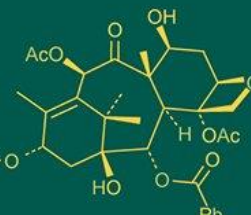
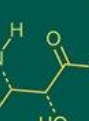
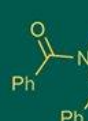


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Effect of foliar application of chitosan on biochemical and yield parameters of mustard (*Brassica juncea* L.)

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Abstract

Chitosan is a natural bio stimulant 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 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 morphological, biochemical and yield parameters including plant height (242.69 cm), chlorophyll content in leaves (1.663 mg g⁻¹), oil content (40.03%), and number of siliqua (396.86/plant), thousand seed weight (5.62 g), mustard yield (18.63 q/ha).

Keywords: Chitosan concentrations, foliar spray, mustard, biochemical, yield parameters

Introduction

Mustard [*Brassica juncea*] is an important oilseed crop belonging to the Brassicaceae family (formerly known as Cruciferae). Indian mustard, commonly referred to as brown mustard, is a natural amphidiploid with a total chromosome count of (2n = 36). It primarily reproduces by self-pollination, though insects and other factors contribute to an estimated 2-15% of pollination. The oil content in rapeseed-mustard crops ranges from 33% to 46%, with an average oil recovery of approximately 32% to 38% (Dhaliwal *et al.*, 2022) [2]. The typical maturity period for this crop ranges from 135 to 150 days, with some varieties maturing in as little as 110 days. Its seeds are referred to by various names in different regions, such as sarson, rai or raya, toria or lahi. White sarson and toria are called rape seed, while rai or raya or laha is referred to as mustard.

Cultivation of mustard has also been extended to non-traditional areas in southern states such as Tamil Nadu, Karnataka and Andhra Pradesh. Indian mustard has now surpassed the cultivation of brown sarson, which used to be an important crop in the rapeseed-mustard area. Toria, gobhi sarson and African sarson are cultivated primarily in irrigated conditions, whereas raya can thrive in both irrigated and rainfed condition.

Mustard is a cool season crop, which needs a temperature range from 6 to 27 °C mustard utilizes the C3 pathway for carbon assimilation and at this temperature the plant attains maximum CO₂ assimilation range. Mustard is typically cultivated in rainfed conditions and is moderately tolerant to soil acidity. It necessitates well-drained soil with a pH close to neutral. Mustard has a low water requirement (240-400 mm), which is suitable for the rainfed cropping system. Approximately 20% of the mustard area is under rainfed conditions.

Indian mustard is the most widely cultivated variety of rapeseed-mustard in India, accounting for approximately 90% of the country's overall rapeseed-mustard cultivation area. In comparison to other crops, its oil has a greater amount of omega-3 fatty acids, is devoid of cholesterol and trans fats and features a lower N-6 to N-3 ratio (Jat *et al.*, 2019) [6].

India is among the largest producers of rapeseed and mustard globally. The oil content in seeds ranges from 37 to 49%.

The oil extracted serves as the primary cooking medium in northern India and cannot be easily substituted with any other edible oil. The seed and oil of mustard have a distinctive pungency due to the presence of glucosinolate and its hydrolysis products, such as allyl isothiocyanate (0.30-0.35%), making it appropriate for use as a condiment in the preparation of pickles and for flavouring curries and vegetables. The oil is consumed by humans across northern India for cooking and frying purposes. It is additionally employed in the production of hair oils and medicines. It is also utilized in soap making, in mixtures with mineral oils for lubrication and for leather softening in the tanning industry. Mustard oil is used in the production of greases. The oil cake is utilized as feed for cattle and as manure. Green stems and leaves serve as a beneficial source of green fodder for cattle. The leaves of younger plants are consumed as green vegetables as they provide sufficient Sulphur and minerals in the diet. Currently, mustard has been recognized as a favourable crop for promoting beekeeping activities. Mustard oil, primarily used for human consumption, is not only a vital component of the human diet but also fights against heart diseases due to its very low levels of artery-clogging saturated fatty acids and high levels of omega-3 fatty acids. These omega-3-rich foods support the brain, enhancing memory and cognitive abilities. This ratio helps in avoiding coronary heart diseases. It can serve as an antibacterial oil and aids in detoxifying the human body. It reduces hair loss through enhanced blood circulation when massaged onto the scalp and stimulates the digestive, circulatory and excretory systems. It can act as an irritant to provoke sensation in numb muscles and organs. It strengthens the immune system, is beneficial for alleviating cough and cold symptoms, protects teeth from bacteria when rubbed on gums and strengthens the gums. Organic mustard oil helps in cancer prevention and is also effective in slowing down the aging process. It aids in activating sweat glands and reducing body temperature.

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 gross plot size was 5.00 m x 2.70 m and the net plot size was 4.80 m x 1.70 m with spacing of 45 cm x 10 cm five plants from each plot were selected randomly and data were collected at 45 and 75 days after sowing. The experiment was carried out in a randomized block design with three replications.

Evaluation of biochemical and yield parameters of mustard

The observations on plant height, chlorophyll content (mg g⁻¹), were recorded 45 days and 75 days after sowing. oil content extracted from mature seeds of mustard. Whereas, observations on 1000 seed weight (g), number of siliqua plant⁻¹, oil content and yield (q/ha) were reordered at maturity.

Estimation of chlorophyll content

The total chlorophyll content of oven-dried leaves was estimated by colorimetric method.

Estimation of oil content

Oil content in leaves was estimated by Micro Soxhlet's procedure.

Results and Discussion

Effect of chitosan on morphological parameters of mustard

The effect of different concentrations of chitosan on morphological characters such as plant height was assessed and depicted in Table1.

Plant height

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. However, treatment T₃ (100 ppm chitosan) and T₅ (200 ppm chitosan) were found to be statistically at par with the T₄ (150 ppm chitosan) with respect to plant height, at 45 DAS.

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. However, treatment T₃ (100 ppm chitosan) and T₅ (200 ppm chitosan) were found to be statistically at par with the T₄ (150 ppm chitosan) with respect to plant height.

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. However, treatment T₃ (100 ppm chitosan) and T₅ (200 ppm chitosan) were found to be statistically at par with the T₄ (150 ppm chitosan) with respect to plant height. Percent increase in plant height with respect to foliar application of 150 ppm chitosan were 23.02% at 45 DAS, 26.72% at 75 DAS and 27.74% at harvest when compared with control (T₁).

Islam *et al.* (2021) [5] 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.

The increase in plant height due to foliar application of chitosan may be attributed to its ability to stimulate cell division and cell elongation through enhanced metabolic activity. Chitosan improves nutrient absorption and translocation, increases chlorophyll content and photosynthetic efficiency, resulting in greater synthesis of carbohydrates and other photo assimilates required for vegetative growth. It also enhances the activity of growth-related enzymes and regulates endogenous phytohormones, which promote stem elongation and overall plant development. The combined effect of improved physiological and biochemical processes ultimately leads to increased plant height (Chande *et al.*, 2021) [1].

B) Effect of chitosan on biochemical parameters of mustard

The effect of different concentrations of chitosan on chlorophyll and oil content were assessed and depicted in Table 1.

1. Chlorophyll content

Chlorophyll content is an important physiological trait that reflects the photosynthetic efficiency and overall physiological status of the plant. Higher chlorophyll content is generally associated with improved light interception, energy production, and enhanced tolerance to environmental stresses.

The effect of different concentrations of chitosan on total chlorophyll content was recorded and depicted in Table 2.

At 45 Days after Sowing

At 45 DAS, leaf chlorophyll content 1.663 mg g^{-1} was significantly highest in treatment T₄ (150 ppm chitosan) followed by treatments T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 1.597 mg g^{-1} and 1.477 mg g^{-1} respectively when compared with treatment T₁ (control) and rest of the treatments under study. However, treatment T₅ (200 ppm chitosan) was found to be statistically at par with the T₄ (150 ppm chitosan) with respect chlorophyll content

At 75 Days after Sowing

At 75 DAS, significantly higher chlorophyll content 1.493 mg g^{-1} was recorded in treatment T₄ (150 ppm chitosan), followed by treatments T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 1.361 mg g^{-1} and 1.300 mg g^{-1} when compared with treatment T₁ (control) and rest of the treatments under study.

Raut *et al.*, (2022) [10] 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 the significantly highest effect on total chlorophyll content in leaves when compared with control and different concentrations.

Foliar application of oligo-chitosan increased chlorophyll content by enhancing photosynthetic activity and maintaining higher photosynthetic pigment levels in rice leaves. The increased chlorophyll content improved light harvesting efficiency, resulting in better plant growth and higher yield (Rahman *et al.* (2024) [9]).

2. Oil content

The effect of different concentrations of chitosan on oil content was recorded and depicted in Table 2.

The data on oil content were recorded after harvesting of the mustard crop. Significantly higher oil content 40.03 % was recorded in treatment T₄ (150 ppm), followed by treatments T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 39.67% and 39.63 % when compared with treatment T₁ (control) and rest of the treatments under study. Treatments T₅ (200 ppm chitosan) T₃ (100 ppm chitosan) were found to be statistically at par with the best treatment T₄ (150 ppm chitosan) with respect to seed oil content.

Data showed that foliar application of 150 ppm chitosan (T₄) stood first in oil content of mustard. Oil content in treatment T₄ (150 ppm chitosan) was increased by 6.14%, in T₅ (200 ppm chitosan) by 4.50% and in T₃ (100 ppm chitosan) by 4.40% over control.

Foliar application of chitosan increased oil content by improving photosynthetic efficiency, nutrient uptake, and assimilate translocation during seed filling. Enhanced carbohydrate production and lipid biosynthesis promoted greater fatty acid accumulation, resulting in higher seed oil content (Monfared *et al.*, 2019) [8].

Esmaeeli *et al.* (2024) [3] investigated the combined effect of chitosan foliar application on Soybean (*Glycine max*). Chitosan application increased oil content (8.1%), compared with untreated plants. The study concluded that foliar application of chitosan at an efficient concentration of about 0.5 g L^{-1} effectively enhances oil content soybean.

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

The effect of different concentrations of chitosan on yield and yield contributing parameters (no. of siliqua/plant, thousand seed weight, and seed yield) were recorded and depicted in Table 2.

1. Thousand Seed weight and no. of siliqua/plant

Significantly highest seed weights 5.62 g was 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 respectively, compared to the control and rest of the treatments. Treatments T₂ (50 ppm chitosan), T₃ (100 ppm chitosan) and T₅ (200 ppm chitosan) were found to be statistically at par with the best treatment T₄ (150 ppm chitosan) with respect to 1000 seed weight.

The highest number of siliquae per plant 396.86 was recorded in treatment T₄ (150 ppm chitosan) followed by T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 388.84 and 378.68 siliqua respectively, compared to the control and rest of the treatments. Whereas treatment T₃ (100 ppm chitosan), T₅ (200 ppm chitosan), T₆ (250 ppm chitosan) and T₇ (300 ppm chitosan) were found to be statistically at par with the T₄ (150 ppm chitosan) respectively with respect to number of siliquae per plant.

Khurizadeh *et al.* (2024) [7] 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 seed yield, and 1000-seed weight.

2. Seed yield plot⁻¹ and ha⁻¹

For seed yield plot⁻¹ treatment T₄ (150 ppm chitosan) recorded the highest yield 1.61 kg among all the treatments, followed by T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 1.56 kg and 1.49 kg seed yield respectively, compared to the control and rest of the treatments. The treatment T₃ (100 ppm chitosan) and T₅ (200 ppm chitosan) were found to be statistically at par with the T₄ (150 ppm chitosan) with respect to seed yield plot⁻¹.

For seed yield q ha⁻¹ treatment T₄ (150 ppm chitosan) recorded the highest yield 18.63 kg among all the treatments, followed by T₅ (200 ppm chitosan) and T₃ (100 ppm chitosan) with 18.05 kg and 17.27 kg seed yield respectively, compared to the control and rest of the treatments. The treatment T₃ (100 ppm chitosan) and T₅ (200 ppm chitosan) were found to be statistically at par with the T₄ (150 ppm chitosan) with respect to seed yield q ha⁻¹.

Raut *et al.* (2022) [10] 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 $\text{plant}^{-1}(\text{g})$, $\text{ha}^{-1}(\text{q})$ and harvest index (%) 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). The treatment T₃ (100 ppm chitosan) and T₅ (200 ppm chitosan) were found to be statistically at par with the T₄ (150 ppm chitosan) with respect to harvest index.

Chande *et al.* (2021) ^[1] 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.

The increase in seed yield following foliar application of chitosan may be due to improved photosynthetic efficiency, enhanced nutrient uptake, and greater antioxidant activity, which collectively may sustain plant growth under varying irrigation conditions. Chitosan may enhance chlorophyll content, may maintain cellular water status, and may reduce oxidative damage, thereby promoting efficient assimilate production and translocation to developing seeds. Improved physiological and biochemical performance may also enhance pod development, seed filling, and final seed yield. These combined effects may contribute to higher soybean productivity (Hamoda *et al.* 2026) ^[4]

Table 1: Effect of foliar application of chitosan on morphological and biochemical parameters of mustard

Tr. No.	Treatments details	Plnat Height (cm)			Total Chlorophyll Content (mg g ⁻¹)		Seed oil content (%)
		45 DAS	75 DAS	Harvest	45 DAS	75 DAS	45 DAS
T ₁	Control water spray	58.80	165.73	189.98	1.375	1.155	38.60
T ₂	Chitosan 50 ppm	62.07	179.47	204.73	1.456	1.241	39.30
T ₃	Chitosan 100 ppm	66.53	194.76	221.54	1.477	1.300	39.63
T ₄	Chitosan 150 ppm	72.34	210.02	242.69	1.663	1.493	40.03
T ₅	Chitosan 200 ppm	68.21	197.84	234.31	1.597	1.361	39.67
T ₆	Chitosan 250 ppm	62.34	181.66	208.62	1.471	1.248	39.17
T ₇	Chitosan 300 ppm	61.78	179.53	203.44	1.441	1.217	39.00
	SE (m)±	2.01	6.70	8.48	0.03	0.04	0.29
	CD at 5%	6.21	20.64	26.13	0.09	0.13	0.63

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

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.

From the overall results, it can be concluded that foliar application of chitosan at different concentrations improved the morphological, biochemical, 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.

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