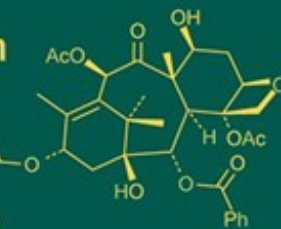
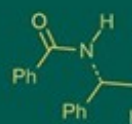


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Influence of foliar application of chitosan on morphological, physiological and yield parameters of mustard (*Brassica Juncea* L.)

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ABSTRACT

Chitosan is a natural biostimulant that enhances plant growth, physiological activities, and crop productivity. A field experiment was conducted under the title of "Effect of foliar application of chitosan on morpho-physiological, biochemical, and yield parameters of mustard (*Brassica juncea* L.) during the Rabi season of 2025–26 at the Experimental Farm of the Agricultural Botany Section, College of Agriculture, Nagpur. The objective of the study was to evaluate the effect of foliar application of chitosan on morpho-physiological and yield parameters of mustard and to identify the optimum chitosan concentration for improving crop performance. The experiment was laid out in a Randomized Block Design with three replications and seven treatments comprising a control and chitosan concentrations of 50, 100, 150, 200, 250, and 300 ppm. Chitosan was applied as a foliar spray at 30 and 60 days after sowing. The pooled results of the experiment revealed that, among the six concentrations of chitosan tested, foliar application of chitosan 150 ppm at 30 and 60 days after sowing (DAS) significantly enhanced all morpho-physiological and yield parameters including plant height (242.69 cm), number of branches (4.65/plant), leaf area (11.73 dm²), dry matter (76.87 g), CGR (17.28 g m⁻² day⁻¹), NAR (0.0410 gdm⁻² day⁻¹), number of siliqua (396.86/plant), thousand seed weight (5.62 g), mustard yield (18.63 q/ha) and harvest index (35.07%) .

Keywords: Chitosan concentrations, Foliar spray, Mustard, Morpho-physiological, Yield parameters

1.

Introduction

Indian mustard (*Brassica juncea* L.) is one of the most important oilseed crops cultivated in India due to its wide adaptability, high seed oil content, and economic importance. As the second most important oilseed crop in the country after groundnut, it plays a significant role in meeting the increasing demand for edible oil and contributes substantially to the agricultural economy. India is the third-largest producer of rapeseed–mustard in the world after Canada and China. Owing to its high productivity and adaptability to diverse agro-climatic conditions, *B. juncea* has emerged as a major component of the Indian oilseed production system (Thakur *et al.*, 2020; Kumar *et al.*, 2025) [2, 1].

Indian mustard, commonly known as "Mohari" in several parts of the country, belongs to the family Brassicaceae (Cruciferae) and the genus *Brassica*. The crop is believed to have originated from the China and India–Middle East centres of diversity. Among the cultivated *Brassica* species, *Brassica rapa* is considered the most ancient species with the widest geographical distribution (Rai *et al.*, 2022) [3].

The oilseed sector is one of the fastest-growing segments of Indian agriculture, with oilseed crops occupying nearly 13% of the gross cultivated area and contributing significantly to the national economy. Oilseed *Brassica* crops account for about 27.8% of the country's oilseed economy and nearly 35% of total oilseed production. In India, mustard is cultivated over an area of about 7.99 million hectares, producing approximately 11.9 million tonnes with an average productivity of 1,524 kg ha⁻¹. Rajasthan is the leading mustard-producing state, followed by Uttar Pradesh (GOI, 2022; Indiatat, 2022) [4, 5].

Chitosan, a natural biopolymer derived from chitin, has gained considerable attention as an eco-friendly biostimulant and plant growth elicitor in sustainable agriculture. It is biodegradable, non-toxic, and biocompatible, and has been reported to enhance plant growth, photosynthetic efficiency, nutrient uptake, antioxidant activity, and tolerance to abiotic stresses. Foliar application of chitosan regulates stomatal behaviour, stimulates enzyme activity, and enhances the accumulation of metabolites involved in growth and stress adaptation. These physiological and biochemical responses ultimately lead to improved crop growth, yield, and quality. Considering its beneficial effects and increasing emphasis on sustainable crop production, the

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present investigation was undertaken to evaluate the effect of foliar application of chitosan on the growth, physiological and yield parameters of Indian mustard.

Materials and Methods

The study was conducted in *Rabi* 2025-26 at the Research farm of the Botany Section, College of Agriculture, Nagpur. Seven treatments included six concentrations of chitosan viz., 50 ppm, 100 ppm, 150 ppm, 200 ppm, 250 ppm and 300 ppm were sprayed at 30 and 60 days of sowing and control plants were sprayed with tap water. The experiment was carried out in a randomized block design.

Evaluation of morpho physiological and yield parameters of mustard

The observations on plant height (cm), leaf area (dm^{-2}), dry matter (g), in leaves were recorded 45 days and 75 days after sowing and crop growth rate (CGR) and net assimilation rate (NAR) were recorded during the 45–75 DAS period. Whereas, observations on number of branches, 1000 seed weight (g), number of siliqua plant⁻¹ and yield (q/ha) were recorded at maturity.

Measurement of leaf area

Leaves were detached from five plants and leaf area was then measured by using leaf area meter in cm^2 and then converted into dm^2 .

Results and Discussion

A) Effect of chitosan on morpho physiological parameters of mustard

The effect of different concentrations of chitosan on morpho-physiological characters (plant height, number of branches/plants, leaf area, dry matter, crop growth rate and net assimilation rate) were assessed and depicted in Table 1.

1. Plant height and number of branches

i) Plant height

The data presented in Table 1 and Fig. 1 revealed that plant height were significantly influenced by chitosan concentrations at 45 and 75 DAS and at harvest.

At 45 days after sowing

The maximum plant height 72.34 cm was recorded the treatment T₄ (150 ppm) followed by T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 68.21 cm and 66.53 cm plant height respectively, compared to control.

At 75 days after sowing

At 75 DAS, maximum plant height 210.02 cm was observed in treatment T₄ (150 ppm) followed by treatment T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 197.84 cm and 194.76 cm plant height, respectively, compared to control.

At harvest

At harvest, significantly higher plant height 242.69 cm was recorded in treatment T₄ (150 ppm chitosan), followed by T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 234.31 cm and 221.54 cm plant height respectively, compared to control.

Islam *et al.* (2021) [6] experiments were conducted to investigate the effect of foliar application of chitosan on mungbean. The experiment comprised five levels of chitosan concentrations viz., 0 (control), 25, 50, 75 and 100 ppm. Foliar application of chitosan increased plant height at 50 ppm followed by 75 ppm and 25 ppm.

Chitosan application increased plant height by promoting cell division and elongation, improving nutrient uptake, chlorophyll content, photosynthetic efficiency and carbohydrate production. It also enhanced growth-related enzymes and regulated phytohormones, thereby promoting stem elongation and overall plant growth (Chande *et al.*, 2021) [7].

ii) Number of branches

The data presented in Table 1 and Fig. 2 number of branches per plant were significantly influenced by chitosan concentrations at harvest. The number of branches per plant was recorded at harvest. The maximum number of branches 4.65 plant⁻¹ was recorded in the treatment T₄ (150 ppm chitosan) followed by T₅ (200 ppm chitosan) and T₆ (250 ppm chitosan) with 4.57 and 4.33 branches per plant, respectively compared to the control and rest of the treatments.

Chande *et al.* (2021) [7] carried out an experiment to investigate the effect of different concentrations (control, 25, 50, 75, 100 and 125 ppm) of chitosan on groundnut. Foliar sprays of 100 ppm chitosan at 25 and 45 DAS significantly enhanced number of branches plant⁻¹ when compared with remaining treatments and control.

2. Leaf area and dry matter

The data presented in Fig. 3 and Fig. 4 show that leaf area and dry matter were significantly influenced by chitosan concentrations at both 45 and 75 days after sowing (DAS).

At 45 days after sowing

At 45 DAS, Maximum leaf area 11.73 dm^2 and dry matter 21.84 g were observed in treatment T₄ (150 ppm chitosan) followed by T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 11.14 dm^2 and 10.82 dm^2 leaf area and 20.47 g and 20.13 g dry matter, respectively compared to the control and rest of the treatments.

At 75 days after sowing

At 75 DAS, leaf area 9.19 dm^2 and 76.87 g dry matter were significantly highest in treatment T₄ (150 ppm) followed by treatments T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 8.98 dm^2 and 8.66 dm^2 leaf area and 73.41 g, 70.97 g dry weight when compared with treatment T₁ (control) and rest of the treatments.

Foliar application of chitosan increased leaf area due to its biostimulant effect, promoting cell division and expansion. It also enhanced chlorophyll synthesis, nutrient uptake and photosynthetic efficiency, resulting in greater carbohydrate production and improved leaf development in sweet basil (*Ocimum basilicum* L.) (Qazizadah *et al.*, 2026) [8].

Foliar application of chitosan increased dry matter production by enhancing chlorophyll content, photosynthetic efficiency, nutrient uptake and leaf expansion. These effects promoted greater assimilate production and biomass accumulation. Chitosan also improved CGR, RGR and NAR, thereby enhancing overall plant growth and biomass production (Gawande *et al.*, 2022) [9].

3. Crop growth rate (CGR) and net assimilation rate (NAR)

Data on crop growth rate (CGR) and net assimilation rate (NAR) were recorded during the 45–75 DAS period and presented in Fig. 5 and Fig. 6 respectively.

At 45–75 DAS, a significantly higher crop growth rate (CGR) 17.28 $\text{g m}^{-2} \text{day}^{-1}$ and net assimilation rate (NAR) 0.0410 $\text{g dm}^{-2} \text{day}^{-1}$ were recorded in treatment T₄ (150 ppm) followed by T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 16.45 $\text{g m}^{-2} \text{day}^{-1}$ and 16.01 $\text{g m}^{-2} \text{day}^{-1}$ CGR and 0.0391 $\text{g dm}^{-2} \text{day}^{-1}$ and 0.0378 $\text{g dm}^{-2} \text{day}^{-1}$ NAR, respectively, compared to the control and rest of the treatments. Whereas treatment T₃ (100 ppm chitosan) and T₅ (200 ppm chitosan) were found to be statistically at par with the T₄ (150 ppm chitosan) respectively with respect to all morpho-physiological parameters.

Gawande *et al.* (2022) [9] evaluated the effect of foliar application of chitosan on growth parameters of cotton using seven treatments: T₁ (control), T₂ (25 ppm), T₃ (50 ppm), T₄ (75 ppm), T₅ (100 ppm), T₆ (125 ppm) and T₇ (150 ppm), with foliar sprays applied at 35 and 55 DAS. The results showed that T₄ (75 ppm chitosan) recorded the highest crop growth rate (CGR) and was significantly superior to the control. Foliar application of chitosan enhanced CGR by promoting dry matter accumulation, leaf area development and photosynthetic efficiency.

Chande *et al.* (2021) [7] carried out an experiment to investigate the effect of different concentrations (control, 25, 50, 75, 100 and

125 ppm) of chitosan on groundnut. Foliar sprays of 100 ppm chitosan at 25 and 45 DAS significantly enhanced net assimilation rate when compared with remaining treatments and control. Chitosan enhancing photosynthetic efficiency, chlorophyll synthesis and nutrient utilization, resulting in higher NAR.

B) Effect of chitosan on yield and yield contributing parameters of mustard

The effect of different concentrations of chitosan on yield and yield contributing parameters (number of siliqua/plant, thousand seed weight, seed yield and harvest index) were recorded and depicted in Table 2.

1. Thousand seed weight and number of siliqua/plant

Significantly highest seed weights 5.62 g and number of siliques per plant 396.86 were observed in treatment T₄ (150 ppm chitosan) followed by T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 5.40 g and 5.35 g seed weight and 388.84 and 378.68 siliqua, respectively, compared to the control and rest of the treatments.

Khurizadeh *et al.* (2024) [10] reported that foliar application of chitosan significantly improved growth, yield, and quality of guar (*Cyamopsis tetragonoloba* L.) under both normal and water-deficit conditions. The application of 150 mg L⁻¹ chitosan was the most effective, increasing 1000-seed weight.

Raut *et al.* (2022) [11] carried out an experiment in chickpea. During investigation chitosan was applied at (0,10 ppm, 20 ppm, 30 ppm, 40 ppm, 50 ppm, 60 ppm, 70 ppm, 80 ppm, 90 ppm and 100 ppm) 25 and 45 DAS. They observed that foliar sprays 60 ppm chitosan result in increase in number of pods plant⁻¹ when compared with control and different concentrations.

2. Seed yield plot⁻¹ and ha⁻¹

Seed yield is influenced by morpho-physiological parameters such as plant height, total dry matter production, leaf area and test weight which are considered as yield contributing parameters. Seed yield plot⁻¹ and ha⁻¹ are the combined effect of yield attributing characters and physiological efficiency of plant.

The highest seed yield 1.61 kg plot⁻¹ and 18.63 q/ha⁻¹ were recorded in treatment T₄ (150 ppm chitosan) followed by T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 1.56 kg and 1.49 kg seed yield plot⁻¹ and 18.05 q/ha and 17.27 seed yield q/ha respectively, compared with the control (T₁).

Raut *et al.* (2022) [11] carried out an experiment in chickpea. During investigation chitosan was applied at (0,10 ppm, 20 ppm, 30 ppm, 40 ppm, 50 ppm, 60 ppm, 70 ppm, 80 ppm, 90 ppm and 100 ppm) 25 and 45 DAS. They observed that foliar sprays 60 ppm chitosan result in increase in seed yield plant⁻¹(g), ha⁻¹(q) when compared with control and different concentrations.

3. Harvest index

A significantly higher harvest index 35.07 % was recorded in treatment T₄ (150 ppm chitosan), followed by T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 34.30 % and 34.00 % respectively, compared with the control (T₁). Whereas treatment T₃ (100 ppm chitosan) and T₅ (200 ppm chitosan) were found to be statistically at par with the T₄ (150 ppm chitosan) respectively with respect to all yield parameters and harvest index.

Chande *et al.* (2021) [7] carried out an experiment to investigate the effect of different concentrations (control, 25, 50, 75, 100 and 125 ppm) of chitosan on groundnut. Foliar sprays of 100 ppm chitosan at 25 and 45 DAS significantly increased harvest index over control.

Foliar application of chitosan enhanced seed yield by improving photosynthesis, nutrient uptake and antioxidant activity. These effects promoted efficient assimilate production and translocation, leading to better seed filling and higher yield (Hammada *et al.*, 2026) [12].

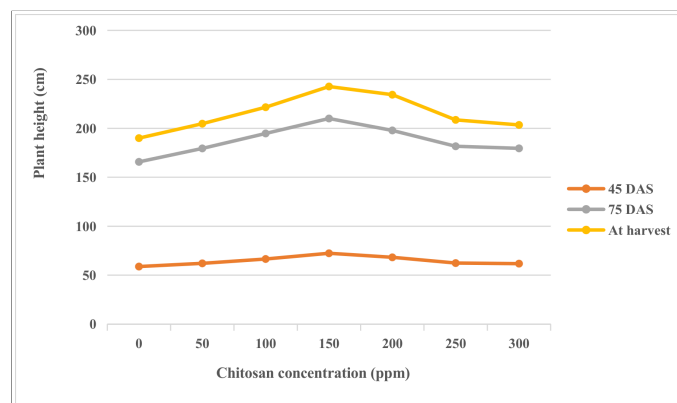


Figure 1. Effect of chitosan on plant height in mustard

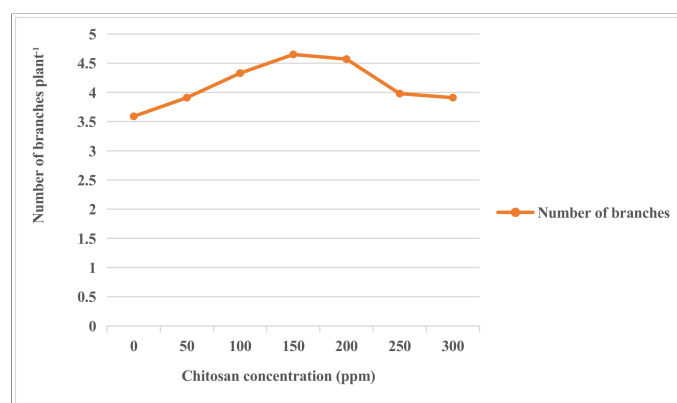


Figure 2. Effect of chitosan on number of branches plant⁻¹ in mustard

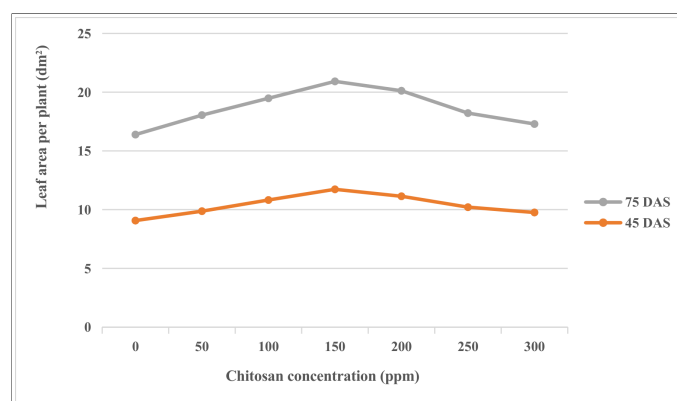


Figure 3. Effect of chitosan on leaf area plant⁻¹ in mustard

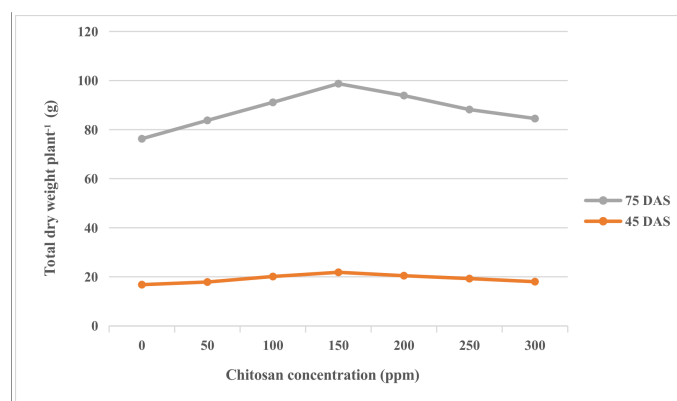


Figure 4. Effect of chitosan on dry weight plant⁻¹ in mustard

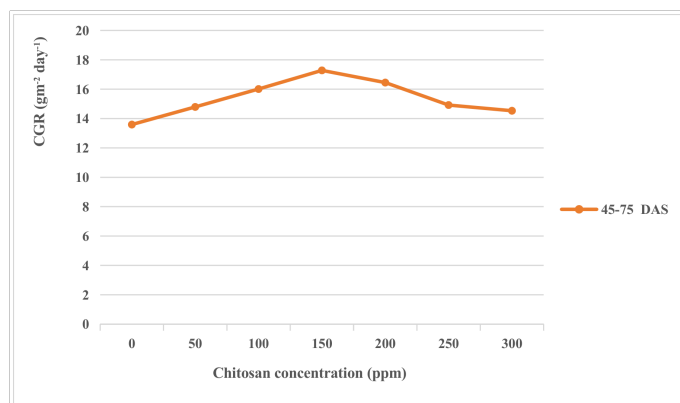


Figure 5. Effect of chitosan on CGR in mustard

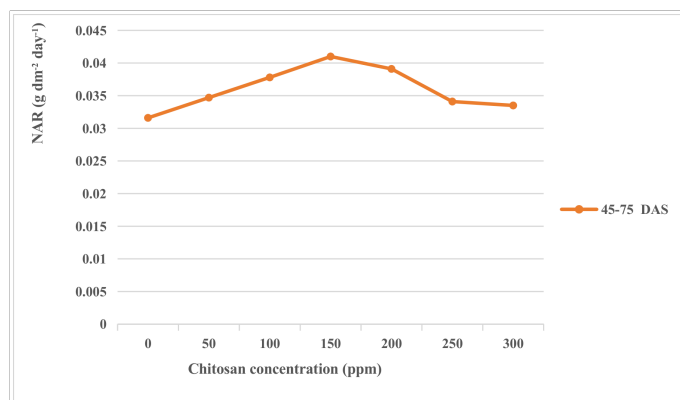


Figure 6. Effect of chitosan on NAR in mustard

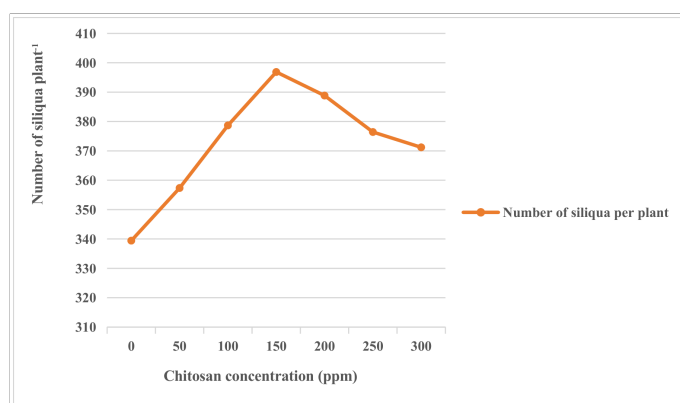


Figure 7. Effect of chitosan on number of siliqua plant⁻¹ in mustard

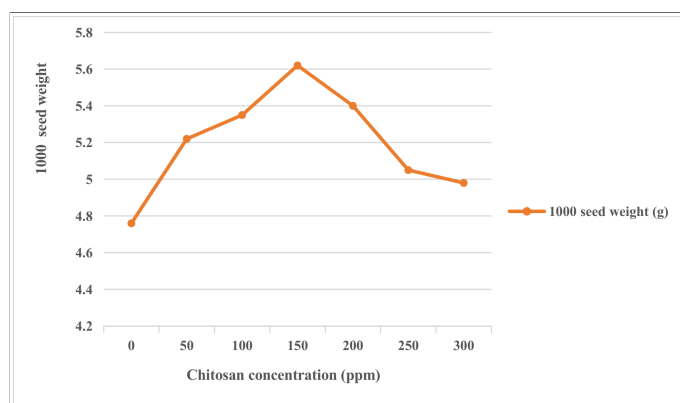


Figure 8. Effect of chitosan on 1000 seed weight (g) in mustard

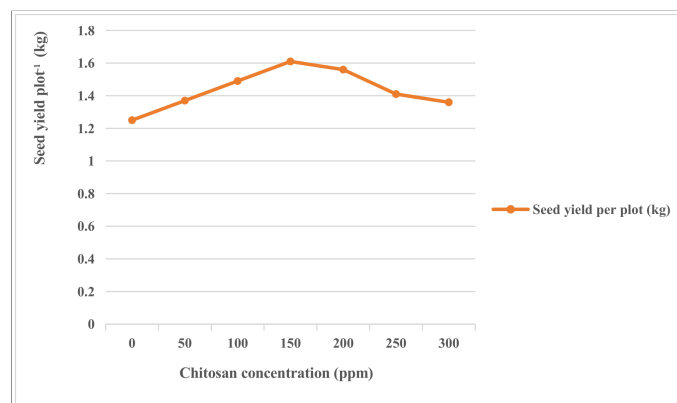


Figure 9. Effect of chitosan on seed yield plot⁻¹(kg) in mustard

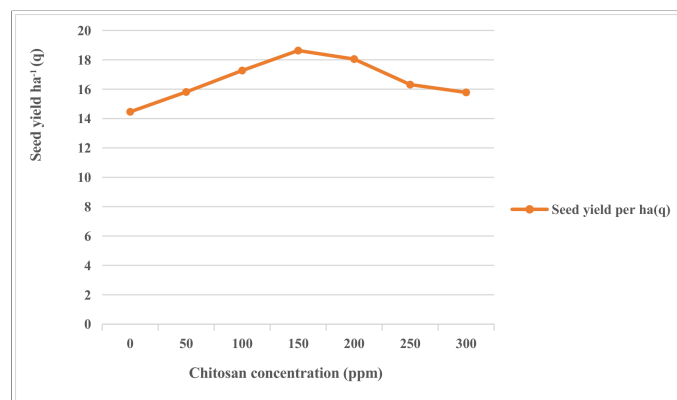


Figure 10. Effect of chitosan on seed yield ha⁻¹ (q) in mustard

Conclusion

Thus, from the present study, it is concluded that the mustard responded positively to foliar application of chitosan at 30 and 60 DAS, resulting in significant variation among the different characters evaluated in the study.

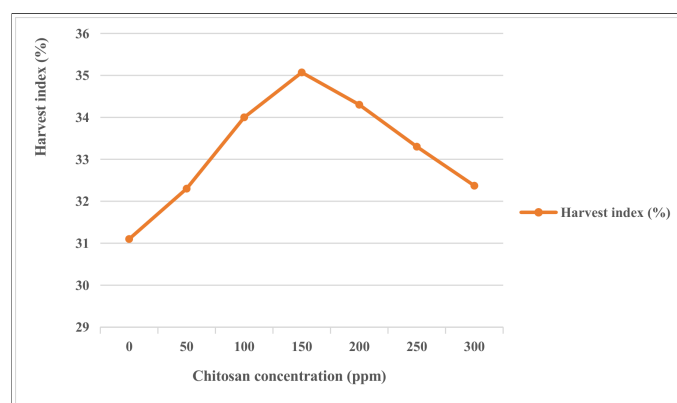


Figure 11. Effect of chitosan on harvest index in mustard

From the overall results, it can be concluded that foliar application of chitosan at different concentrations improved the morpho physiological, yield and yield-contributing parameters, thereby contributing to higher seed yield in the present investigation.

The highest increase in seed yield over the control was recorded with foliar application of 150 ppm chitosan at 30 and 60 DAS, resulting in an increase of 28.8%. This was followed by foliar application of 200 ppm chitosan at 30 and 60 DAS, which improved seed yield by 24.8% over the control.

Table 1. Effect of foliar spray of chitosan on morpho-physiological parameters of mustard

Tr. No.	Treatments details	Plnat Height (cm)			No. of branches/plant at harvest	Leaf area (dm ²)		Dry matter (g)		CGR (g m ⁻² day ⁻¹)	NAR (gdm ² day ⁻¹)
		45DAS	75DAS	Harvest		45DAS	75DAS	45DAS	75DAS	45-75 DAS	45-75 DAS
T ₁	Control Water spray	58.80	165.73	189.98	3.59	9.07	7.32	16.81	59.45	13.59	0.0316
T ₂	Chitosan 50 ppm	62.07	179.47	204.73	3.91	9.87	8.18	17.89	65.87	14.79	0.0347
T ₃	Chitosan 100 ppm	66.53	194.76	221.54	4.33	10.82	8.66	20.13	70.97	16.01	0.0378
T ₄	Chitosan 150 ppm	72.34	210.02	242.69	4.65	11.73	9.19	21.84	76.87	17.28	0.0410
T ₅	Chitosan 200 ppm	68.21	197.84	234.31	4.57	11.14	8.98	20.47	73.41	16.45	0.0391
T ₆	Chitosan 250 ppm	62.34	181.66	208.62	3.98	10.21	8.01	19.28	68.89	14.92	0.0341
T ₇	Chitosan 300 ppm	61.78	179.53	203.44	3.91	9.76	7.53	18.03	66.47	14.53	0.0335
	SE (m)±	2.01	6.70	8.48	0.17	0.41	0.30	0.60	2.07	0.50	0.00059
	CD at 5%	6.21	20.64	26.13	0.51	1.26	0.93	1.86	6.38	1.53	0.0018

Table 2. Effect of foliar application of chitosan on yield parameters of mustard

Tr. No.	Treatments details	Number of siliqua plant ⁻¹	1000 seed weight (g)	Seed yield plot ⁻¹ (kg)	Seed yield ha ⁻¹ (q)	Harvest index (%)
T ₁	Control water spray	339.43	4.76	1.25	14.46	31.10
T ₂	Chitosan 50 ppm	357.36	5.22	1.37	15.81	32.30
T ₃	Chitosan 100 ppm	378.68	5.35	1.49	17.27	34.00
T ₄	Chitosan 150 ppm	396.86	5.62	1.61	18.63	35.07
T ₅	Chitosan 200 ppm	388.84	5.40	1.56	18.05	34.30
T ₆	Chitosan 250 ppm	376.42	5.05	1.41	16.31	33.30
T ₇	Chitosan 300 ppm	371.21	4.98	1.36	15.78	32.37
	SE (m)±	8.72	0.13	0.05	0.53	0.55
	CD at 5%	26.88	0.41	0.14	1.63	1.70

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