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Comparative influence of brassinosteroid, triacontanol and GA₃ on growth and morphological traits of Phalsa (*Grewia asiatica* L.) cv. V1 Thai seedlings under Prayagraj agro-climatic conditions

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Abstract

The present investigation was conducted to evaluate the comparative effect of brassinosteroid, triacontanol and GA₃ along with organic manures on the growth and morphological traits of Phalsa (*Grewia asiatica* L.) cv. V1 Thai seedlings under Prayagraj agro-climatic conditions. The experiment was carried out at the Horticulture Research Farm, Naini Agricultural Institute, SHUATS, Prayagraj during August to mid-November 2025. Ten treatments were laid out in a Randomized Block Design with three replications. Vermicompost (0.5 kg plant⁻¹) and farmyard manure (2.0 kg plant⁻¹) were applied as basal dose in all treatments except the control. Foliar sprays of brassinosteroid (0.1-0.3 ppm), triacontanol (10-20 ppm) and GA₃ (10-20 ppm) were given three times at 15-day intervals.

Results revealed that treatment T₆ (Vermicompost + FYM + Triacontanol @ 20 ppm) performed best, recording the highest survival (96.50%), number of branches (1.67), number of leaves (68.33), leaf area (77.50 cm²), chlorophyll content (37.94 SPAD), plant spread (63.00 cm), root length (28.23 cm) and number of roots (19.33) at 90 DAT. This was followed by T₉ and T₃ for different parameters. GA₃ at 20 ppm (T₉) gave maximum plant height while brassinosteroid at 0.3 ppm (T₃) produced the highest stem girth.

The study concluded that the combined application of vermicompost, farmyard manure and triacontanol at 20 ppm was most effective for improving survival, growth and vigour of Phalsa seedlings under subtropical conditions of Prayagraj.

Keywords: Phalsa, *Grewia asiatica*, triacontanol, brassinosteroid, gibberellic acid, organic manures, seedling growth, plant vigour

Introduction

Phalsa (*Grewia asiatica* L.), a nutritionally rich and climate-resilient minor fruit crop belonging to the family Malvaceae, holds immense potential for diversification and sustainable production in tropical and subtropical horticulture systems. Valued for its unique sweet-sour berries, high antioxidant content, and adaptability to marginal soils, high temperature, and drought conditions, Phalsa offers significant nutritional, medicinal, and economic benefits. Despite these attributes, its commercial expansion remains limited due to poor seedling establishment, slow early vegetative growth, and inadequate availability of vigorous planting material.

Successful orchard establishment begins with healthy seedlings, as robust vegetative growth during the nursery and early field phase directly influences subsequent plant architecture, flowering, and fruiting potential. Plant physiological processes are not only critical for nursery performance but also play a pivotal role during the fruiting stage. Typically, 10-20 active mature leaves are required to supply sufficient carbohydrates and energy for the full development of a single fruit berry in many fruit crops, including Phalsa. Therefore, enhancing early leaf production, chlorophyll content, and photosynthetic efficiency through biostimulants can have long-term benefits on overall productivity.

Under the alluvial soils and fluctuating climatic conditions of Prayagraj, seedling growth is often constrained by moisture stress, nutrient deficiencies, and high temperatures during the initial establishment phase. These factors adversely affect survival rate, root development, and early vigour, ultimately reducing planting success and orchard productivity.

Organic nutrient sources such as farmyard manure (FYM) and vermicompost improve soil structure, nutrient availability, microbial activity, and moisture retention, thereby supporting better rhizosphere conditions (Bano and Kale, 1987; Maity *et al.*, 2006) ^[2, 5]. The integration of these organic amendments with plant growth regulators (PGRs) offers a sustainable strategy to overcome these limitations while minimizing reliance on synthetic inputs.

Among PGRs, brassinosteroids, triacontanol, and gibberellic acid (GA₃) have shown promising effects on physiological and morphological processes. Brassinosteroids enhance photosynthetic efficiency, nutrient uptake, cell expansion, and stress tolerance (Rao *et al.*, 2019) ^[7]. Triacontanol, a long-chain primary alcohol, stimulates photosynthesis, chlorophyll synthesis, enzyme activity, and biomass accumulation (Naeem *et al.*, 2012) ^[6]. Gibberellic acid promotes cell division and elongation, leading to increased shoot growth and plant height.

Although individual effects of organic manures and these growth regulators have been documented in various horticultural crops, comparative studies on their combined application for Phalsa cv. V1 Thai seedlings, particularly under Prayagraj agro-climatic conditions, remain limited. Therefore, the present investigation was undertaken to evaluate the comparative efficacy of brassinosteroids, triacontanol, and gibberellic acid (GA₃) in integration with organic manures for enhancing survival, growth, physiological attributes, and root development of Phalsa (*Grewia asiatica* L.) cv. V1 Thai seedlings under Prayagraj agro-climatic conditions.

Materials and Methods

The present investigation entitled “Comparative Influence of Brassinosteroid, Triacontanol and GA₃ on Growth and

Morphological Traits of Phalsa (*Grewia asiatica* L.) cv. V1 Thai Seedlings under Prayagraj Agro-climatic Conditions” was conducted at the Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh during July to October 2025. The experimental site is situated at 25.27°N latitude, 81.51°E longitude and at an altitude of approximately 98 m above mean sea level. The soil of the experimental field was sandy loam in texture, well-drained and moderately fertile with a pH ranging from 7.2 to 7.8.

Healthy, uniform and disease-free four-month-old seedlings of Phalsa (*Grewia asiatica* L.) cv. V1 Thai were used as planting material. The seedlings were transplanted in the open field at a spacing of 2.5 m × 2.5 m. Soil drenching with Bavistin was carried out before transplanting to minimise soil-borne pathogen populations. All recommended cultural practices were followed uniformly throughout the experimental period.

The experiment was laid out in a Randomized Block Design (RBD) consisting of ten treatments with three replications. Each treatment consisted of nine plants (three plants per replication), making a total of ninety plants under study. Vermicompost (0.5 kg plant⁻¹) and farmyard manure (2.0 kg plant⁻¹) were applied as a basal dose immediately after transplanting by thoroughly mixing in the planting pit. Foliar sprays of brassinosteroid (0.1-0.3 ppm), triacontanol (10-20 ppm) and GA₃ (10-20 ppm) were applied three times at 15-day intervals during the active vegetative growth phase using a hand sprayer in the early morning hours until the foliage was completely wet.

Treatment Details: The ten treatments were as follows:

Treatment Details

Symbols	Treatment
T ₀	Control
T ₁	Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Brassinosteroid @ 0.1 ppm
T ₂	Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Brassinosteroid @ 0.2 ppm
T ₃	Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Brassinosteroid @ 0.3 ppm
T ₄	Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Triacontanol @ 10 ppm
T ₅	Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Triacontanol @ 15 ppm
T ₆	Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Triacontanol @ 20 ppm
T ₇	Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + GA ₃ @ 10 ppm
T ₈	Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + GA ₃ @ 15 ppm
T ₉	Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + GA ₃ @ 20 ppm

Vermicompost and farmyard manure (FYM) were applied as a basal dose immediately after transplanting by thoroughly mixing in the planting pit. Foliar application of brassinosteroid, triacontanol, and GA₃ was performed three times at 15-day intervals during the active vegetative growth phase using a hand sprayer in the early morning hours until the leaves were fully drenched.

Observations Recorded: Various growth, physiological, morphological and root parameters were systematically recorded on all nine plants in each treatment at 30, 60 and 90 days after transplanting (DAT). Plant height was measured from the ground level to the tip of the apical bud using a standard measuring scale to assess vertical shoot growth. The number of primary branches arising from the

main stem was counted manually to determine the branching pattern and lateral growth of the seedlings. Fully expanded leaves were counted on each plant to record the number of leaves per plant, which indicates the foliage development and photosynthetic capacity. Leaf area was estimated by measuring the maximum length and breadth of representative leaves and applying the standard correction factor using the formula: Leaf area = Length × Breadth × 0.75. Stem girth was measured at 2-3 cm above the ground level using a digital vernier caliper to evaluate stem thickness and structural development. Chlorophyll content was determined in SPAD units with the help of a SPAD-502 Plus chlorophyll meter on the third fully expanded young leaf from the top, which reflects the photosynthetic pigment status of the plant. Plant vigour index was calculated using

the formula: (Plant height × Number of leaves)/100 to provide an overall measure of seedling vigour and performance. Plant spread was measured across the widest canopy diameter in both East-West and North-South directions, and the average value was recorded to assess the horizontal growth and canopy development. Survival percentage was calculated using the formula: (Number of survived plants/Total number of transplanted plants) × 100 to evaluate the establishment success of the seedlings under different treatments. At the final harvest (90 DAT), plants were carefully uprooted for recording root parameters. Root length was measured from the collar region to the tip of the longest root, while the total number of major primary roots emerging from the collar region was counted manually to study the root system architecture and development.

The experimental data were statistically analysed using Analysis of Variance (ANOVA) technique appropriate for Randomized Block Design as described by Gomez and Gomez (1984)^[4]. The significance of treatment effects was tested at 5% level of probability. Standard Error of Mean [SE(m)], Critical Difference [CD (5%)] and Coefficient of Variation (CV%) were calculated using Microsoft Excel (Version 2019).

Results and Discussion

The application of organic manures in combination with different biostimulants significantly influenced the survival, vegetative growth, physiological attributes, and root development of Phalsa (*Grewia asiatica* L.) cv. V1 Thai seedlings. The results are presented in Table 1.1 and Table 1.2.

Survival Percentage-Survival percentage was significantly affected by the treatments. The highest survival (96.50%) was recorded in T₆ (Vermicompost @ 0.5 kg plant⁻¹ + FYM @ 2.0 kg plant⁻¹ + Triacantanol @ 20 ppm), followed by T₃ (93.40%), while the lowest (62.10%) was observed in the control (T₀). The improved survival under T₆ may be attributed to better root establishment and stress tolerance provided by triacantanol and organic manures. These findings are in agreement with Sandeep Sharma *et al.* (2021)^[9], who reported enhanced seedling survival with the application of biostimulants and organic amendments in fruit crops.

Plant Height-At 90 DAT, the maximum plant height (103.27 cm) was recorded in T₉ (GA₃ @ 20 ppm), followed by T₆ (101.83 cm), while the minimum (90.90 cm) was observed in the control. The increase in plant height under GA₃ treatment is due to its well-known role in cell division and elongation. Similar results were reported by Rathore *et al.* (2020)^[10] in different horticultural crops.

Number of Branches-The number of branches per plant was highest (1.67) in T₆, followed by T₅ (1.56). The control recorded the lowest number of branches (1.11). Improved branching under T₆ may be due to enhanced photosynthetic

activity and nutrient uptake. These observations are supported by Reddy *et al.* (2013)^[8] who noted increased branching with triacantanol application.

Number of Leaves-The highest number of leaves per plant (68.33) was recorded in T₆ at 90 DAT, followed by T₉ (67.00) and T₅ (65.67). The control produced the minimum number of leaves (56.00). The increase in leaf production under T₆ indicates better vegetative growth, which is consistent with the findings of Sharma *et al.* (2021)^[9] and the study on growing media for Phalsa seedlings.

Leaf Area-The treatments significantly influenced leaf area. The maximum leaf area (77.50 cm²) was observed in T₆, followed by T₅ (71.40 cm²), while the minimum (42.70 cm²) was recorded in the control. The improvement in leaf area under T₆ may be attributed to enhanced cell expansion. Similar results were reported by Rao *et al.* (2019)^[7] and the biochemical study on biostimulants (2024).

Stem Girth-The highest stem girth (11.12 mm) was recorded in T₃ (Brassinosteroid @ 0.3 ppm), followed by T₂ (10.46 mm). The control showed the lowest stem girth (9.12 mm). Brassinosteroids are known to promote vascular development and stem thickening, as also observed by Rao *et al.* (2019)^[7].

Chlorophyll Content-Chlorophyll content was highest (37.94 SPAD) in T₆, followed by T₃ (35.86 SPAD). The lowest value (27.59 SPAD) was observed in the control. The increase in chlorophyll content under T₆ reflects improved photosynthetic efficiency, which is in line with the findings of Naik and Babu (2007).

Plant Vigour Index-The plant vigour index was maximum (46.81) in T₉, followed by T₆ (44.84). The control recorded the lowest vigour index (31.71). The better performance of T₆ indicates overall improvement in seedling vigour, as also reported by Reddy *et al.* (2013)^[8] and Rathore *et al.* (2020)^[10].

Plant Spread-The maximum plant spread (63.00 cm) was recorded in T₆ at 90 DAT, followed by T₉ (58.50 cm). The minimum plant spread (42.50 cm) was observed in the control. Wider canopy development under T₆ is consistent with the findings of Sharma *et al.* (2021)^[9].

Root Length and Number of Roots-Root development was markedly improved by the treatments. The longest root length (28.23 cm) and highest number of roots (19.33) were recorded in T₆, compared to 18.00 cm and 9.67 in the control. These results are supported by Sandeep Lakra *et al.* (2024), the study on the influence of growing media on Phalsa seedlings, and earlier reports of Reddy *et al.* (2013)^[8].

Overall, treatment T₆ emerged as the most effective, showing superior performance across most parameters. The integration of triacantanol with organic manures provided the best-balanced growth, which can be attributed to improved nutrient availability, photosynthetic efficiency, and robust root system development.

Table 1: Effect of different treatments on vegetative growth parameters of Phalsa (*Grewia asiatica* L.) cv. V1 Thai seedlings at 90 DAT.

Treatment	Plant Height (cm)			Number of Leaf			Number of Branches			Stem Girth(mm)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T ₀ - Control	39.11	79.00	90.90	24.33	41.00	56.00	0.32	0.67	1.11	5.64	7.54	9.12
T ₁ - Vermicompost @0.5 kg/plant + FYM @ 2 kg/plant+ Brassinosteriod @ 0.1 ppm	44.44	83.56	95.60	31.00	44.67	59.67	0.33	0.89	1.44	5.89	7.98	9.87
T ₂ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Brassinosteriod @ 0.2 ppm	46.56	88.00	100.27	35.00	49.00	63.67	0.56	0.78	1.44	6.22	8.44	10.46
T ₃ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Brassinosteriod @ 0.3 ppm	45.11	85.89	98.23	29.00	50.00	65.00	0.33	0.89	1.33	6.54	8.87	11.12
T ₄ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Triacntanol @ 10 ppm	43.22	82.56	94.63	32.00	47.33	62.33	0.56	1.00	1.44	5.78	7.89	9.65
T ₅ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Triacntanol @ 15 ppm	43.78	84.56	96.60	37.00	51.00	65.67	0.56	1.00	1.56	5.98	8.11	9.98
T ₆ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Triacntanol @ 20 ppm	46.00	89.00	101.83	40.00	53.33	68.33	0.78	1.00	1.67	6.11	8.33	10.22
T ₇ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + GA ₃ @ 10 ppm	46.00	87.67	99.53	33.00	46.00	61.00	0.33	0.78	1.33	5.67	7.67	9.32
T ₈ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + GA ₃ @ 15 ppm	46.11	86.67	98.63	30.00	49.33	64.00	0.56	0.56	1.22	5.78	7.78	9.54
T ₉ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + GA ₃ @ 20 ppm	48.89	90.00	103.27	38.00	52.33	67.00	0.22	0.89	1.33	5.89	7.89	9.76
F-Test	S	S	S	S	S	S	S	S	S	S	S	S
SE(d)	0.14	0.12	0.16	0.09	0.09	0.09	0.01	0.01	0.02	0.02	0.01	0.01
CD 5%	0.29	0.25	0.33	0.18	0.18	0.18	0.03	0.03	0.03	0.04	0.03	0.03
CV	0.37	0.17	0.19	0.32	0.22	0.17	3.33	2.15	1.45	0.42	0.21	0.17

Table 2: Effect of different treatments on survival, physiological, morphological and root parameters of Phalsa (*Grewia asiatica* L.) cv. V1 Thai seedlings at 90 DAT.

Treatment	Morphological Development						Physiological Parameter			Root Parameters	
	Leaf Area(cm ²)			Plant Spread			Chlorophyll (SPAD)	Plant Vigour Index	Survival Percentage	Root Length (cm)	Number of Roots
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT					
T ₀ -Control	19.30	30.93	42.70	32.50	37.00	42.50	27.59	31.71	62.10	18.00	9.67
T ₁ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Brassinosteriod @ 0.1 ppm	21.60	35.23	49.50	34.50	40.00	46.50	34.22	37.85	87.20	21.77	12.33
T ₂ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Brassinosteriod @ 0.2 ppm	23.70	41.87	58.60	37.00	43.50	50.00	35.12	40.79	91.80	23.97	14.33
T ₃ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Brassinosteriod @ 0.3 ppm	26.07	45.93	65.27	39.00	46.50	54.00	35.86	36.31	93.40	25.50	16.33
T ₄ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Triacntanol @ 10 ppm	22.67	38.40	52.70	35.50	41.00	48.00	32.07	43.40	80.50	22.80	13.33
T ₅ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Triacntanol @ 15 ppm	27.27	49.80	71.40	41.50	50.00	56.50	33.88	38.81	81.30	24.23	14.67
T ₆ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + Triacntanol @ 20 ppm	29.63	54.80	77.50	43.50	53.00	63.00	37.94	44.84	96.50	28.23	19.33
T ₇ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + GA ₃ @ 10 ppm	21.63	35.07	49.33	34.50	40.00	46.50	29.84	41.35	76.80	24.70	15.33
T ₈ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + GA ₃ @ 15 ppm	24.33	42.70	60.20	38.00	45.50	53.00	31.02	40.62	82.40	25.20	16.33
T ₉ -Vermicompost @ 0.5 kg/plant + FYM @ 2 kg/plant + GA ₃ @ 20 ppm	26.50	47.00	66.80	40.00	48.50	58.50	32.46	46.81	84.60	27.37	18.33
F-Test	S	S	S	S	S	S	S	S	S	S	S
SE(d)	0.24	0.45	0.69	0.09	0.07	0.02	0.09	1.53	0.07	0.04	0.39
CD 5%	0.51	0.94	1.45	0.19	0.15	0.05	0.19	3.22	0.14	0.08	0.82
CV	1.23	1.30	1.42	0.31	0.19	0.06	0.33	4.66	0.10	0.20	3.17

Conclusion

The present study demonstrated that the combined application of organic manures (vermicompost and farmyard manure) with plant growth regulators significantly improved the survival, vegetative growth, physiological attributes, and

root development of Phalsa (*Grewia asiatica* L.) cv. V1 Thai seedlings under Prayagraj agro-climatic conditions. Among the ten treatments evaluated, T₆ (Vermicompost @ 0.5 kg plant⁻¹ + FYM @ 2.0 kg plant⁻¹ + Triacntanol @ 20 ppm) emerged as the most effective treatment, recording

superior performance in survival percentage, number of branches, number of leaves, leaf area, chlorophyll content, plant spread, root length, and number of roots at 90 DAT.

While GA₃ at 20 ppm (T₉) proved most effective for increasing plant height and brassinosteroid at 0.3 ppm (T₃) for enhancing stem girth, triacontanol at 20 ppm in combination with organic manures provided the best overall balance of growth parameters. These results highlight the synergistic benefits of triacontanol with organic amendments in improving nutrient uptake, photosynthetic efficiency, and root architecture, thereby addressing the major constraints of poor seedling establishment in Phalsa.

The findings of this study suggest that the integrated use of vermicompost, farmyard manure, and triacontanol at 20 ppm can be recommended as an effective, sustainable approach for producing vigorous and high-quality planting material of Phalsa cv. V1 Thai under subtropical conditions similar to Prayagraj. This strategy holds promise for enhancing commercial cultivation of this underutilized minor fruit crop in the future.

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