gyanendra Tiwari, Vibha Pandey, R Shiv Rama Krishnan, Yogendra Singh, Sachin Nagre, Ankita Singh and Kumar Jai Anand

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Abstract

Pot experiments were conducted during the *Rabi* seasons of 2024-25 and 2025-26 at the Department of Plant Physiology, College of Agriculture, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh, India, to assess the comparative efficacy of plant based and synthetic growth modulators on growth and reproductive development of lentil (*Lens culinaris* Medik.) varieties. The experiment was laid out in a Factorial Completely Randomized Block Design with three replications, comprising two varieties, L 4717 (V₁-small seeded) and L 4727 (V₂-bold seeded), and eleven modulator treatments. The treatments included RKN-affected plant extract control (water-spray), (RKN) at 10, 20 and 30 ppm, wilt-affected plant extract (WAPE) at 10, 20 and 30 ppm, salicylic acid at 100 and 200 ppm, and Trichoderma @ 6 g kg⁻¹, fungicide (Carbendazim + Mancozeb) @ 2 g kg⁻¹. Modulators were applied at the four-leaf stage and again before floral initiation. Growth and reproductive responses were assessed through plant height, branches, no. of nodes, leaves and pods at different developmental stages. Significant variation was observed among varieties, modulators and their interactions. L 4727 (V₂) exhibited greater plant height, reaching 26.68 cm at maturity, whereas L 4717 (V₁) showed greater branching and pod production during later development. Among modulators, RKN @ 10 ppm produced the most consistent response, recording maximum pooled plant height at 60 DAS (24.08 cm) and maturity (25.39 cm), branches at 60 DAS (5.21 plant⁻¹), leaves at 60 DAS (47.19 plant⁻¹) and maturity (43.55 plant⁻¹), and pods at maturity (23.02 plant⁻¹). WAPE @ 10 ppm produced the highest pod number at 60 DAS (11.84 plant⁻¹), whereas Trichoderma @ 6 g kg⁻¹ promoted early plant height (15.00 cm at 30 DAS). The strongest interaction response was observed in L 4717 × RKN (V₁T₂) @ 10 ppm, producing 5.75 branches, 53.71 leaves and 23.73 pods plant⁻¹ at the respective developmental stages. Overall, RKN @ 10 ppm, particularly in L 4717, demonstrated considerable potential for improving lentil plant architecture and reproductive sink establishment.

Keywords: Lentil, biological modulators, synthetic modulators, Root Knot Nematode (RKN) affected plant extract, WAPE (Wilt Affected Plant Extract)

Introduction

Lentil (*Lens culinaris* Medik.) is an important *rabi*-season food legume valued for its nutritional, economic and agronomic significance. The crop is widely cultivated under diverse environments and contributes substantially to dietary protein and nutritional security. Its seeds are rich in protein and contain appreciable amounts of carbohydrates, dietary fibre, minerals and other nutritionally important compounds. The productivity of lentil, however, is strongly influenced by environmental conditions, genotype and crop management. Significant genotypic variation in physiological responses to drought and other environmental stresses has been reported in lentil, indicating considerable scope for improving crop performance through physiological and agronomic interventions (Mishra *et al.*, 2016; Sehgal *et al.*, 2017; Dash *et al.*, 2020) ^[1, 2, 4].

Lentil productivity represents the integrated outcome of phenological development, canopy establishment, photosynthetic activity, biomass accumulation and partitioning towards reproductive organs. The establishment and maintenance of an efficient photosynthetic canopy are particularly important because leaf development and biomass accumulation determine the assimilatory capacity of the crop, while reproductive development governs the conversion of

assimilates into pods and seeds. Mondal *et al.* (2014) [5] demonstrated considerable variation in growth and dry-matter partitioning among plant parts of lentil, whereas Whitehead *et al.* (2000) [6] emphasized the importance of biomass and nitrogen accumulation and their partitioning in determining lentil productivity. Environmental stresses can further modify relative water content, chlorophyll concentration and osmotic adjustment, thereby influencing the maintenance of photosynthetic activity and reproductive development (Dash *et al.*, 2017; Dash *et al.*, 2020) [3, 4].

Biological and synthetic modulators offer promising approaches for regulating crop growth and improving plant performance under variable growing conditions. Plant growth regulators can influence cell division and expansion, shoot development, flowering, pod formation, assimilate partitioning and yield formation in lentil, (Giannakoula *et al.*, 2012; Prasad *et al.*, 2023) [7, 8]. These findings indicate that manipulation of plant developmental processes through exogenous modulators can substantially alter the source-sink relationship and reproductive performance of lentil. Many modulators were tested in linseed by many scientist, viz., in SA (Kayednezami *et al.*, 2012; Laishram *et al.*, 2020; Dhar *et al.*, 2025), in *Trichoderma* (Rai (2019) Javeria *et al.* (2020) Marra *et al.* (2021), Plant extracts against root knot and wilt diseases (Sunarto *et al.*, 2019; De Kesel *et al.*, 2022; Fought and Kuć, 1996; Gawande *et al.*, 2015, and Wilt infected plant extract as modulators in chickpea (Thakur *et al.*, 2025) [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20]

Previous studies have demonstrated that growth regulators, microbial preparations and plant-derived inputs can differentially influence lentil growth, photosynthetic pigments, biomass accumulation and reproductive performance (Karpenko *et al.*, 2019; Prasad *et al.*, 2023) [8, 19]. Consequently, evaluating multiple growth and reproductive traits at successive developmental stages provides a more meaningful assessment of the physiological consequences of biological and synthetic treatments.

Despite considerable research on individual plant growth regulators, salicylic acid, microbial inoculants and plant-derived preparations, comparative information on biological, plant based and synthetic modulators evaluated within a common experimental framework, particularly across contrasting lentil genotypes, remains limited. Furthermore, the differential response of lentil genotypes to affected-plant extracts and their potential influence on vegetative architecture and reproductive sink establishment remain insufficiently characterized. Therefore, the present investigation was conducted to evaluate the responses of contrasting lentil genotypes to selected biological and synthetic modulators, with emphasis on plant growth, canopy development and reproductive attributes, and to identify modulator-genotype combinations capable of promoting favourable plant architecture and reproductive sink establishment.

Materials and Methods

Pot experiments were conducted in 2x11 factorial randomized design with three replications during the rabi seasons of 2024-25 and 2025-26 at the Department of Plant Physiology, College of Agriculture JNKVV, Jabalpur, Madhya Pradesh, India. The experiment comprised of two contrasting lentil (*Lens culinaris* Medik.) varieties, L 4717 (V₁-small seeded) and L 4727 (V₂-bold seeded) and 11 modulators (i.e., T₁, control (water spray); T₂, RKN-affected plant extract @ 10 ppm; T₃, RKN-affected plant extract @ 20 ppm; T₄, RKN-affected plant extract @ 30 ppm; T₅, wilt-affected plant extract (WAPE) @ 10 ppm; T₆, WAPE @ 20 ppm; T₇, WAPE @ 30 ppm; T₈, salicylic acid @ 100 ppm; T₉, salicylic acid @ 200 ppm; T₁₀, *Trichoderma* @ 6 g kg⁻¹; and T₁₁,

fungicide @ 2 g kg⁻¹. Each pot had an area of approximately 0.138 m², a diameter of 0.42 m, and contained approximately 30 kg soil. The modulators were applied at two critical developmental stages, namely the four-leaf stage and immediately before floral initiation, as specified in the experimental programme.

Growth and reproductive development were monitored at defined developmental stages. Plant height (cm), number of branches plant⁻¹, number of nodes plant⁻¹ and number of leaves plant⁻¹ were recorded at 30, 60 DAS and maturity. The present study focused on the available observations at 30 and 60 DAS and maturity. Number of pods plant⁻¹ was recorded at 60 DAS and maturity. Measurements were made on representative plants from each experimental unit, and treatment means were calculated for statistical analysis.

Statistical analysis

The experimental data were statistically analyzed using the Factorial Completely Randomized Design (FCRD) following the standard statistical procedures described by Fisher, R. A. (1935) and Cochran, W. G. and Cox, G. M. (1957). The analysis of variance (ANOVA) was carried out to determine the significance of the effects of individual factors and their interaction. Where the treatment effects were found to be significant, the appropriate critical difference (CD) was used for comparison of treatment means.

Results and Discussion

The present investigation revealed substantial variation in the growth and reproductive behaviour of lentil in response to genotype and application of biological and synthetic modulators. The magnitude of response varied with developmental stage, modulator type and concentration, and significant variety × modulator interactions were observed for several growth attributes. This indicates that the tested modulators did not act as generalized growth promoters; rather, their effects were expressed through genotype-dependent and stage-specific modifications of plant development. Such differential responsiveness is consistent with earlier studies in lentil showing that exogenous regulators can modify plant architecture, biomass accumulation and reproductive development, but the most effective treatment for vegetative growth is not necessarily the most effective for reproductive productivity (Effendi *et al.*, 1989; Giannakoula *et al.*, 2012; Prasad *et al.*, 2023) [7, 8]. The present experiment therefore provides evidence that comparative evaluation of biological and synthetic modulators can reveal treatment-specific physiological responses that may ultimately influence source establishment and sink development.

Plant height increased progressively from 30 DAS to maturity, although the relative performance of the two varieties differed with crop age. L 4727 (bold seeded) was significantly taller than L 4717 (small seeded) in the pooled analysis at 30 DAS, recording 14.47 and 13.82 cm, respectively. Among the modulators, *Trichoderma* @ 6 g kg⁻¹ produced the maximum pooled plant height of 15.00 cm, followed by fungicide @ 2 g kg⁻¹ (14.64 cm), whereas WAPE @ 30 ppm recorded the minimum (13.66 cm). The significant variety × modulator interaction, with L 4727 × fungicide @ 2 g kg⁻¹ recording 15.71 cm, demonstrated that shoot elongation was strongly dependent on genotype-specific treatment response. At 60 DAS, the superiority of L 4727 was maintained, with a pooled plant height of 22.93 cm compared with 21.09 cm in L 4717. RKN @ 10 ppm produced the highest pooled treatment mean (24.08 cm), while WAPE @ 10 ppm recorded the lowest (20.06 cm). At maturity, L 4727 attained 26.68 cm compared with 21.52 cm in L 4717, while RKN @ 10 ppm

maintained a high pooled value of 25.39 cm. The response pattern is broadly comparable with the findings of Prasad *et al.* (2023) ^[8], who observed marked differences among synthetic PGRs for plant height in lentil, with GA₃ promoting shoot elongation. Similarly, Dhar *et al.* (2025) ^[11] reported enhanced early plant height following physiological modulator application. However, the present results are physiologically important because the treatment producing maximum height was not consistently superior for other components of plant architecture. This indicates that increased shoot elongation alone cannot be considered an adequate indicator of treatment effectiveness.

Branch development exhibited a pronounced developmental shift between the two varieties. L 4727 initially produced more branches at 30 DAS, with a pooled value of 3.51 branches plant⁻¹ compared with 3.24 in L 4717. However, L 4717 subsequently expressed greater branching at 60 DAS and maturity, recording 4.26 and 4.83 branches plant⁻¹, respectively, compared with 3.90 and 4.42 in L 4727. RKN @ 10 ppm produced the highest pooled branching at 30 DAS (4.10) and 60 DAS (5.21), whereas RKN @ 30 ppm recorded the maximum treatment mean at maturity (5.33). The most pronounced interaction response was observed in L 4717 × RKN @ 10 ppm, which produced 5.75 and 5.76 branches plant⁻¹ at 60 DAS and maturity, respectively. The improvement in branching is consistent with previous reports that physiological modulators can modify lentil shoot architecture. Seaweed extracts increased branches plant⁻¹ in late-sown lentil (Mallikarjun and Jata, 2019), while Laishram *et al.* (2020) ^[10] observed improved branching following SA application. Dhar *et al.* (2025) ^[11] similarly reported marked enhancement of branching under SA treatment. In the present experiment, however, the stronger response of L 4717 to RKN @ 10 ppm suggests that the biological response was not solely treatment-driven but depended on the inherent developmental characteristics of the genotype. From a physiological standpoint, greater branch production increases the potential number of sites for leaf initiation and reproductive development and may consequently influence sink establishment. Node production further demonstrated that plant height and architectural development were not necessarily governed by identical treatment responses. L 4717 recorded significantly more nodes at 30 and 60 DAS, with pooled values of 8.93 and 14.88 nodes plant⁻¹, respectively, compared with 8.56 and 13.04 in L 4727. At maturity, however, L 4727 recorded significantly more nodes (13.84) than L 4717 (12.85). At 60 DAS, RKN @ 30 ppm produced the highest treatment mean (14.99 nodes plant⁻¹), while the interaction L 4717 × WAPE @ 10 ppm reached 17.24 nodes plant⁻¹. The stage-dependent reversal between varieties suggests differences in the temporal regulation of node initiation and subsequent shoot development. Because nodes represent developmental positions from which leaves and reproductive structures arise, their accumulation provides an important component of canopy and sink establishment. Earlier work has demonstrated substantial genotypic differences in lentil architecture, biomass accumulation and partitioning, with these differences being associated with productivity (Whitehead *et al.*, 2000; Mondal *et al.*, 2014) ^[5, 6]. The present findings therefore suggest that the tested modulators may have altered the developmental trajectory of the crop rather than simply increasing overall vegetative size.

Leaf production provided further evidence of this developmental plasticity. At 30 DAS, varietal differences were non-significant, whereas significant treatment differences were observed. Salicylic acid @ 100 ppm produced the highest pooled leaf number (28.96 plant⁻¹), followed by SA @ 200 ppm (28.26 plant⁻¹). At 60 DAS, L 4717 produced substantially more leaves

than L 4727, with pooled values of 43.26 and 37.15 plant⁻¹, respectively. RKN @ 10 ppm produced the highest treatment mean (47.19 leaves plant⁻¹), and the L 4717 × RKN @ 10 ppm combination recorded 53.71 leaves plant⁻¹. At maturity, the varietal ranking reversed, with L 4727 recording 40.00 leaves plant⁻¹ compared with 31.28 in L 4717. The highest interaction value was observed in L 4727 × SA @ 100 ppm (53.18 leaves plant⁻¹). The reversal in leaf number between 60 DAS and maturity is particularly relevant physiologically because the final number of leaves reflects both leaf initiation and leaf persistence. Thus, the greater leaf number of L 4727 at maturity may indicate a greater capacity for maintenance of the assimilatory canopy, whereas the higher mid-season leaf number of L 4717 may reflect more rapid vegetative development during the active growth phase. Previous studies have shown that biological preparations and plant growth regulators can modify photosynthetic pigment accumulation and canopy development in lentil (Karpenko *et al.*, 2019; Prasad *et al.*, 2023) ^[8, 19]. The present results extend these observations by demonstrating that such responses may differ considerably between developmental stages and genotypes.

The transition from vegetative development to reproductive establishment was reflected most clearly in pod formation. At 60 DAS, L 4717 produced significantly more pods plant⁻¹ than L 4727, with pooled values of 11.83 and 8.55, respectively. WAPE @ 10 ppm produced the highest treatment mean (11.84 pods plant⁻¹), closely followed by RKN @ 10 ppm (11.75 pods plant⁻¹). The L 4717 × RKN @ 10 ppm combination produced 14.22 pods plant⁻¹, demonstrating a strong genotype-specific reproductive response. At maturity, L 4717 maintained its superiority, producing 18.88 pods plant⁻¹ compared with 17.10 in L 4727. RKN @ 10 ppm produced the highest pooled treatment mean (23.02 pods plant⁻¹), while L 4717 × RKN @ 10 ppm recorded the maximum interaction value of 23.73 pods plant⁻¹. These results are consistent with previous findings that physiological modulators can influence reproductive sink formation in lentil. Mallikarjun and Jata (2019) reported increased pod production following seaweed extract application, while Azarnia *et al.* (2020) demonstrated significant effects of GA₃ and SA, alone and in combination with mycorrhizal inoculation, on pod formation, filled-pod ratio and seed yield. Prasad *et al.* (2023) ^[8] further showed that the regulator producing maximum vegetative growth was not necessarily the treatment producing maximum pod number and yield. The present response of RKN @ 10 ppm is therefore particularly important because it combined favourable vegetative attributes with enhanced reproductive establishment.

The association between vegetative architecture and pod formation provides an important physiological interpretation of the present findings. L 4717 × RKN @ 10 ppm repeatedly showed high values for branches, leaves and pods, suggesting that the treatment may have established a favourable source-sink framework before and during reproductive development. Greater branch and leaf development can increase the potential photosynthetic surface, while greater node production provides additional sites for reproductive development. Nevertheless, these morphological observations should not be interpreted as direct evidence of increased photosynthetic carbon assimilation or assimilate partitioning. Lentil productivity depends not only on biomass production but also on the efficiency with which assimilates are transferred towards reproductive sinks. Whitehead *et al.* (2000) ^[6] emphasized the importance of biomass partitioning in lentil productivity, while Zakeri and Bueckert (2015) demonstrated that a major proportion of dry matter and nitrogen accumulation occurs after flowering and is ultimately concentrated in reproductive structures. Thus, the superior pod

production observed in the present experiment provides a strong basis for examining whether the corresponding treatments also improved physiological source activity during reproductive development.

The response of *Trichoderma* in the present experiment deserves separate physiological consideration. *Trichoderma* @ 6 g kg⁻¹ produced the highest plant height at 30 DAS and a comparatively high leaf number, indicating a favourable effect during early crop establishment. Previous research has established that *Trichoderma* in lentil may function beyond pathogen suppression. Rai (2019) [12] reported improvements in growth, nodulation and yield-related characteristics following *Trichoderma* application, while Marra *et al.* (2021) [14] demonstrated that specific *Trichoderma* strains and their metabolites could improve plant growth, seed production and mineral accumulation. Javeria *et al.* (2020) [13] also established strong antagonistic activity of selected isolates against *Fusarium oxysporum* f. sp. *lentis*. The early growth response observed in the present experiment is therefore compatible with the dual role of *Trichoderma* as a biological protection agent and plant-growth-promoting microorganism. However, because disease incidence and root colonization were not measured as components of the present growth analysis, the exact mechanism responsible for the observed response cannot be distinguished.

The response to salicylic acid also agrees with the established role of SA as a physiological signalling molecule. In the present experiment, SA @ 100 ppm produced the highest leaf number at 30 DAS, while its interaction with L 4727 produced the maximum leaf number at maturity. Previous studies have shown that SA can improve growth, yield attributes and physiological performance of lentil under adverse environmental conditions. Kayednezami *et al.* (2012) [9] reported improved growth and yield under salinity following foliar SA application, while Laishram *et al.* (2020) [10] observed increased plant height, branching, biomass and pod production following SA-based treatment. Dhar *et al.* (2025) [11] further reported enhanced branching, pod-bearing capacity and chlorophyll status under SA application. Therefore, the higher leaf retention observed in L 4727 × SA @ 100 ppm at maturity may be physiologically relevant because maintenance of a functional canopy during reproductive development is essential for sustaining carbon assimilation. Confirmation of this interpretation, however, requires corresponding measurements of chlorophyll content, photosynthetic rate and canopy senescence. The most distinctive aspect of the present study is the inclusion of WAPE and RKN-affected plant extract as biological modulators. Direct evidence concerning RKN-affected plant extract in lentil was not identified in the reviewed literature; therefore, the present results should be interpreted as novel rather than as confirmation of an established lentil response. Nevertheless, previous work provides a mechanistic context for the broader concept of plant-

derived extracts as biological elicitors. Sunarto *et al.* (2019) [15] demonstrated that botanical extracts could reduce root-knot nematode development and stimulate systemic resistance, while De Kesel *et al.* (2022) [16] showed that plant-derived extracts could simultaneously suppress *Meloidogyne* infection and induce host defence responses involving ethylene, reactive oxygen species and cell-wall-associated processes. These studies used extracts from healthy plant material and therefore should not be presented as direct evidence for RKN-affected plant extract. Instead, they support the broader proposition that plant-derived preparations can contain biologically active compounds capable of modifying host physiology.

Evidence from wilt-affected plant extracts provides a closer conceptual parallel to the present experiment. Thakur (2025) [20], in a study conducted at JNKVV, Jabalpur, demonstrated that sterilized *Fusarium*-wilt-affected plant extract at 20 ppm induced tolerance against *Fusarium* wilt in chickpea and improved photosynthetic rate, chlorophyll content and water-use efficiency, together with enhanced proline accumulation and ROS-scavenging activity. Earlier investigations also showed that plant extracts could induce systemic resistance and improve growth under pathogen pressure (Fought and Kuć, 1996; Gawande *et al.*, 2015; Akladios *et al.*, 2015) [17, 18]. These findings are particularly relevant to the present experiment because they suggest that affected plant material may contain or retain compounds capable of functioning as biological signals. The present response of WAPE, including its relatively strong effect on pod formation at 60 DAS, therefore warrants further investigation through direct assessment of defence-related metabolites, antioxidant enzymes and signalling compounds. At present, however, the observed growth response should be described as a biological-modulator effect rather than attributed to a specific elicitor or signalling pathway.

An important feature emerging from the overall dataset is that no single treatment was uniformly superior for every trait and developmental stage. This agrees with the established principle that the physiological response to a regulator depends on concentration, genotype, developmental stage and environmental conditions. Giannakoula *et al.* (2012) [7] demonstrated that GA₃ promoted vegetative growth but did not necessarily improve seed development, whereas growth-retarding regulators could enhance seed weight. Prasad *et al.* (2023) [8] similarly showed that GA₃ was particularly effective for plant height, whereas TIBA was superior for branching, pod formation and seed yield. The present results follow the same physiological principle: *Trichoderma* was particularly effective for early plant height, SA influenced leaf development at selected stages, WAPE @ 10 ppm was prominent in early pod formation, whereas RKN @ 10 ppm showed the most consistent response across several growth and reproductive traits.

Tables: Effect of bio and synthetic modulators on growth parameters

Treatments	Plant Height 30 DAS			Plant Height 60 DAS			Plant Height at maturity		
	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled
V1	13.95	13.69	13.82	21.24	20.88	21.09	21.74	21.26	21.52
V2	14.36	14.59	14.47	22.91	22.95	22.93	26.72	26.65	26.68
SEm±	0.169	0.153	0.111	0.215	0.203	0.13	0.212	0.36	0.206
CD (0.05)	NS	0.435	0.316	0.613	0.579	0.371	0.603	1.027	0.587
T1	13.72	13.81	13.76	22.91	21.76	22.33	25.32	24.1	24.71
T2	13.74	13.94	13.84	24.17	23.67	24.08	26.13	24.65	25.39
T3	14.4	13.95	14.17	23.14	22.68	22.91	22.93	22.81	22.87
T4	14.39	14.61	14.50	22.46	22.54	22.5	23.66	24.17	23.91
T5	14.24	13.81	14.02	19.85	20.27	20.06	24.4	25.31	24.86
T6	13.73	14.18	13.95	21.33	21.3	21.18	21.46	22.26	21.86

T7	13.64	13.68	13.66	21.24	21.38	21.31	24.5	22.57	23.54
T8	13.92	13.9	13.91	20.83	20.51	20.67	24.34	23.69	24.01
T9	14.09	14.2	14.14	22.76	22.76	22.75	24.79	25.52	25.15
T10	15.08	14.92	15	21.5	22.18	21.84	23.6	24.21	23.91
T11	14.74	14.54	14.64	22.62	22.92	22.45	25.4	24.36	24.88
SEm±	0.396	0.358	0.26	0.504	0.477	0.305	0.497	0.845	0.483
CD (0.05)	NS	NS	0.741	1.437	1.359	0.87	1.416	NS	1.377

INTERACTION (V×T)

	Plant Height 30 DAS			Plant Height 60 DAS			Plant Height at maturity		
Treatments	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled
V1T1	13.9	13.5	13.7	21.97	20.63	21.3	21.34	20.92	21.13
V1T2	13.33	13.18	13.26	24.3	24.75	24.53	23.79	22.48	23.13
V1T3	14.69	13.98	14.34	25.6	24.13	24.86	20.55	20.13	20.34
V1T4	14.66	14.15	14.4	22.53	21.9	22.22	20.79	21.46	21.13
V1T5	14.4	13.93	14.16	20.37	20.76	20.56	22.69	22.51	22.6
V1T6	13.75	13.83	13.79	21.47	20.78	21.12	18.9	19.9	19.4
V1T7	13.68	13.58	13.63	18.07	18.93	18.5	22.03	20.26	21.14
V1T8	13.18	13.09	13.13	19.9	19.4	19.65	22.52	20.56	21.54
V1T9	13.66	13.75	13.7	20.87	20.75	20.81	23.09	22.96	23.02
V1T10	14.42	14.24	14.33	18.57	18.83	18.7	19.97	20.85	20.41
V1T11	13.78	13.36	13.57	20	19.47	19.74	23.49	22.17	22.83
V2T1	13.54	14.12	13.83	23.86	22.88	23.37	29.31	27.29	28.3
V2T2	14.16	14.69	14.42	24.03	23.24	23.64	28.47	26.83	27.65
V2T3	14.1	13.92	14.01	20.68	21.24	20.96	25.31	25.49	25.4
V2T4	14.11	15.06	14.59	22.38	23.17	22.78	26.53	26.87	26.7
V2T5	14.08	13.69	13.89	19.33	19.77	19.55	26.11	28.12	27.12
V2T6	13.7	14.53	14.11	21.2	21.28	21.24	24.02	24.62	24.32
V2T7	13.61	13.78	13.7	24.41	23.83	24.12	26.98	24.89	25.93
V2T8	14.67	14.71	14.69	21.75	21.61	21.68	26.16	26.81	26.49
V2T9	14.52	14.65	14.59	24.64	24.76	24.7	26.49	28.07	27.28
V2T10	15.74	15.6	15.67	24.44	25.52	24.98	27.23	27.58	27.4
V2T11	15.71	15.71	15.71	25.24	25.11	25.17	27.31	26.55	26.93
SEm±	0.56	0.506	0.367	0.713	0.674	0.432	0.703	1.195	0.683
CD (0.05)	NS	NS	1.047	2.033	1.921	1.231	2.003	NS	NS

	No. of Branches 30 DAS			No. of Branches 60 DAS			No. of Branches at maturity		
Treatments	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled
V1	3.25	3.24	3.24	4.24	4.28	4.26	4.89	4.73	4.83
V2	3.51	3.5	3.51	3.9	3.9	3.9	4.49	4.35	4.42
SEm±	0.04	0.04	0.028	0.04	0.046	0.029	0.056	0.114	0.061
CD (0.05)	0.114	0.113	0.081	0.115	0.132	0.083	0.159	0.325	0.175
T1	3.39	3.4	3.39	3.96	3.91	3.93	4.67	4.57	4.65
T2	4.07	4.13	4.1	5.13	5.29	5.21	5.4	5.07	5.25
T3	3.56	3.58	3.57	4.26	4.4	4.33	4.68	4.57	4.49
T4	3.42	3.45	3.44	4.19	4.25	4.22	5.34	5.23	5.33
T5	3.71	3.57	3.64	4.49	4.49	4.49	4.42	4.63	4.58
T6	3.41	3.41	3.41	3.92	3.99	3.95	4.13	3.97	4.05
T7	3.52	3.47	3.49	3.79	3.75	3.77	4.59	4.25	4.34
T8	3.33	3.33	3.33	4.12	4.06	4.09	4.95	5.03	4.99
T9	2.92	2.99	2.96	3.53	3.53	3.53	4.51	4.27	4.38
T10	3.28	3.24	3.26	4.1	4.01	4.06	4.49	4.4	4.44
T11	2.54	2.52	2.53	3.27	3.29	3.28	4.39	4.23	4.41
SEm±	0.094	0.093	0.066	0.095	0.109	0.069	0.131	0.267	0.144
CD (0.05)	0.268	0.265	0.189	0.27	0.309	0.195	0.373	0.762	0.409

INTERACTION (V×T)

	No. of Branches 30 DAS			No. of Branches 60 DAS			No. of Branches at maturity		
Treatments	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled
V1T1	3.24	3.25	3.24	4.05	4.07	4.06	4.65	4.73	4.69
V1T2	4.05	4.21	4.13	5.72	5.78	5.75	5.92	5.6	5.76
V1T3	3.42	3.38	3.4	4.25	4.64	4.44	5.17	5	5.08
V1T4	3.74	3.79	3.77	4.31	4.38	4.34	5.76	5.6	5.68
V1T5	3.62	3.4	3.51	4.63	4.75	4.69	4.18	4.13	4.16
V1T6	3.24	3.31	3.28	4.2	4.19	4.2	4.28	4	4.14
V1T7	3.49	3.44	3.46	3.91	3.87	3.89	4.48	4.11	4.29
V1T8	3.1	3.01	3.05	4.3	4.37	4.34	4.74	5.2	4.97
V1T9	2.74	2.81	2.77	3.61	3.51	3.56	5.02	4.87	4.95
V1T10	3.35	3.26	3.3	4.62	4.51	4.57	4.74	4.67	4.71
V1T11	1.73	1.79	1.76	3	3.02	3.01	4.8	4.67	4.73

V2T1	3.53	3.56	3.55	3.87	3.75	3.81	4.69	4.4	4.55
V2T2	4.09	4.05	4.07	4.54	4.79	4.67	4.87	4.53	4.7
V2T3	3.69	3.79	3.74	4.28	4.17	4.22	4.2	4.13	4.17
V2T4	3.09	3.12	3.11	4.06	4.13	4.09	4.92	4.87	4.89
V2T5	3.8	3.75	3.78	4.35	4.22	4.28	4.66	5.13	4.9
V2T6	3.59	3.5	3.55	3.64	3.78	3.71	3.97	3.93	3.95
V2T7	3.54	3.5	3.52	3.67	3.63	3.65	4.7	4.4	4.55
V2T8	3.57	3.65	3.61	3.93	3.75	3.84	5.16	4.87	5.01
V2T9	3.1	3.17	3.14	3.46	3.56	3.51	4	3.67	3.83
V2T10	3.21	3.22	3.21	3.58	3.52	3.55	4.23	4.13	4.18
V2T11	3.34	3.25	3.3	3.53	3.56	3.55	3.98	3.8	3.89
SEm±	0.133	0.131	0.094	0.134	0.153	0.097	0.185	0.378	0.203
CD (0.05)	0.379	0.374	0.267	0.382	0.437	0.276	0.528	NS	0.579

Treatments	No. of Nodes 30 DAS			No. of Nodes 60 DAS			No. of Nodes at maturity		
	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled
V1	9.03	8.82	8.93	15.13	14.64	14.88	13.01	12.68	12.85
V2	8.61	8.49	8.56	13.34	12.74	13.04	14.08	13.6	13.84
SEm±	0.093	0.107	0.065	0.087	0.146	0.092	0.205	0.327	0.163
CD (0.05)	0.264	0.306	0.185	0.249	0.415	0.263	0.583	NS	0.464
T1	9.27	8.95	9.11	14.68	13.88	14.28	13.41	12.88	13.15
T2	9.18	8.79	8.99	14.05	13.73	13.89	14.2	13.47	13.83
T3	8.44	8.25	8.35	13.42	12.98	13.2	13.8	12.8	13.3
T4	8.81	8.73	8.77	15.36	14.63	14.99	12.87	12.77	12.82
T5	8.6	8.4	8.5	14.63	14.71	14.67	12.83	12.63	12.73
T6	8.84	8.49	8.67	14.58	14.37	14.47	14.15	13.67	13.91
T7	9.09	8.96	9.02	14.49	13.85	14.17	13.22	12.67	12.94
T8	8.18	8.17	8.13	14.34	13.91	14.13	12.99	13.3	13.14
T9	9.09	8.82	8.95	13.49	12.52	13.01	13.43	13.7	13.57
T10	8.94	8.83	8.89	13.54	12.92	13.23	13.92	13.13	13.53
T11	8.7	8.8	8.75	13.99	13.1	13.54	14.15	13.53	13.84
SEm±	0.217	0.252	0.152	0.205	0.342	0.216	0.48	0.768	0.382
CD (0.05)	0.619	NS	0.434	0.583	0.974	0.617	NS	NS	NS

INTERACTION (V×T)									
Treatments	No. of Nodes 30 DAS			No. of Nodes 60 DAS			No. of Nodes at maturity		
	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled
V1T1	9.87	9.13	9.5	15.6	14.96	15.28	12.85	12.9	12.88
V1T2	9.21	8.67	8.94	14.74	14.3	14.52	13.84	12.73	13.29
V1T3	8.49	8.29	8.39	13.93	14	13.96	13.32	12.53	12.93
V1T4	8.37	8.54	8.46	15.72	14.85	15.28	12.1	11.67	11.89
V1T5	8.6	8.5	8.55	17.29	17.2	17.24	11.8	11.87	11.83
V1T6	9.04	8.46	8.75	15.99	15.7	15.85	13.69	13.67	13.68
V1T7	9.05	8.96	9.01	14.92	14.31	14.62	11.8	11.73	11.76
V1T8	8.41	8.5	8.45	14.55	14.5	14.52	11.94	11.67	11.8
V1T9	9.47	9.3	9.38	14.39	13.33	13.86	12.74	12.8	12.77
V1T10	9.58	9.42	9.5	14.29	13.88	14.08	14.1	13.07	13.59
V1T11	9.3	9.25	9.28	14.95	14	14.48	14.92	14.87	14.89
V2T1	8.66	8.78	8.72	13.75	12.79	13.27	13.97	12.87	13.42
V2T2	9.16	8.92	9.04	13.37	13.17	13.27	14.56	14.2	14.38
V2T3	8.4	8.22	8.31	12.92	11.96	12.44	14.29	13.07	13.68
V2T4	9.24	8.92	9.08	14.99	14.42	14.71	13.65	13.87	13.76
V2T5	8.61	8.3	8.45	11.97	12.23	12.1	13.85	13.4	13.63
V2T6	8.64	8.53	8.58	13.16	13.03	13.1	14.61	13.67	14.14
V2T7	9.12	8.96	9.04	14.05	13.39	13.72	14.65	13.6	14.12
V2T8	7.95	7.83	7.89	14.13	13.33	13.73	14.04	14.93	14.49
V2T9	8.71	8.33	8.52	12.59	11.71	12.15	14.13	14.6	14.36
V2T10	8.31	8.25	8.28	12.78	11.96	12.37	13.73	13.2	13.46
V2T11	8.09	8.34	8.22	13.02	12.21	12.61	13.38	12.2	12.79
SEm±	0.307	0.356	0.215	0.289	0.483	0.306	0.679	1.086	0.54
CD (0.05)	0.876	NS	0.614	0.825	1.378	0.872	NS	NS	1.539

Treatments	No. of leaves 30 DAS			No. of leaves 60 DAS			No. of leaves at maturity		
	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled
V1	27.12	26.97	27.05	43.71	42.68	43.26	31.26	31.37	31.28
V2	27.03	26.59	26.81	37.29	37.02	37.15	39.82	40.15	40
SEm±	0.148	0.238	0.118	0.214	0.379	0.232	0.357	0.496	0.29
CD (0.05)	NS	NS	NS	0.611	1.08	0.662	1.018	1.414	0.826
T1	26.81	26.18	26.5	41.9	40.52	41.21	28.57	27.84	28.2
T2	27.1	28.7	27.9	47.46	46.93	47.19	42.92	44.18	43.55

T3	27.67	26.9	27.28	39.13	38.88	39.34	31.19	31.32	31.26
T4	26.69	25.47	26.08	40.46	39.18	39.82	39.67	39.73	39.7
T5	25.81	26.48	26.14	43.14	41.94	42.54	37.55	37.23	37.39
T6	27.42	26.64	27.03	36.5	36.38	36.44	30.1	29.94	30.02
T7	26.51	26.97	26.74	40.16	38.94	39.55	32.31	32.55	32.43
T8	29.32	28.61	28.96	42.89	41.73	42.31	40.85	41.05	40.95
T9	28.43	28.09	28.26	36.44	36.46	36.45	37.11	37.63	37.37
T10	28.11	27.01	27.56	39.28	39.48	39.38	40.27	41.01	40.64
T11	23.97	23.58	23.77	38.15	37.91	38.03	30.37	30.7	30.54
SEm±	0.348	0.558	0.277	0.503	0.889	0.544	0.838	1.163	0.68
CD (0.05)	0.992	1.59	0.791	1.433	2.533	1.552	2.388	3.316	1.938

INTERACTION (V×T)

Treatments	No. of leaves 30 DAS			No. of leaves 60 DAS			No. of leaves at maturity		
	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled
V1T1	28.95	28.33	28.64	51.4	49.75	50.57	22.56	21.88	22.22
V1T2	25.38	27.4	26.39	54.34	53.08	53.71	41.12	42.8	41.96
V1T3	27.92	27.38	27.65	42.83	42.67	42.75	29.75	29.91	29.83
V1T4	28.52	27.13	27.82	43.88	41.87	42.87	34.58	34.42	34.5
V1T5	24.24	25.13	24.68	45.85	43.42	44.64	31.66	31.2	31.43
V1T6	26.31	25.9	26.1	37.78	38.14	37.96	25.58	25.21	25.4
V1T7	25.04	26.73	25.88	45.05	41.88	43.46	28.51	28.33	28.42
V1T8	29.84	28.58	29.21	42.87	41.25	42.06	29.12	28.33	28.73
V1T9	30.56	30.05	30.31	37.05	37.88	37.46	32.94	34.29	33.62
V1T10	29.47	28.13	28.8	42.17	42.17	42.17	34.59	34.12	34.36
V1T11	22.09	21.96	22.02	37.63	37.4	37.52	33.43	33.87	33.65
V2T1	24.67	24.04	24.35	32.4	31.29	31.85	34.58	33.8	34.19
V2T2	28.81	30	29.41	40.58	40.77	40.67	44.72	45.57	45.14
V2T3	27.42	26.42	26.92	35.44	35.08	35.26	32.63	32.73	32.68
V2T4	24.86	23.82	24.34	37.04	36.5	36.77	44.76	45.03	44.9
V2T5	27.37	27.83	27.6	40.43	40.46	40.44	43.44	43.27	43.35
V2T6	28.54	27.38	27.96	35.22	34.63	34.92	34.61	34.67	34.64
V2T7	27.99	27.21	27.6	35.27	36	35.64	36.11	36.77	36.44
V2T8	28.8	28.63	28.72	42.91	42.21	42.56	52.58	53.77	53.18
V2T9	26.3	26.13	26.21	35.83	35.04	35.43	41.28	40.97	41.12
V2T10	26.75	25.89	26.32	36.4	36.79	36.6	45.95	47.91	46.93
V2T11	25.84	25.19	25.52	38.68	38.42	38.55	27.31	27.53	27.42
SEm±	0.492	0.789	0.392	0.711	1.257	0.77	1.185	1.645	0.962
CD (0.05)	1.402	2.249	1.118	2.026	3.582	2.195	3.376	4.688	2.739

Treatments	No. of Pods 60 DAS			No. of Pods at maturity		
	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled
V1	11.91	11.74	11.83	18.9	18.86	18.88
V2	8.62	8.48	8.55	17.11	17.09	17.1
SEm±	0.084	0.112	0.066	0.132	0.227	0.141
CD (0.05)	0.24	0.319	0.187	0.375	0.647	0.402
T1	10.78	10.33	10.55	13.44	14.5	13.97
T2	12.02	11.48	11.75	22.57	23.47	23.02
T3	10.13	9.86	10	16.84	16.3	16.57
T4	9.75	9.4	9.57	19.28	19.15	19.21
T5	11.66	12.01	11.84	20.23	19.35	19.79
T6	9.68	9.53	9.61	14.56	13.64	14.1
T7	9.81	9.52	9.67	15.99	17.03	16.51
T8	9.86	10.17	10.01	19.86	19.96	19.91
T9	9.35	8.91	9.13	21.29	20.01	20.65
T10	9.82	9.74	9.78	18.2	18.58	18.39
T11	10.07	10.28	10.18	15.79	15.74	15.77
SEm±	0.197	0.262	0.154	0.309	0.533	0.331
CD (0.05)	0.562	0.748	0.439	0.881	1.518	0.943

INTERACTION (V×T)

Treatments	No. of Pods 60 DAS			No. of Pods at maturity		
	2024-25	2025-26	Pooled	2024-25	2025-26	Pooled
V1T1	13.81	13.08	13.45	12.9	14	13.45
V1T2	14.85	13.58	14.22	23.13	24.33	23.73
V1T3	12.64	12.31	12.47	21.14	20.33	20.74
V1T4	12.05	11.46	11.75	20.83	21.29	21.06
V1T5	13.03	14	13.52	19.52	17.8	18.66
V1T6	12.04	11.88	11.96	15.82	15.07	15.44
V1T7	11.27	10	10.64	16.94	18.6	17.77

V1T8	10.07	10.54	10.31	16.71	16.9	16.8
V1T9	10.96	10.38	10.67	24.5	22.53	23.52
V1T10	11.47	11.72	11.6	17.63	18.73	18.18
V1T11	9.63	10.19	9.91	18.82	17.84	18.33
V2T1	7.75	7.58	7.66	13.98	15	14.49
V2T2	9.19	9.37	9.28	22.02	22.6	22.31
V2T3	7.63	7.41	7.52	12.54	12.27	12.4
V2T4	7.45	7.33	7.39	17.73	17.01	17.37
V2T5	10.29	10.03	10.16	20.95	20.91	20.93
V2T6	7.32	7.19	7.26	13.3	12.21	12.75
V2T7	9.15	9.04	9.1	15.04	15.47	15.25
V2T8	9.64	9.79	9.72	23	23.03	23.02
V2T9	7.74	7.44	7.59	18.07	17.49	17.78
V2T10	8.16	7.75	7.96	18.77	18.43	18.6
V2T11	10.51	10.38	10.44	12.77	13.64	13.21
SEm±	0.279	0.371	0.218	0.437	0.753	0.468
CD (0.05)	0.795	1.058	0.62	1.245	2.146	1.333

Conclusion

The present study demonstrated that lentil growth and reproductive development were significantly influenced by variety, modulator and their interaction. L 4727 exhibited greater plant height, reaching 26.68 cm at maturity, whereas L 4717 showed superior branching and pod formation. Among the modulators, RKN @ 10 ppm exhibited the most consistent positive response, recording maximum plant height at 60 DAS (24.08 cm) and maturity (25.39 cm), branches at 60 DAS (5.21 plant⁻¹), leaves at 60 DAS (47.19 plant⁻¹) and maturity (43.55 plant⁻¹), and pods at maturity (23.02 plant⁻¹). The most prominent interaction was L 4717 × RKN @ 10 ppm, which produced 5.75 branches, 53.71 leaves and 23.73 pods plant⁻¹ at the respective stages. Overall, RKN @ 10 ppm, particularly with L 4717, showed strong potential for enhancing vegetative growth and reproductive development of lentil.

References

- Mishra BK, Srivastava JP, Lal JP, Sheshshayee MS. Physiological and biochemical adaptations in lentil genotypes under drought stress. *Russian Journal of Plant Physiology*. 2016;63(5):695-708.
- Sehgal A, Sita K, Kumar J, Kumar S, Singh S, Siddique KH, et al. Effects of drought, heat and their interaction on the growth, yield and photosynthetic function of lentil (*Lens culinaris* Medik.) genotypes varying in heat and drought sensitivity. *Frontiers in Plant Science*. 2017;8:1776.
- Dash AP, De DK, Nath R, Sarker A, Mohanty S. Comparative study of relative water, chlorophyll and proline content in drought tolerant and susceptible genotypes of lentil (*Lens culinaris* Medik.). *Research Journal of Agricultural Sciences*. 2017;8(5):1081-1086.
- Dash AP, De DK, Nath R, Sarker A, Mohanty S, Bhattacharya PK. Effects of drought stress on relative water, chlorophyll and proline content in tolerant and susceptible genotypes of lentil (*Lens culinaris* Medik.). *Journal of Crop and Weed*. 2020;16(1):192-198.
- Mondal MMA, Puteh AB, Kashem MA, Haque MA, Razzque AHM. Growth and dry mass partitioning in plant parts of lentil. *Legume Research*. 2014;37(4):434-438.
- Whitehead SJ, Summerfield RJ, Muehlbauer FJ, Coyne CJ, Ellis RH, Wheeler TR. Crop improvement and the accumulation and partitioning of biomass and nitrogen in lentil. *Crop Science*. 2000;40(1):110-120.
- Giannakoula AE, Ilias IF, Maksimović JD, Maksimović V, Živanović BD, et al. The effects of plant growth regulators on growth, yield, and phenolic profile of lentil plants. *Journal of Food Composition and Analysis*. 2012;28(1):46-53.
- Prasad J, Tripathi DK, Rawat DK, Kumar M, Prajapati SK, Prajapati BK. Effect of plant growth regulators on the morphology, flowering, maturity, yield attributes, and yield of lentil (*Lens culinaris* L. Medik.). *International Journal of Environment and Climate Change*. 2023;13(6):64-75.
- Kayednezami R, Balouchi HR, Yadavi A. Effect of foliar application of salicylic acid on yield and yield components and some physiological traits of lentil (*Lens culinaris* Medik.) varieties under salt stress. *Iranian Journal of Plant Physiology*. 2012;2(2):427-433.
- Laishram B, Singh TB, Kalpana A, Wangkheirakpam M, Chongtham SK, Singh WJ. Effect of salicylic acid and potassium nitrate on growth and yield of lentil (*Lens culinaris* L.) under rainfed condition. *International Journal of Current Microbiology and Applied Sciences*. 2020;9(11):2779-2791.
- Dhar A, Dey S, Sarkar S, Sau S, Brahmachari K, Banerjee H, et al. Growth and yield of lentil (*Lens culinaris* Medik.) as affected by stress-mitigating chemical spray and soil variability. *Journal of Food Legumes*. 2025;38(1):63-69.
- Rai D. Effect of different *Trichoderma* isolates on growth, nodulation and yield of lentil (*Lens culinaris* Medik.). *Journal of Pharmacognosy and Phytochemistry*. 2019;8(4):2348-2351.
- Javeria S, Kumar A, Kharkwal AC, Varma A, Sharma P. Exploiting plant growth promoting *Trichoderma* for lentil wilt management. *The Indian Journal of Agricultural Sciences*. 2020;90(5):1020-1024.
- Marra R, Lombardi N, Piccolo A, Bazghaleh N, Prashar P, Vandenberg A, et al. Mineral biofortification and growth stimulation of lentil plants inoculated with *Trichoderma* strains and metabolites. *Microorganisms*. 2021;10(1):87.
- Sunarto T, Suganda T, Sianipar MS, Irawan AW. Induced systemic resistance in rice plant with plant extract to rice root-knot nematode (*Meloidogyne graminicola* Golden and Birchfields). *Jurnal Agrikultura*. 2019;30(2):57-62.
- De Kesel J, Desmedt W, Degroote E, Singh RR, Nguyen GT, et al. Cucurbitaceae cold peeling extracts protect plants from root-knot nematode infections through induced resistance and nematicidal effects. *Frontiers in Plant Science*. 2022;12:785699.
- Fought L, Kuć JA. Lack of specificity in plant extracts and chemicals as inducers of systemic resistance in cucumber plants to anthracnose. *Journal of Phytopathology*. 1996;144(1):1-6.
- Gawande AD, Gangopadhyay S, Rakhonde PN, Mane SS. Evaluation of plant extracts for induction of defence against

- Fusarium* wilt in chickpea. Indian Phytopathology. 2015;68(3):264-269.
19. Karpenko V, Novikova T, Prytulia P, Hnatyuk M. Pigments content in the leaves of lentil under the action of biological preparations. Scientific Horizons. 2019;80(7):41-47.
 20. Thakur S. Spraying *Fusarium* wilt affected plant extract induces tolerance against *Fusarium* wilt by modulating physiology and stress mitigating activities in chickpea (*Cicer arietinum* L.) plant. In: M.P. Young Scientist Congress Abstract Booklet. Jabalpur: Jawaharlal Nehru Krishi Vishwavidyalaya; 2025.