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# Effect of chitosan on breaking yield barrier of soybean

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## ABSTRACT

*Chitosan is a versatile biopolymer derived from chitin, a natural compound found in the exoskeletons of crustaceans such as shrimp and crabs, as well as in the cell walls of fungi. In agriculture, chitosan has gained attention for its diverse applications and positive effects on plant growth and protection. Therefore, this study was conducted during Kharif 2019, 2020, and 2021 to investigate the impact of varying concentrations of chitosan morpho-physiological parameters and yield of soybean. The pooled results of the experiment revealed that, among the ten concentrations of chitosan tested, foliar application of chitosan @ 60 ppm at 25 and 40 days after sowing (DAS) significantly enhanced all morpho-physiological parameters including plant height(52.53 cm), number of branches (4.53/plant), leaf area (32.14 $dm^2$), dry matter(19.73 g), hundred seed weight (15.20 g), number of pods (36.67/plant), nitrogen content in leaves(6.0 %), chlorophyll content(1.94 mg/g), and soybean yield (24.24 q/ha).*

***Keywords:*** *Chitosan, Soybean, morpho-physiological parameters, yield*

## Introduction

Soybean holds significant importance as both an oilseed and leguminous crop, gaining prominence in India and other developing nations as a means to combat malnutrition. Its cultivation has witnessed substantial growth in recent years due to its high nutritive value, serving as a cost-effective and rich source of high-quality protein. Often referred to as the "Wonder crop," "Golden bean," or "Miracle bean," soybean has revolutionized the agricultural economy, proving valuable as food, feed, and a source for various industrial products. Soybean protein contains all essential amino acids crucial for human dietary needs. Beyond protein and oil, soybean comprises 20.9% carbohydrates, 60% polyunsaturated fatty acids, various vitamins (A, B, C, D, E, K), phosphorus, iron, calcium, and all essential amino acids. With the highest lysine content (5%) among oilseed crops, it is aptly termed the "Poor man's meal." Recognizing the nutritional and production significance of soybean, it becomes imperative to cultivate it with the expectation of higher yields.

Chitosan polymers and oligomers or their derivatives exhibit agriculturally relevant biological activities, including plant growth-promoting activities, plant resistance-inducing elicitor and priming activities [18, 17] and antimicrobial activities [13]. Chitosan can exert positive influences on crop production, acting either as a biopesticide protecting plants from disease resistance, or as a biostimulant or biofertilizer to increase food production through stimulation of growth and development, improve nutrient and water use efficiency, increase of abiotic stress tolerance, and improvement in crop productivity and quality of the harvest [17, 9, 10, 14]. Such uses as biostimulants or biopesticides are becoming increasingly attractive to decrease the input of agrochemicals through a partial replacement by agro-biologics in conventional agriculture [8].

There are countless examples in literature describing beneficial effects of chitosan treatments such as foliar spray, seed coating, or root dipping in different crop species. The recent literature describes effects of chitosans and chitosan nanoformulations relevant crop plants such as soybean [19, 11], maize [5, 6], and beans [4]. Therefore, this study was conducted to investigate the impact of varying concentrations of chitosan on overcoming the yield barriers of soybean.

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## Material and Methods

### *Field experiments*

The study was conducted in three consecutive seasons during Kharif 2019, 2020, and 2021 at the Research farm of the Botany Section, College of Agriculture, Nagpur, Dr. PDKV, Akola (Maharashtra). Eleven treatments included ten concentrations of chitosan *viz.,* 10 ppm, 20 ppm, 30 ppm, 40 ppm, 50 ppm, 60 ppm, 70 ppm, 80 ppm, 90 ppm, and 100 ppm, were sprayed at 25 and 40 days of sowing and control plants were sprayed with tap water. The gross plot size was 3.00 m x 2.20 m and the net plot size was 2.40 m x 2.00 m with spacing of 30 cm x 10 cm five plants from each plot were selected randomly and data were collected at 35 and 50 days after sowing. The experiments were carried out in a randomized block design with four eleven and three replicates.

### *Evaluation of morpho-physiological characters and yield of soybean*

The observations on plant height (cm), no. of branches, 100 seed weight (g), no. of pods/plant, and yield (q/ha) were reordered at maturity. Whereas, observations on leaf area (dm2), dry matter (g), chlorophyll content (mg g-1), and nitrogen content (%) in leaves were recorded 35 days and 50 days after sowing.


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***Measurement of leaf area***

Leaf area was measured by using Systronics make leaf area meter 211 instrument.

***Estimation of chlorophyll content***

The total chlorophyll content of oven-dried leaves was estimated by colorimetric method[2].

***Estimation of nitrogen content in leaves***

Nitrogen content in leaves was estimated by Micro Kjeldahl's method[15].

***Statistical analysis***

The analysis of variance was done in a randomized block design. The results were presented at a 5% level of significance. The critical difference (CD) values were calculated to compare various treatment means.

## Results and Discussion

***A) Effect of chitosan on morpho-physiological characters of soybean***

The effect of different concentrations of chitosan on morpho-physiological characters (plant height, no. of branches/plant, leaf area, dry matter, chlorophyll content, and nitrogen content) were assessed and depicted in Table1.

**1. Plant height and no. of branches**

The maximum (52.53 cm) plant height was recorded the treatment $T_7$ (60 ppm) followed by $T_6$ (50 ppm) and $T_5$ (40 ppm)with 52.27 cm and 52.00 cmplant height respectively, compared to control. The maximum number of branches (4.53/plant) was recorded in the treatment $T_7$ (60 ppm) followed by $T_6$ (50 ppm) and $T_5$ (40 ppm) with 4.10 and 4.00 branches per plant, respectively compared to the control.

The present findings were by following the earlier studies on pigeon peas and groundnuts [16,3]. Foliar application of chitosan at 25 ppm increased the number of branches in soybean [12].

**2. Leaf area and dry matter**

**At 35 Days After Sowing**

Maximum leaf area (19.33 $dm^2$) and highest dry matter content (8.23 g) were observed in treatment $T_7$ (60 ppm) followed by treatment $T_6$ (50 ppm) and $T_5$ (40 ppm) with 16.23 $dm^2$ and 16.03 $dm^2$ leaf area and 8.13 g and 7.97 g dry matter, respectively.

**At 50 Days After Sowing**

Remarkable and significant variation in leaf area and dry matter production was 50 days after sowing. Maximum leaf area (32.14 $dm^2$) and highest dry matter content (19.73 g) were observed in treatment $T_7$(60 ppm) followed by treatment $T_6$ (50 ppm) and $T_5$ (40 ppm) with 28.43 $dm^2$ and 25.44 $dm^2$ leaf area and 19.30 g and 19.17 g dry matter, respectively.

Foliar application of chitosan at 50 ppm, 100 ppm, and 60 ppm concentrations significantly enhances leaf area and dry matter in pigeon pea and groundnut crops, respectively [16,3]. Foliar application of chitosan at 25 ppm increased leaf area/plant in soybean [12].

**3. Chlorophyll and nitrogen content**

**At 35 Days After Sowing**

The highest chlorophyll content (2.02 mg/g) and nitrogen content (5.41%) were observed in treatment $T_7$ (60 ppm) followed by treatment $T_6$ (50 ppm) and $T_5$ (40 ppm) with 1.99 mg/g and 1.92 mg/g chlorophyll content and 4.85 per cent and 4.76 percent nitrogen content, respectively.

**At 50 Days After Sowing**

Remarkable and significant variation in leaf area and dry matter production was 50 days after sowing. Highest chlorophyll content 1.94 mg/g) and nitrogen content (6.0 %) observed in treatment $T_7$(60 ppm) followed by treatment $T_6$ (50 ppm) and $T_5$ (40 ppm) with 1.93 mg/g and 1.89 mg/g chlorophyll content and 5.86 percent and 5.74 percent nitrogen content, respectively.

Foliar application of chitosan at 100 ppm and 60 ppm concentrations significantly enhances chlorophyll and nitrogen content in leaves of groundnut [3]. Application of copper-chitosan nano-composites @ 75 ppm attributed to maximum leaf chlorophyll content in onion [1]. Foliar application of 50 ppm chitosan significantly enhanced leaf nitrogen content in leaves when applied at 45 and 65 DAS[7].

***B) Effect of chitosan on yield and yield attributing characters of soybean***

The effect of different concentrations of chitosan on yield and yield attributing characters (hundred seed weight, no. of pods/plant, and seed yield) were recorded and depicted in Table 2.

**1. Hundred Seed weight and no. of pods/plant**

Significantly highest seed weights (15.20 g) and no. of pods (36.67/plant) were observed in treatment $T_7$(60 ppm chitosan) followed by $T_6$ (50 ppm) and $T_5$ (40 ppm) with 14.00 g and 12.90 g seed weight and 33.93 and 32.87 pods/ plant, respectively.

Foliar sprays of chitosan at 25 ppm and 100 ppm significantly increased 100 seed weight in soybean and groundnut crops, respectively [12, 3]. Chitosan at 50 ppm significantly increased the number of pods planted in pigeon peas [7].

**2. Seed yield/ha and input-output ratio**

The highest seed yield (24.24 q/ha)was recorded in $T_7$ (60 ppm chitosan) followed by T6 (50 ppm) and $T_5$ (40 ppm) with 22.43 q/ha and 21.31 q/ha, respectively. All the treatments showed an increase in yield over control. In treatment, $T_7$ (60 ppm chitosan) 38.79 per cent increased yield over control followed by $T_6$ (50 ppm) and $T_5$ (40 ppm) with 28.42 per cent and 21.97 per cent, respectively. The maximum input-output ratio (1:2.65) was observed in treatment $T_7$ (60 ppm chitosan) followed by $T_6$ (50 ppm) and $T_5$ (40 ppm) with 1:2.45 and 1:2.33, respectively.

Foliar application of chitosan at 50 ppm,100 ppm, and 60 ppm significantly enhanced seed yield in pigeon pea and groundnut, respectively [7,3].

## Conclusion

Thus from the present study, it is concluded that the foliar application of 60 ppm chitosan at 25 and 40 days after sowing increased plant height, no. of branches, leaf area, dry matter content, chlorophyll content, nitrogen content in leaves, 100 seed weight, no. of pods/plant and yield of soybean crop.

### Conflict of Interest

The authors declare no conflict of interest in the subject matter or materials discussed in this manuscript.


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***Table 1. Effect of foliar spray of chitosan on morpho-physiological parameters of soybean (pooled data).***

| Tr. No. | Treatments details | Plant Height (cm) | No. of branches/plant at maturity | Leaf area ($dm^2$) | | Dry matter (g) | | Chlorophyll (mg/g) | | N content in leaves (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 35DAS | 50DAS | 35DAS | 50DAS | 35DAS | 50DAS | 35DAS | 50DAS |
| $T_1$ | Control water spray | 40.13 | 3.03 | 11.04 | 16.55 | 5.63 | 15.67 | 1.50 | 1.29 | 3.38 | 4.43 |
| $T_2$ | Chitosan 10 ppm | 42.67 | 3.53 | 11.37 | 17.91 | 5.80 | 16.17 | 1.51 | 1.55 | 3.41 | 4.50 |
| $T_3$ | Chitosan 20 ppm | 48.27 | 3.77 | 13.24 | 21.54 | 7.27 | 16.53 | 1.73 | 1.76 | 4.15 | 4.85 |
| $T_4$ | Chitosan 30 ppm | 48.80 | 3.80 | 14.66 | 21.64 | 7.37 | 16.63 | 1.74 | 1.80 | 4.22 | 5.18 |
| $T_5$ | Chitosan 40 ppm | 52.00 | 4.00 | 16.03 | 25.44 | 7.97 | 19.17 | 1.92 | 1.89 | 4.76 | 5.74 |
| $T_6$ | Chitosan 50 ppm | 52.27 | 4.10 | 16.23 | 28.43 | 8.13 | 19.30 | 1.99 | 1.93 | 4.85 | 5.86 |
| $T_7$ | Chitosan 60 ppm | 52.53 | 4.53 | 19.33 | 32.14 | 8.23 | 19.73 | 2.02 | 1.94 | 5.41 | 6.00 |
| $T_8$ | Chitosan 70 ppm | 50.07 | 3.93 | 15.46 | 24.55 | 7.80 | 18.83 | 1.75 | 1.88 | 4.74 | 5.32 |
| $T_9$ | Chitosan 80 ppm | 49.47 | 3.87 | 15.22 | 24.35 | 7.40 | 17.23 | 1.74 | 1.87 | 4.25 | 5.20 |
| $T_{10}$ | Chitosan 90ppm | 47.53 | 3.73 | 12.76 | 21.38 | 7.07 | 16.83 | 1.67 | 1.75 | 4.01 | 4.76 |
| $T_{11}$ | Chitosan 100ppm | 46.53 | 3.67 | 12.32 | 20.39 | 6.17 | 16.73 | 1.53 | 1.70 | 3.78 | 4.53 |
| | SE (m) ± | 1.45 | 0.17 | 0.90 | 1.58 | 0.48 | 0.72 | 0.09 | 0.09 | 0.20 | 0.14 |
| | CD at 5% | 4.29 | 0.50 | 2.66 | 2.75 | 1.43 | 1.24 | 0.28 | 0.27 | 0.60 | 0.44 |
| | CV % | 5.22 | 7.79 | 10.88 | 11.90 | 11.74 | 7.11 | 9.69 | 9.01 | 8.26 | 5.02 |

***Table 2. Effect of foliar spray chitosan on yield and yield contributing parameters of soybean (pooled data).***

| Tr. No. | Treatments details | 100 seed weight (g) | No. of pods/ plant | Seed yield (q/ha) | % increase over control | Input output ratio |
|---|---|---|---|---|---|---|
| $T_1$ | Control water spray | 10.10 | 20.27 | 17.47 | 0.00 | 1:1.97 |
| $T_2$ | Chitosan 10 ppm | 10.20 | 22.07 | 18.19 | 4.13 | 1:1.98 |
| $T_3$ | Chitosan 20 ppm | 11.90 | 27.13 | 19.48 | 11.52 | 1:2.13 |
| $T_4$ | Chitosan 30 ppm | 12.30 | 29.40 | 20.27 | 16.07 | 1:2.21 |
| $T_5$ | Chitosan 40 ppm | 12.90 | 32.87 | 21.31 | 21.97 | 1:2.33 |
| $T_6$ | Chitosan 50 ppm | 14.00 | 33.93 | 22.43 | 28.42 | 1:2.45 |
| $T_7$ | Chitosan 60 ppm | 15.20 | 36.67 | 24.24 | 38.79 | 1:2.65 |
| $T_8$ | Chitosan 70 ppm | 12.60 | 32.80 | 21.28 | 21.85 | 1:2.32 |
| $T_9$ | Chitosan 80 ppm | 12.43 | 30.93 | 19.60 | 12.19 | 1:2.14 |
| $T_{10}$ | Chitosan 90 ppm | 11.20 | 26.07 | 18.49 | 5.87 | 1:2.02 |
| $T_{11}$ | Chitosan 100 ppm | 10.80 | 22.27 | 18.28 | 4.67 | 1:1.99 |
| | SE (m) ± | 0.28 | 2.92 | 0.68 | | |
| | CD at 5% | 0.83 | 8.63 | 2.01 | | |
| | CV % | 4.01 | 17.69 | 5.86 | | |

## REFERENCE

1. Aziz, M.E., S. Morsi, M. S. Dina, M.S. Abdel-Aziz, S. Mohamed A. Elwahed, A. Essam and A.M. Youssef, (2018). Preparation and characterization of chitosan/polyacrylic acid/copper nanocomposites and their impact on onion production. Biomac. 11:155.

2. Bruinsma, J., (1982). A comment on the spectrophotometric determination of chlorophyll. Biomiochem. Bio-Phy. Acta., 52:576-578.

3. Chande, Kantilal B., Deotale, R. D., Mate, P. R., Purane, A. A. and Baviska, S. B.(2020). Evaluation of morpho-physiological traits and yield of groundnut by foliar application of chitosan. J. Soils and Crops, 30(2): 268-272.

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4. Chatelain, P. G., Pintado, M.E., Vasconcelos, M. W. (2014). Evaluation of chitooligosaccharide application on mineral accumulation and plant growth of *Phaseolus vulgaris*. Plant Science, *215-216*:134-140.

5. Choudhary, R. C., Kumaraswamy, R. V., Kumari, S., Sharma, S. S., Pal, A., Raliya, R., Biswas, P., Saharan, V. (2017). Cu-chitosan nanoparticle boost defense responses and plant growth in maize (*Zea mays* L.). Scientific Reports*, 7*(9754).

6. Choudhary, R. C., Kumaraswamy, R. V., Kumari, S., Sharma, S. S., Pal, A., Raliya, R.; Biswas, P., Saharan, V. (2019). Zinc encapsulated chitosan nanoparticle to promote maize crop yield. International Journal of Biological Macromolecules*, 127*:126-135.

7. Deotale, R.D.,Thakare,O.G., Shende,P.V., Patil,S. R., Kamdi, S. R., Meshram, M. P.and Madke, V. S. (2019). Impact of foliar sprays of chitosan and IBA on chemical, biochemical and yield contributing parameters of pigeonpea. J. Soils and Crops, 29(2): 306-311.

8. Gozzo, F and Faoro, F. (2013). Systemic acquired resistance (50 years after discovery): moving from the lab to the field. Journal of Agricultural and Food Chemistry, 61: 12473-402 12491.

9. Hidangmayum, A, Dwivedi, P., Katiyar, D., Hemantaranjan, A. (2019). Application of chitosan on plant responses with special reference to abiotic stress. Physiology and Molecular Biology of Plants, *25*(2): 313-326

10. Li, R., He, J., Xie, H., Wang, W., Bose, S. K., Sun, Y., Hu, J., Yin, H. (2019). Effects of chitosan nanoparticles on seed germination and seedling growth of wheat (*Triticum aestivum* L.). International Journal of Biological Macromolecules, 126: 91-100.

11. Mehmood, S., Ahmed, W., Ikram, M., Imtiaz, M., Mahmood, S., Tu, S., and Chen, D. (2020). Chitosan modified biochar increases soybean (Glycine max L.) resistance to salt-stress by augmenting root morphology, antioxidant defense mechanisms and the expression of stress-responsive genes. Plants, 9(1173): 2-25.

12. Meshram, S. D., Deotale, R. D., Chute, K. H., Jadhav G. N. and Padghan,G. A. (2018). Morpho-physiological and yield responses of soybean foliar sprays of chitosan and IBA. J. Soils and Crops. 28(1):121-127.

13. Sahariah, P. and Másson, M. (2017). Antimicrobial chitosan and chitosan derivatives: A review of the structure-activity relationship. Biomacromolecules, 18(11): 3846-3868.

14. Sharma, G.; Kumar, A.; Devi, K. A.; Prajapati, D.; Bhagat, D.; Pal, A.; Raliya, R.; Biswas, P.; Saharan, V. (2020). Chitosan nanofertilizer to foster source activity in maize. International Journal of Biological Macromolecules, 145: 226-234.

15. Somichi, Y., Douglas, S. Y. and James,A. P. (1972). Laboratory manual. Physiological studies in rice analysis for total nitrogen (organic N) in plant tissue. The Inter. Res. Instti. Los Banos, Languna, Phillipine: II.

16. Thakare, O. G.,Deotale, R. D., Dhogade,A. P., Guddhe, V. A., Jadhav, N. D. and Korade,S. B. (2019). Foliar application of chitosan and IBA improved morpho- physiological attributes and yield in pigeonpea. J. Soils and Crops, 29 (1): 131-135

17. Trouvelot, S., Héloir, M-C., Poinssot, B., Gauthier, A., Paris, F., Guillier, C., Combier, M., Trdá, L., Daire, X., Adrian, M. (2014). Carbohydrates in plant immunity and plant protection: roles and potential application as foliar sprays. Frontiers in Plant Science, 545 5:592.

18. Vander, P., Vårum, K. M., Domard, A., El Gueddari, N. E., Moerschbacher, B. M. (1998). Comparison of the ability of partially N-acetylated chitosans and chitooligosaccharides to elicit resistance reactions in wheat leaves. Plant Physiol*.* 118:1353-1359.

19. Yang, R.; Jiang, Y.; Xiu, L.; Huang, H. (2019). Effect of chitosan pre-soaking on the growth and quality of yellow soybean sprouts. Journal of the Science Food and Agriculture, 99(4), 1596-1603.



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