The Pharma Innovation Journal 2022; SP-11(4): 239-242

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(4): 239-242

www.thepharmajournal.com
Received: 07-02-2022
Accepted: 10-03-2022

Vaishnavi Gawande
M.Sc., Department of Plant Physiology, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

TH Rathod
Head, Department of Plant Physiology, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

SM Shinde
Assistant Professor, Department of Agricultural Botany, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

SB Deshmukh
Assistant Cotton Breeder, Cotton Research Unit, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Corresponding Author
Vaishnavi Gawande
M.Sc., Department of Plant Physiology, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Impact of chitosan on morpho-physiological parameters of crop plant

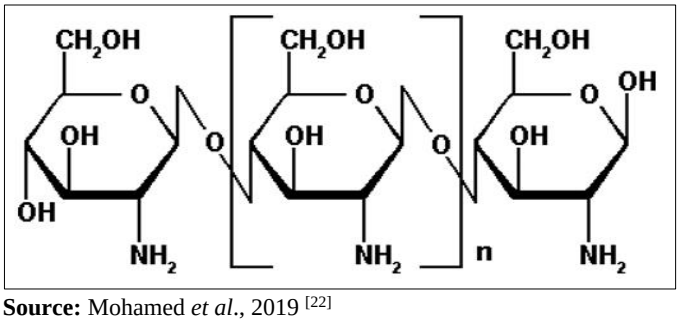
Vaishnavi Gawande, TH Rathod, SM Shinde and SB Deshmukh

Abstract
Soil health is the most crucial element in today's agricultural world due to the increased use of chemical inputs. So, for aiding and prolonging soil health, it becomes more and more important to use biopolymer-based material. Chitosan is the biopolymer that is produced from organisms. The biodegradable nature of biopolymers makes them environment-friendly and conserves the soil. This review paper aims to survey the influence of chitosan on morphological and physiological parameters of crops. This review firstly comments on the effect of chitosan on some vital morphological parameters like plant height, leaf area, leaf area index and secondly it through light on important physiological parameters like dry matter and relative water content. Furthermore, this review concludes the positive influence of chitosan in agriculture.

Keywords: chitosan, morpho-physiological, crop

1. Introduction
Chitosan is a natural, safe and cheap biopolymer produced from chitin, the major constituent of arthropod's exoskeleton and fungi cell walls and provided as second renewable carbon source after lignocellulosic biomass (Kurita, K., 2006; Malerba and Cerana, 2016) [18, 21]. Biopolymers are kind of polymers, that produced by living organisms such as alginate and carrageenan, which produced naturally occurring anionic polysaccharide isolated from the seaweeds (Ghoda, E.A. *et al*., 2017; Mohamed *et al*., 2019) [22]. This biopolymer is a large cationic polysaccharide mainly obtained from waste materials from seafood processing (Guan *et al*., 2009), with antiviral, antibacterial, and antifungal properties (El-Hadrami *et al*., 2010; Lizarraga-Paulin *et al*., 2013) [9, 20]. Chitosan stimulates vital processes of plants on every level of biological process, from single cells and tissues, through physiological and biochemical processes, to changes on the molecular level related to expression of genes (Limpanavech, 2008; Nguyen, 2013; Islam 2018) [19, 16].

2. Structure and mode of action



Source: Mohamed *et al*., 2019 [22]

Structure of chitosan

2.1 Mode of action of chitosan
The mode of action of chitosan is yet not completely known. For induction of defense response in plants, CHT may directly affect gene expression interacting with chromatin (Hadwiger, L. A. 2015; Malerba and Cerana, 2016) [15, 21]. Few efforts were done to study the effects of chitosan on plant growth, development and productivity, which is mainly attributed to the stimulation of plant's immunity against microorganisms like bacteria (Islam *et al*., 2018)

[16]. Chitosan is a biopolymer with antiviral, antibacterial and antifungal properties (El Hadrami *et al*., 2010; Lizarraga-Paulin *et al*., 2013) [9, 20]. When chitosan is being used in plants, it reduces transpiration (Dzung *et al*., 2011; Islam *et al*., 2018) [7, 16]. Chitosan plays a key role in the defense system of plants. Foliar application of CHT enhanced fruit yield, plant height and leaf number in okra (*Hibiscus esculentus* L.) (Mondal *et al*., 2012) [25]. Because of its biopolymer properties, this compound can also form physical barriers around the penetration sites of pathogens, preventing them from spreading to healthy tissues. This and bioactive derivatives can activate H+-ATPase, depolarizing biological membranes and inducing other series of the event (Amborabe *et al*., 2008) [3].

3. Effect on parameters

A) Effect on morphological parameters

Gornik *et al.* (2008) [13] conducted an experiment to evaluate the effect of treatment to grapevine cuttings with chitosan (Biochikol 020) on their rooting, subsequent plant development and reaction to drought stress. Biochikol 020 PC solution was used at concentrations of 0.5, 1 and 2% for 24 hours at 25^0c. The result indicated that biochikol 020 PC applied at 1% stimulated the growth of cuttings by increasing number of internodes in comparison with control. El-Tantawy (2009) [11] performed an experiment to study the effect of organic manure, goat manure and spraying with amendment substances like chitosan on tomato plants. The result indicates the positive effect on morphological characters like plant height, number of branches and leaves per plant were observed by chitosan spray. Abdel-Mawgoud *et al.* (2010) [1] conducted an experiment to investigate the effect of foliar application of chitosan on strawberry plants. Chitosan sprays were carried out three times starting from ten weeks after transplanting with four weeks intervals in concentration of 0, 1, 2, 3 and 4 cm^3/l. The result revealed the increase in morphological characters like plant height and number of leaves were found significant in 2 cm^3/l concentration. Mondal *et al.* (2011) [26] conducted an experiment to evaluate the effect of plant growth promoter on growth parameters and yield of Indian spinach. The experiment has five concentrations of chitosan *viz*., 0, 25, 50, 75 and 100 ppm. Two sprays were carried out at 15 and 25 DAS. The result showed that desired growth in characters like plant height, number of branches, number of leaves per plant and leaf area $plant^{-1}$ were obtained due to foliar application of chitosan @ 75 ppm. Farouk and Amany (2012) [12] carried out an experiment and observed that foliar application of chitosan @ 250 ppm, increased plant morphological characters like plant height, branch number and leaf number of cowpea. Mondal *et al.* (2012) [25] studied the effect of different concentrations of chitosan *viz*., 0, 50, 75, 100 and 125 ppm on okra. The result indicated that spraying of chitosan @ 100 or 125 ppm at 25, 40 and 55 DAS has significantly increased morphological parameters like plant height, leaf number of okra. El-Miniawy *et al.* (2013) [10] conducted an experiment to investigate the effect of foliar spray of chitosan *viz*., 2.5 or 5.0 ml/l with different number of application i.e. once, twice and three times on strawberry. The result shows that foliar spraying of chitosan at 5.0 ml three times showed significant increase in morphological characters like plant length, number of leaves per plant and leaf area as compared to control. Mondal *et al.* (2013, a) [23] tried different concentrations of chitosan *viz*., 0, 50, 75, 100 and 125 ppm and sprayed three times at 35, 50 and 65 DAS on maize. The result suggested that foliar spray of chitosan at 100 ppm significantly increased plant height, leaf number, leaf length and leaf area $plant^{-1}$ of maize. Mondal *et al.* (2013, b) [24] carried out an experiment to evaluate the effect of foliar application of chitosan on mungbean plants. In the experiment five concentrations of chitosan *viz*., 0, 25, 50, 75 and 100 ppm were applied at 25 and 35 DAS. Results showed that 50 ppm chitosan increase growth parameters like plant height, number of branches, number of leaves and leaf area $plant^{-1}$. Sathiyabama *et al.* (2013) [30] conducted an experiment to evaluate the effect of foliar application of chitosan on tomato plants. 0.1% (m/w) of chitosan was used. The result revealed that there was an increase in morpho-physiological characters like number of flowers and fresh weight in chitosan treated plants than control. Sharifa and Abu-Muriefah (2013) [31] did an experiment to study the effect of chitosan @ 100, 200 and 400 ppm on common bean. The result reported that application of chitosan @ 200 ppm has significantly increased plant growth *viz*., number of branches, leaf number, plant height and leaf area $plant^{-1}$. Salachna and Zawadzinska (2014) [30] carried out the experiment aiming to determine the effect of chitosan molecular weight on growth and yield of flowers and corms of potted fressia (an ornamental plant). Fressia corms were soaked in 0.5% chitosan solution with low molecular weight (2 kDa), medium molecular weight (50 kDa) and high molecular weight (970 kDa). The result revealed that the high molecular weight (970 kDa) showed increase in morphological characters like plant height, number of leaves and days to flowering. Agbodjato *et al*. (2015) carried out an experiment to assess the combined effects of three plant growth promoting Rhizobacteria (*Azospirillum lipoferum*, *Pseudomonas fluorescens* and *Pseudomonas putida)*, chitosan (a biostimulating molecule) and half or complete dose of nitrogen-phosphorus-potassium (NPK) and urea. Results obtained that the combination of *P. putida* along with chitosan and half dose of NPK-Urea increased height and circumference of maize plant. Ahmed *et al.* (2016) [2] conducted an experiment to study the effect of foliar application of chitosan. Two concentrations of chitosan @ 250 and 500 ppm were sprayed on novel orange. The result indicated that increase in morphological parameters like shoot length, leaves number and leaf area were recorded at concentration of 500 ppm chitosan. Rabbi *et al*. (2016) [28] carried out experiment comprising of different concentrations of chitosan *viz*., 0 (control), 25, 50, 75 and 100 ppm at 30 and 40 DAS on mungbean plant. Results showed that foliar application of chitosan @ 50 ppm significantly enhanced morphological characters such as plant height, number of branches, number of leaves and leaf area $plant^{-1}$. Deotale *et al.* (2018) [6] conducted a field experiment to investigate the effect of different concentration of chitosan and IBA @ 25, 50, 75, 100, 125 ppm. The foliar spray was given at 30 DAS on soybean. The increase in morphological characters like plant height, number of branches and leaf area were recorded at 25 ppm concentration of chitosan. Islam *et al.* (2018) [16] conducted an experiment in which different concentration of oligochitosan which were prepared from chitosan and were examined to study the effect on chilli and tomato plant. Four chitosan levels @ 25, 50, 75 and 100 ppm with control were taken as treatments. In case of the tomato, morphological parameters like plant height, leaves per plant and branches per plant were observed at 100 ppm concentration. In case of chili increase in the morphological characters like plant height,

leaves per plant and branches per plant were observed at 75 ppm concentration. Ananthaselvi *et al*. (2019) [4] conducted an experiment to investigate the effect of foliar spray of chitosan on morphological, growth and flowering characters of the African marigold under induced drought condition. The experiment consists of three levels of water stress i.e. 100%, 70% & 50% field capacity and three levels of chitosan sprays *viz*., 0, 0.2 g l^{-1} & 0.4 g l^{-1}. The result indicated that 70% field capacity with 0.2 g l^{-1} of chitosan improved morphological parameter like plant height (cm). Parvin *et al*. (2019) [27] conducted an experiment to study the effect of different application methods of chitosan on growth and yield of tomato. The study concluded that foliar application of chitosan has increased morphological parameter like plant height.

B) Effect on physiological parameters

El-Tantawy (2009) [11] performed and experiment to evaluate the effect of organic manure, goat manure and spraying with amendment substances like chitosan on tomato plants. The result revealed that increase in physiological characters like dry weight was found by application of chitosan. Abdel-Mawgoud *et al.* (2010) [1] did an experiment to evaluate the effect of foliar spray of chitosan on strawberry. Chitosan concentrations were 1, 2, 3, 4 cm^3/l and applied three times starting from ten weeks after transplanting with four weeks interval. The result showed an increase in physiological characters like dry weight in 2 cm^3/ l in strawberry. Mondal *et al.* (2011) [26] carried out an experiment to study the effect of chitosan @ 0, 25, 50, 75 and 100 ppm on Indian spinach. For this two sprays were carried out @ 15 and 25 DAS. The result indicated that chitosan @ 75 ppm has significantly increase specific leaf weight of Indian spinach. Farouk and Amany (2012) [12] conducted a farm experiment and observed that foliar sprays of chitosan @ 250 ppm has increased plant physiological characters like shoot dry weight and shoot fresh weight of cowpea. Mondal *et al.* (2012) [25] conducted an experiment comprising of different concentrations of chitosan *viz*., 0, 50, 75, 100 and 125 ppm on okra. Three sprays were carried out at 25, 40 and 55 DAS. Result showed that spraying of chitosan @ 125 ppm has significantly increased physiological characters like total dry mass $plant^{-1}$, absolute growth rate and relative growth rate of okra. Mondal *et al.* (2013, b) [24] carried out a field experiment to study the effect of foliar application of chitosan on mungbean plant. Five concentrations of chitosan *viz*., 0, 25, 50, 75 and 100 ppm were taken with two sprays at 25 and 35 DAS. Results revealed that 50 ppm chitosan enhanced the physiological parameter like dry weight of plant. Sathiyabama *et al*. (2013) [30] performed an experiment to investigate the effect of foliar sprays of chitosan on tomato. 0.1% (m/w) of chitosan was used. The result indicated that an increase in physiological character like fresh weight in chitosan treated plants than control. Islam *et al*. (2016) [17] performed an experiment to evaluate the effect of foliar sprays of chitosan on summer and winter tomato, summer mungbean, maize and aman and boro rice. Chitosan was sprayed at four concentrations *viz*., 25, 50, 75 and 100 ppm for two times at vegetative and flowering stages of tomato and mungbean. For maize and rice chitosan was sprayed three times at vegetative and flowering stages at concentration of 50, 75, 100 and 125 ppm for maize and @ 25, 50 and 75 ppm for rice. The result showed that increase in physiological character like reproductive efficiency was observed best at 75 ppm for summer and winter tomato. In summer mungbean physiological parameters were observed more at 50 ppm concentration of chitosan. For maize more physiological characters were observed at 100 ppm concentration. For boro and aman rice physiological characters were increased at 50 ppm concentration of chitosan. Rabbi *et al*. (2016) [28] examined different concentrations of chitosan *viz*., 0 (control), 25, 50, 75 and 100 ppm at 30 and 40 DAS on mungbean plant. Results showed that foliar application of chitosan @ 50 ppm significantly enhanced physiological characters such as total dry mass (TDM) over control. Dzung *et al*. (2017) [8] investigated the effect of foliar application of OC with 7.8, 5.0 and 2.5 kDa prepared from chitosan on chilli crop. The result indicated that the OC with 2-5 kDa proved best for increasing the physiological parameter like dry weight. Deotale *et al.* (2018) [6] conducted a field experiment to evaluate the effect of different concentrations of chitosan and IBA @ 25, 50, 75, 100 and 125 ppm. The foliar application was at 30 DAS. The increase in physiological parameters like total dry weight, relative growth rate and net assimilation rate was found best @ 25 ppm chitosan in soybean.

4. Conclusion

Various crops responded to the application of chitosan and also gave significant variation among different parameters studied. With respect to morpho-physiological parameters also showed significant difference. In recent times, 'bio' products are progressively promoted for sustainable development and for environment protection. As chitosan is a biopolymer, produced from living organisms, it would not only reduce the use of chemical inputs and their detrimental impact on nature and natural resources, but it would also improve agro-ecosystem health.

5. Acknowledgment

Vaishnavi Gawande expresses her deep gratitude to Dr. A. B. Bhosale for all his guidance and support.

6. References

1. Abdel-Mawgoud AMR, Tantawy AS, El-Nemr MA, Sassine YN. Growth and yield responses of strawberry plants to chitosan application. European J of Scientific Res. 2010;39:170-177.
2. Ahmed AHH, Ella Nesiem MRA, Allam HA, El-Wakil AF. Effect of pre-harvest chitosan foliar application on growth, yield and chemical composition of Washington navel orange trees grown in two different regions. African J of Biochem. Res. 2016;10(7):59-69.
3. Amborabe BE, Bonmort J, Fleurat-Lessard P, Roblin G. Early events Induced by chitosan on plant cells. J of Experimental Bot. 2008;59:2317-2324.
4. Ananthaselvi K, Thamarai SP, Subramanian S, Chandrashekhar C. Effect of chitosan on growth and yield of African Marigold (*Tagetes erecta* L.) under drought induced stress condition. Int. J Chem. Studies. 2019;7(3):3612-3615.
5. Chen ZJ, Scheffler BE, Dennis E, Zhang T, Guo W, Chen X, *et al*. Toward sequencing cotton (*Gossypium*) genomes. Plant Physio. 2007;145(4):1303-1310.
6. Deotale RD, Meshram SD, Kamdi SR, Patil SR, Shinde RD, Chute KH. Influence of chitosan and indole-3-butyric acid in improving chemical, biochemical and yield contributing parameters of soybean. Int. J of Che. Studies. 2018;6(1):751-756.

7. Dzung NA, Khanh VTP, Dzung TT. Research on impact of chitosan oligomers on biophysical characteristics, growth, development and drought resistance of coffee. Carbohydrate Polymers. 2011;84(2):751-755.
8. Dzung PD, Phu DV, Du BD, Ngoc LS, Duy NN, Hiet HD, *et al*. Effect of foliar application of oligochitosan with different molecular weight on growth promotion and fruit yield enhancement of chilli plant. Plant Production Sci. 2017;20(4):389-395.
9. El Hadrami A, Adam LR, El-Hadrami I, Daayf F. Chitosan in plant protection. Mar. Drugs. 2010;8:968-987. [DOI: 10.3390/md8040968].
10. El-Miniawy SM, Ragab ME, Youssef SM, Metwally AA. Response of strawberry plants to foliar spraying of chitosan. Res. J Agil. And Biol. Sci. 2013;9(6):366-372.
11. El-Tantawy EM. Behavior of tomato plants as affected by spraying with chitosan and aminofort as natural stimulator substances under application of soil organic amendments. Pak. J Biol. Sci. 2009;12(17):1164-1173.
12. Farouk S, Amany AR. Improving growth and yield of cowpea by foliar application of chitosan under water stress. Egyptian J Bio. 2012;14:14-26.
13. Gornik K, Grzesik M, Romanowska-Duda B. The effect of chitosan on rooting of grapevine cuttings and on subsequent plant growth under drought and temperature stress. J of Fruit and Ornamental Plant Res. 2008;16:333-343.
14. Guan YJ, Hu J, Wang XJ, Shao CX. Seed priming with chitosan improves maize germination and seedling growth in relation to physiological changes under low temperature stress. J Zhejiang University Sci. B. 2009;10(6):427-433.
15. Hadwiger LA. Anatomy of a nonhost disease resistance response of pea to *Fusarium solani*: PR gene elicitation via DNase, chitosan and chromatin alterations. Front. Plant Sci, 2015, 12. DOI: 10.3389/fpls.2015.00373.
16. Islam MM, Md. Humayun K, Mamun ANK, Islam M, Md. Islam M, Das P. Studies on yield and yield attributes in tomato and chilli using foliar application of oligo-chitosan. GSC Biological and Pharmaceutical Sci. 2018;3(3):020-028. DOI: 10.30574/gscbps.2018.3.3.0038.
17. Islam MT, Mondal MMA, Rahman MS, Khanam S, Akter MB, Haque MA *et al*. Effect of foliar application of chitosan on growth and yield in tomato, mungbean, maize and rice. Int. J Sustain. Crop Prod. 2016;11(2):7-17.
18. Kurita K. Chitin and Chitosan: Functional biopolymers from marine crustaceans. Marine Biotech. 2006;8(3):203-226.
19. Limpanavech P, Chaiyasuta S, Pichyangkura R, Khunwasi C, Chadchawan S, Lotrakul P, *et al*. Chitosan effects on floral production, gene expression and anatomical changes in the Dendrobium orchid. Scientia Horticulturae. 2008;116:65-72.
20. Lizarraga-Paulin EG, Miranda-Castro SP, Moreno-Martinez E, Lara-Sagahon AV, Torres-Pacheco I. Maize seed coatings and seedling sprayings with chitosan and hydrogen peroxide: their influence on some phenological and biochemical behaviors. J of Zhejiang Uni. Sci. B. 2013;14(2):87-96. DOI: 10.1631/jzus.b1200270.
21. Malerba M, Cerana R. Chitosan effects on plant systems. Int. J of Mol. Sci. 2016;17(7):996.
22. Mohamed EH, Bai J, Dou D. Biopolymers; Definition; Classification and Applications. Egypt J Chem. 2019;62(9):1725-1737.
23. Mondal MMA, Puteh A, Dafader NC, Rafii MY, Malek MA. Foliar application of chitosan improves growth and yield in maize. J of Food Agriculture & Environment. 2013;11(2):520-523.
24. Mondal MMA, Malek MA, Puteh AB, Ismail MR. Foliar application of chitosan on growth and yield attributes of mungbean [*Vigna radiata* (L.) Wilczek]. Bangladesh J. Bot. 2013;42(1):179-183.
25. Mondal MMA, Malek MA, Puteh AB, Ismail MR, Ashrafuzzaman M, Naher L. Effect of foliar application of chitosan on growth and yield in okra, Australian J Crop Sci. 2012;6(5):918-921.
26. Mondal MMA, Rana MIK, Dafader NC, Haque ME. Effect of foliar application of chitosan on growth and yield in Indian spinach. J Agrofor. Environ. 2011;5(1):99-102.
27. Parvin MA, Zakir HM, Sultana N, Kafi A, Seal HP. Effect of different application methods of chitosan on growth, yield and quality of tomato (*Lycopersicon esculentum* Mill). Archives of Agril. Env. Sci. 2019;4(3):261-267.
28. Rabbi F, Rahman M, Mondal, MMA Bhowal SK, Haque A. Effect of chitosan application on plant characters, yield attributes and yield of mungbean. Res. J of Agri. and Environ. Management. 2016;5(3):095-100.
29. Salachna P, Zawadzinska A. Effect of chitosan on plant growth, flowering and corms yield of potted fressia. J. of Ecol. Engineering. 2014;15(3):97-102.
30. Sathiyabama M, Akila G, Charles RE. Chitosan-induced defence responses in tomato plants against early blight disease caused by Alternaria solani (Ellis and Martin) Sorauer. Archives of phytopathology and plant protection, 2013. Retrieved from http://dx.doi.org/10.1080/03235408.2013.858423.
31. Sharifa S, Abu-Muriefah. Effect of chitosan on common bean (*Phaseolus vulgaris* L.) plants grown under water stress conditions. Int. Res. J of Agril. Sci. and Soil Sci. 2013;3(6):192-199.