

REVIEW ARTICLE

A REVIEW ON CHITOSAN: A NEW SOLUTION FOR COMBATING ABIOTIC STRESSES IN AGRICULTURE

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ABSTRACT

Chitosan is a second most abundant naturally occurring polysaccharide after cellulose derived from chitin which commercially produced from seafood shells, fungi (*Aspergillus* and mucus) and also from algae by alkaline deacetylation of chitin. It is bio adhesive, biocompatible, biodegradable, organic molecule. Chitosan has wide spread application in agriculture. Chitosan acts as bio-stimulant which upon application to plants stimulates photosynthetic rate, enhances antioxidant production, increases tolerance to biotic and abiotic stresses. Chitosan causes hydrolysis of peptidoglycan of microbes resulting to death of microbes. Recent studies have shown that chitosan induces mechanisms in plants against various biotic and abiotic stresses and helps in formation of barriers that enhances plant's productivity. This paper takes a closer look at the genesis, structural alteration and physiological responses of chitosan foliar applications on plants. As, Abiotic stresses is an important multidimensional environment stresses that damage plant's physiology, biochemical properties and Molecular traits. Chitosan help to combat abiotic and biotic stresses.

Keywords: Chitosan, Biotic, Abiotic, Agriculture.

1. INTRODUCTION

Chitosan is a natural biopolymer molecule which is second most abundant extracted by deacetylation of chitin. Source of chitosan is Shell of seafoods, Algae, and various microbes also produce chitin in cell walls, membranes and spores, including fungi (Castro et al. 2012) and the spines of diatoms (Bartnicki-Garcia et al. 1982). It produced from crustacean shells due to removal of Protein, mineral, colour followed by removal of acetyl group (deacetylation) as shown in figure 1 (Chemical and Biological preparation). Activity of Chitosan are predominantly dependent on its degree of deacetylation, molecular weight and pH of solution (Xu et al. 2007). Difference of chitin and chitosan by degree of acetylation and deacetylation as, chitin-Degree of acetylation- 0.90 and Chitosan-degree of deacetylation- > 0.65 (Daniel Elieh-Ali-Komi et al. 2016). Chitosan Registered (licensed for sale) as active ingredient in 1986 (Chitosan; Poly-D-glucosamine (128930) Fact Sheet").

Chitosan is a weak base and is insoluble in water, but soluble in dilute aqueous acidic solutions below its pI (~6.3), in which it covers -NH₂ (glucosamine) into the soluble protonated Form -NH₃⁺ (Jagadish et al. 2017). Commercially, Chitosan is available with >85% deacetylation units and molecular weight between 100 & 1000kDa. Structure of chitosan was identified by X-ray diffraction, infrared spectra, and enzymatic analysis. Chitosan composed of D-glucosamine and N-acetyl-D-glucosamine linked with 1,4-glycoside

bond in which glucosamine backbone of chitosan contains high degree of amine group. The glucosamine backbone of Chitosan Contain Amine group which offers the opportunity to form complex of Chitosan with negative charge DNA molecule (Zhao et al. 2011) which help in transcriptional regulation. It is also used as Nanoparticle (Zhau et al. 2014). There are several derivate of Chitosan like Oligochitosan. Oligo-chitosan (82.20 kDa) was prepared from chitosan (337.73kDa) by application of 100 kGy γ -irradiation (Muley et al. 2019). Before this during 2003 chitosan, cellulose, alginate and starch have been successfully degraded by application of gamma irradiation as glycosidic bond between C1 and C4 positions of the monomeric sugar residues is broken down and respective oligomers are generated (Cho, Kim, & Rhim, 2003). Chitosan form gel tha absorb water due to its high molecular weight (MW) and porous structure (Tamura et al. 2006). Advanced development of chitosan hydrogels has led to new drug delivery systems that can release their active ingredients in response to environmental stimuli (Hamedi et al. 2016).

2. IMPORTANCE

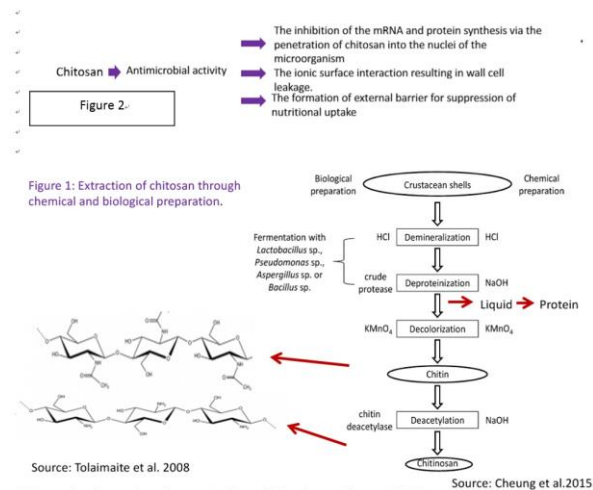
2.1. Antioxidant Activity

Chitosan show Antioxidant Activity solution which was estimated by using 1,1-diphenyl-2-picrylhydrazyl (DPPH) and 2,2'-azino-

bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) assay (Muley et al., 2018). The free radical activity of Chitosan by presence of Nitrogen containing group (-NH₂).

2.2. Antimicrobial Activity

Goy et al. 2009 Suggested three mechanism of Chitosan which are - The inhibition of the mRNA and protein synthesis via the penetration of Chitosan into the nuclei of the microorganism. The ionic surface interaction resulting in cell wall leakage. The formation of external barrier for suppression of nutritional uptake. Also, a supportive figure for Antimicrobial activity in figure 3 (sharif et al. 2018). (Liang et al. 2017), it help to destruction of bacterial cell wall.



2.3. Gene Expression

Hadwiger et al. 1986 Reported Chitosan Activates genes and inhibite RNA Synthesis in fungi and also help in increasing pathogen protection. In dendrobium, Chitosan induced expression of Ycf2 gene in young leaves, conferring enlarged Chloroplast (Limpanavech et al. 2008).

2.4. Surface modification

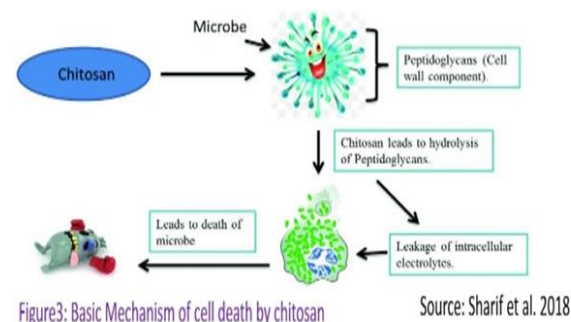
Cotton is most important crop in all over world as well as in India due to flexibility, versatility but due to intrinsic problems such as shrinkage, wrinkle formation and microbial degradation which may be overcome by surface modification with chitosan (Bhaskar et al. 2012).

2.5. Chitosan-DNA Complex

Chitosan has also used and studied for its Activity to protect DNA against nuclease degradation and transfect DNA to several kinds of cells (Bravo-anaya et al. 2016). It is possible because Chitosan composed of D-glucosamine and N-acetyl-D-glucosamine linked with 1,4-glycoside bond in which glucosamine backbone of chitosan contains high degree of amine group. Amine group can get inter linked with DNA molecules therefore form Chitosan-DNA complex.

2.6. Biofertilizer

As, day by day chemical uses increases and due to which lot of side effect on environment and on human directly or indirectly. Chitosan act as Biofertilizer which help to reduce the use of chemicals. Chitosan with lysozyme produce a beneficial role which can reduced the rate of lesions in tomato stems. Application of Chitosan in soil help to reduce the late blight disease and also increase nutritional uptake (O'Herlihy et al. 2003).



2.7. Effect on Abiotic stresses

As, Abiotic stresses is an important multidimensional environment stresses that damage plant's physiology, biochemical properties and Molecular traits. Yang et al. 2009, In Apples young seedlings were foliar sprayed with chitosan, which showed enhanced antioxidant activity, reduced electrolyte leakage, and restored moisture content under continuous drought stress for 35 days. Muley et al. 2019, Gamma radiation degradation of chitosan (Oligochitosan) for application in growth promotion and induction of Stress tolerance in potato. As, it act as osmoprotectant, and also help in antioxidant production. Rahat sharif et al. 2018 explain Positive effect against Abiotic stresses (Drought tolerance in plants like Apples, rice, grapevine, moth orchid and Heat tolerance).

Heat stress it, is complicated abiotic issue in Agriculture and need to combact which is overcome by Chitosan. In may papers HS related genes induced by Chitosan (Zhang et al. 2008, Choi et al. 2013).

2.8. Insecticidal Activity

Chitosan and its derivatives show good insecticidal activities. Chitin derivative also show insecticidal property against the oleander aphid (Aphis nerii) and larvae of leaf-worm (Spodoptera littoralis) of cotton crops (Rabea et al. 2005). Also, a Nano-chitosan has potential insecticidal against soyabean insect (Sahab et al. 2015).

2.9. Growth promotion

Application of Chitosan help to promote growth. Muley et al. 2019 described that

derivative of Chitosan like Oligochitosan which is derived by Gamma radiation promote growth of potato plant and determined by growth associated parameters. Chitosan help act as extra reservoir of nitrogen (Shibuya et al. 2001). Oligochitosan at 1% concentration was found to promotion of growth of Malabar spinach (Rahman et al., 2013).

Future Thrust:

The plethora of available and ongoing research on chitosan utilization continues to present its efficacy. Chitosan has shown great importance in improving the physiological mechanisms and post-harvest shelf life of fruits and vegetable against biotic and abiotic stress. In addition, chitosan derivatives possess good insecticidal activity. Chitosan plays a role in regulating gene expression and inducing molecular defense systems in plants. Moreover, bio-fertilizer and fertilizer coated in chitosan triggers the plant growth more, compared to synthetic fertilizers. Furthermore, chitosan and its derivatives provide good antifungal activity. Therefore, more research is required to utilize chitosan against abiotic stresses for utilization in Agriculture.

3. CONCLUSION

Chitosan Research increases day by day. Chitosan proved it's effeciencially in several aspect in terms of biotic and abiotic. Additionally, Derivative of Chitosan like COS or Oligochitosan has effectively effect in growth promotion, Microbial, insecticidal and abiotic Activity. Chitosan has also role in gene expression, modification of post harvest crops. Chitosan also, effective in Biofertilizers and Nanoparticles in drug delivery. It has Antigunal and nematodal activities (Mishra et al. 2014, Zhang et al. 2018). To the best of our knowledge, there is no large amount of research available on chitosan involvement in response to Abiotic stresses. Therefore, more work will be required in abiotic stresses which reduce overuse of synthetic fertilizers.

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