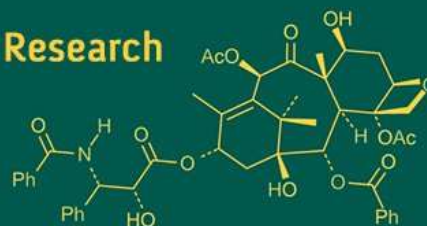
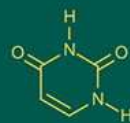
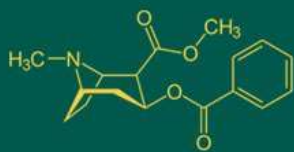


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Deshmukh Yash R
PG Scholar, Department of
Agricultural Botany, Plant
Physiology, Post Graduate
Institute, Dr. PDKV, Akola,
Maharashtra, India

Dr. PP Gawande
Assistant Professor, College of
Forestry, Dr. PDKV, Akola,
Maharashtra, India

Yadav Nikhil R
M.Sc. Agriculture, Genetics
and Plant Breeding, Dr.
PDKV, Akola, Maharashtra,
India

Patil Snehal G
Young Professional-I,
Department of Agricultural
Botany, Dr. PDKV, Akola,
Maharashtra, India

Ingole DR
PG Scholar, Department of
Agricultural Botany, Plant
Physiology, Post Graduate
Institute, Dr. PDKV, Akola,
Maharashtra, India

Tayade AK
PG Scholar, Department of
Agricultural Botany, Plant
Physiology, Post Graduate
Institute, Dr. PDKV, Akola,
Maharashtra, India

Corresponding Author:
Deshmukh Yash R
PG Scholar, Department of
Agricultural Botany, Plant
Physiology, Post Graduate
Institute, Dr. PDKV, Akola,
Maharashtra, India

Effect of chitosan and Triacontanol on growth and physiological traits of black gram (*Vigna mungo* L.)

Deshmukh Yash R, PP Gawande, Yadav Nikhil R, Patil Snehal G, Ingole DR and Tayade AK

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Abstract

A field experiment was conducted during the *Kharif* season of 2025 at the Research Field of Agriculture Botany, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, to study the effect of foliar application of chitosan and triacontanol on growth and physiological traits of black gram (*Vigna mungo* L.). The experiment was laid out in a Randomized Block Design with three replications and ten treatments comprising chitosan at 50, 75 and 100 ppm, triacontanol at 2, 4 and 6 ppm, their combinations and an untreated control. Foliar applications were given at 30 and 45 days after sowing (DAS). Observations were recorded on plant height, number of branches plant⁻¹, leaf area, leaf area index, relative growth rate (RGR) and crop growth rate (CGR). Treatment effects on plant height, number of branches, leaf area and leaf area index were non-significant at 30 DAS but became significant at later growth stages. The combined application of chitosan 75 ppm + triacontanol 6 ppm (T₇) recorded the maximum plant height of 49.30 and 71.10 cm and the highest number of branches of 5.90 and 7.90 plant⁻¹ at 45 and 60 DAS, respectively. In contrast, chitosan 75 ppm + triacontanol 4 ppm (T₆) recorded the highest leaf area at 30, 45 and 60 DAS, with values of 6.18, 15.78 and 25.37 dm² plant⁻¹, respectively. T₆ also recorded the highest RGR during both 30-45 DAS (0.02547 g g⁻¹ day⁻¹) and 45-60 DAS (0.01090 g g⁻¹ day⁻¹). Similarly, the maximum CGR was observed under T₆ during 30-45 DAS (12.60 g m⁻² day⁻¹) and 45-60 DAS (16.00 g m⁻² day⁻¹). Days to 50 percent flowering were not significantly affected by the treatments. Overall, the combined application of chitosan 75 ppm + triacontanol 4 ppm showed the most consistent improvement in physiological growth performance of black gram. The findings suggest that combined foliar application of chitosan and triacontanol may enhance vegetative growth and biomass accumulation in black gram under the agro-climatic conditions of Akola.

Keywords: Black gram, chitosan, triacontanol, plant growth, leaf area, relative growth rate, crop growth rate, physiological traits

1. Introduction

Black gram (*Vigna mungo* L.) is an important short-duration pulse crop cultivated extensively in India due to its nutritional value, adaptability and role in sustainable agriculture. It is a valuable source of dietary protein, carbohydrates, minerals and other nutrients. However, its productivity is influenced by environmental conditions, vegetative growth, canopy development, photosynthetic efficiency and assimilate partitioning. Therefore, improving growth and physiological efficiency is essential for enhancing productivity.

Chitosan is a naturally occurring biopolymer derived from chitin and is considered an inexpensive and renewable biomaterial. It has been reported to influence various physiological and biochemical processes in plants, including growth, nutrient utilization, photosynthetic activity and stress tolerance (Kurita, 2006; Malerba and Cerana, 2016) [7, 8]. Its effectiveness, however, depends on crop, concentration and environmental conditions.

Triacontanol is a long-chain aliphatic alcohol that acts as a potent plant growth regulator at low concentrations. It has been associated with enhanced photosynthetic activity, chlorophyll accumulation, biomass production and plant growth. Beneficial effects of triacontanol on growth and physiological attributes have been reported in green gram, black gram and rice. The combined application of chitosan and triacontanol may produce complementary effects by enhancing different aspects of plant growth and physiological activity.

However, limited information is available on their combined application in black gram under the agro-climatic conditions of the Akola region. Therefore, the present investigation was undertaken to evaluate the effect of foliar application of chitosan and triacontanol, individually and in combination, on growth and physiological traits of black gram.

2. Materials and Methods

The field experiment was conducted during *Kharif* of 2025 at the Department of Agricultural Botany research field, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India. The black gram variety PDKV Blackgold (AKU 10-1) was utilized. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Sowing was carried out manually on June 20, 2025, by maintaining a spacing of 45 cm × 10 cm. Each net plot measured 3.00 m × 2.25 m (6.75 m²). Standard agronomic and plant protection practices were followed throughout the crop growth period.

The foliar treatments were applied at 30 and 45 days after sowing (DAS): T₁: Control; T₂: Chitosan @ 50 ppm; T₃: Chitosan @ 75 ppm; T₄: Chitosan @ 100 ppm; T₅: Chitosan @ 75 ppm + Triacontanol @ 2 ppm; T₆: Chitosan @ 75 ppm + Triacontanol @ 4 ppm; T₇: Chitosan @ 75 ppm + Triacontanol @ 6 ppm; T₈: Triacontanol @ 2 ppm; T₉: Triacontanol @ 4 ppm; and T₁₀: Triacontanol @ 6 ppm. The treatments were evaluated for their individual and combined effects on growth, physiological traits and yield of black gram.

Five representative plants were randomly selected and tagged in each net plot for recording morphological and physiological observations at different growth stages.

Observations on plant height, number of branches plant⁻¹, leaf area and leaf area index (LAI) were recorded at 30, 45 and 60 DAS. Growth indices such as relative growth rate (RGR) and crop growth rate (CGR) were also determined from the recorded observations.

At harvest, five representative plants were randomly selected from each net plot for recording yield attributes, including number of pods plant⁻¹, seed yield plant⁻¹ (g) and 100-seed weight (g). Seed yield and other yield parameters were recorded following standard procedures. The harvest index and economics of the treatments were also worked out based on the recorded yield and cost of cultivation.

The data obtained for various observations were subjected to analysis of variance (ANOVA) appropriate for RBD as described by Panse and Sukhatme (1954). The standard error of mean SE(m) and critical difference (CD) at 5% probability level were calculated wherever the treatment effects were significant.

3. Results and Discussion

3.1 Morphological Growth Parameters

3.1.1 Plant Height

Plant height increased progressively from 30 to 60 DAS in all treatments (Table 1). Treatment effects were non-significant at 30 DAS but significant at 45 and 60 DAS.

The maximum plant height was recorded with T₇ (Chitosan 75 ppm + Triacontanol 6 ppm), recording 20.47, 49.30 and 71.10 cm at 30, 45 and 60 DAS, respectively. The combined application of chitosan and triacontanol was generally more effective than their individual application. Similar enhancement in plant height following triacontanol application was reported by Kumaravelu *et al.* (2000) [6] in green gram and Varma *et al.* (2009) [14] in black gram.

Table 1: Effect of chitosan and triacontanol on plant height, number of branches plant⁻¹ and days to 50% flowering in Black gram

Treatments	Plant height (cm) 30 DAS	Plant height (cm) 45 DAS	Plant height (cm) 60 DAS	Number of branches plant ⁻¹ 30 DAS	Number of branches plant ⁻¹ 45 DAS	Number of branches plant ⁻¹ 60 DAS	Days to 50% flowering
T ₁ Control	18.47	40.8	59.2	2.1	3.2	5.7	40
T ₂ Chitosan 50 ppm	19.27	42.2	61.5	2.3	4.4	5.9	40.67
T ₃ Chitosan 75 ppm	19.33	44.1	63.8	2.5	4.7	6.2	40
T ₄ Chitosan 100 ppm	19.6	45.4	65.5	2.8	5.1	6.7	40.67
T ₅ Chitosan 75 ppm + TRIA 2 ppm	20.31	47.1	68.5	3	5.4	7.1	40.33
T ₆ Chitosan 75 ppm + TRIA 4 ppm	20.27	48.3	69.8	3.1	5.6	7.7	39.67
T ₇ Chitosan 75 ppm + TRIA 6 ppm	20.47	49.3	71.1	3.33	5.9	7.9	40.67
T ₈ TRIA 2 ppm	19.37	44.4	62.8	2.7	5	6.5	40
T ₉ TRIA 4 ppm	19.77	46.1	65.2	2.7	5.1	6.8	40.33
T ₁₀ TRIA 6 ppm	20.23	47.2	68.2	3.1	5.5	7.3	40
SE(m)±	0.707	0.660	0.819	0.248	0.118	0.197	1.138
CD at 5%	2.099	1.960	2.434	0.735	0.351	0.586	3.381

3.1.2 Number of branches plant⁻¹

Number of branches plant⁻¹ increased with crop age (Table 1). Treatment effects were non-significant at 30 DAS but significant at 45 and 60 DAS. T₇ recorded the maximum branching, with 5.90 and 7.90 branches plant⁻¹ at 45 and 60 DAS, respectively.

Combined application of chitosan and triacontanol resulted in greater branching than their individual application. Similar improvement in branching due to triacontanol application was reported by Varma *et al.* (2009) [14].

3.1.3 Day to 50% flowering

The application of chitosan and triacontanol had only a limited influence on the days to 50 percent flowering (Table

1). The values ranged from 39.67 to 40.67 days and the treatment effect was non-significant. The earliest 50 percent flowering was recorded under T₆ (39.67 days), whereas T₂, T₄ and T₇ recorded the maximum value of 40.67 days. The relatively narrow variation indicated that flowering time was comparatively stable and was influenced more by varietal and environmental factors than by the treatments.

3.1.4 Leaf area

Leaf area increased progressively with crop growth (Table 2). At 30 DAS, the treatment effect was non-significant, whereas the leaf area was significantly influenced by the treatments at 45 and 60 DAS. The highest leaf area was recorded in T₆ (15.78 and 25.37 dm² plant⁻¹ at 45 and 60

DAS, respectively), followed by T₇. The higher leaf area under the combined treatment indicated better development of the photosynthetically active surface.

Kumaravelu *et al.* (2000)^[6] reported that foliar application of triacontanol significantly promoted plant growth and increased chlorophyll and fresh mass in green gram. Similarly, Khandaker *et al.* (2013)^[5] observed improvement in leaf development and vegetative growth following triacontanol application.

Sharifa and Abu-Muriefah (2013)^[13] did an experiment to study the effect of chitosan at 100, 200 and 400 ppm on common bean. The result reported that application of reported that application of chitosan at 200 ppm has significantly increased leaf area per plant.

3.1.5 Leaf area index

Leaf area index was maximum under T₆, recording 3.507 at 45 DAS and 5.638 at 60 DAS (Table 2). T₆ was statistically at par with T₇, indicating the superior canopy development under the combined application of chitosan 75 ppm and triacontanol 4 ppm. The leaf area index also increased with advancement of crop growth and was numerically highest under T₆ (Chitosan 75 ppm + Triacontanol 4 ppm). The treatment effect was non-significant at 30 DAS but significant at 45 and 60 DAS. The higher LAI under the combined treatment indicated improved canopy development and greater leaf surface available for photosynthesis.

Table 2: Effect of chitosan and triacontanol on Leaf area (dm² plant⁻¹) and Leaf area Index (LAI) in black gram

Treatments	Leaf area 30 DAS	Leaf area 45 DAS	Leaf area 60 DAS	Leaf area index 30 DAS	Leaf area index 45 DAS	Leaf area index 60 DAS
T ₁ Control	5.08	9.77	15.97	1.129	2.171	3.549
T ₂ Chitosan 50 ppm	4.98	11.5	18.4	1.106	2.556	4.089
T ₃ Chitosan 75 ppm	5.08	11	17.53	1.129	2.444	3.896
T ₄ Chitosan 100 ppm	5.05	11.84	19.03	1.123	2.631	4.229
T ₅ Chitosan 75 ppm + TRIA 2 ppm	5.06	13.41	21.5	1.124	2.98	4.778
T ₆ Chitosan 75 ppm + TRIA 4 ppm	4.96	15.78	25.37	1.102	3.507	5.638
T ₇ Chitosan 75 ppm + TRIA 6 ppm	5.04	14.95	24	1.12	3.322	5.333
T ₈ TRIA 2 ppm	4.98	12.11	19.5	1.106	2.691	4.333
T ₉ TRIA 4 ppm	5.11	12.66	20.33	1.135	2.813	4.518
T ₁₀ TRIA 6 ppm	4.96	14	22.5	1.102	3.111	5
SE(m)±	0.488	0.284	0.47	0.025	0.075	0.118
CD at 5%	1.33	0.843	1.357	0.075	0.222	0.352

The present findings are in agreement with Mondal *et al.* (2013)^[10], who reported that foliar application of chitosan at different concentrations (25, 50, 75 and 100 ppm) improved vegetative growth and leaf area in mungbean, with 50 ppm chitosan being the most effective concentration.

Kumaravelu *et al.* (2000)^[6] reported enhanced vegetative growth and chlorophyll accumulation following triacontanol application in green gram. Chen *et al.* (2002)^[1] also reported that triacontanol improved chlorophyll content and net photosynthetic rate in rice.

3.2 Physiological parameters

3.2.1 Relative growth rate (g g⁻¹ day⁻¹)

Relative growth rate (RGR) was significantly influenced by the treatments during both growth periods (Table 3). T₆ recorded the highest RGR of 0.02547 and 0.01090 g g⁻¹ day⁻¹ during 30-45 and 45-60 DAS, respectively, followed by T₇. The control recorded the lowest values. The enhanced RGR under combined treatments may be attributed to improved photosynthetic activity and biomass accumulation associated with chitosan and triacontanol application.

The higher relative growth rate recorded under triacontanol treatments may be associated with enhanced photosynthetic

efficiency and metabolic activity. Kumaravelu *et al.* (2000)^[6] reported that triacontanol application improved plant growth, fresh mass and chlorophyll content in green gram. Chen *et al.* (2002)^[1] also observed increased dry weight, protein content, chlorophyll level and net photosynthetic rate following triacontanol application in rice.

Deotale *et al.* (2018)^[2] revealed the response of soybean to treatment with chitosan and IBA at 25, 50, 75, 100, 125 ppm. The foliar spray was given at 30 DAS on soybean. The increase in relative growth rate was recorded at 25 ppm concentration of chitosan.

3.2.2 Crop growth rate (g m⁻² day⁻¹)

Crop growth rate (CGR) was significantly influenced by the treatments during both growth periods (Table 3). The highest CGR was recorded under T₆, with 12.60 and 16.00 g m⁻² day⁻¹ during 30-45 and 45-60 DAS, respectively, followed by T₇. The control recorded the lowest CGR. The higher CGR under combined application indicated greater biomass accumulation and efficient assimilate production during active crop growth. Similar physiological enhancement following triacontanol application was reported by Chen *et al.* (2002)^[1].

Table 3: Effect of chitosan and triacontanol on the relative growth rate and crop growth rate in black gram

Treatments	RGR 30-45 DAS	RGR 45-60 DAS	CGR 30-45 DAS	CGR 45-60 DAS
T ₁ Control	0.02273	0.01	7.83	10.1
T ₂ Chitosan 50 ppm	0.02297	0.01	8.47	10.9
T ₃ Chitosan 75 ppm	0.02327	0.0106	8.8	11.61
T ₄ Chitosan 100 ppm	0.02387	0.01067	9.43	12.2
T ₅ Chitosan 75 ppm + TRIA 2 ppm	0.02517	0.0107	10.33	13.43
T ₆ Chitosan 75 ppm + TRIA 4 ppm	0.02547	0.0109	12.6	16
T ₇ Chitosan 75 ppm + TRIA 6 ppm	0.0252	0.01087	11.8	14.93
T ₈ TRIA 2 ppm	0.0237	0.01063	9.3	12.07
T ₉ TRIA 4 ppm	0.02453	0.01063	10.1	12.87
T ₁₀ TRIA 6 ppm	0.02517	0.0108	11.17	13.85
SE(m)±	0.001	0.000	0.273	0.395
CD at 5%	0.002	0.001	0.812	1.173

4. Conclusion

The present investigation demonstrated that foliar application of chitosan and triacontanol improved growth and physiological performance of black gram. The combined treatments were generally superior to their individual application. T₇ (Chitosan 75 ppm + Triacontanol 6 ppm) recorded the maximum plant height and number of branches plant⁻¹, whereas T₆ (Chitosan 75 ppm + Triacontanol 4 ppm) recorded the highest leaf area, leaf area index, relative growth rate and crop growth rate. The treatments had no significant effect on days to 50% flowering. Overall, the combined application of chitosan 75 ppm with triacontanol 4-6 ppm showed better potential for improving vegetative growth, canopy development and physiological efficiency of black gram under *Kharif* conditions.

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