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IMPACT OF CHITOSAN FOLIAR APPLICATION ON GROWTH AND PRODUCTIVITY OF VEGETABLES IN PROTECTED CULTIVATION

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Abstract

Chitosan is a natural biopolymer extracted from chitin and recently provides an environmentally safe approach that has gained popularity as an enhancer of vegetable growth promotion, particularly under protected conditions. Foliar-applied Chitosan takes part in the physiological and biochemical activities of plants by influencing photosynthesis, nutrient uptake, and enzymatic activity thus improving plant growth and productivity. It can also be described as an inducer of plant defense resistance to fungal and bacterial pathogens whereby the chemical pesticides' usage is reduced. Chitosan applied foliar increases yield quality, shelf life, and fruit quality of typical fruits such as tomato, cucumber, capsicum, and leafy vegetables. The net house or polyhouse type of protected cultivation assists the entrepreneur to manage year-round vegetable cropping with some difficulties related to disease attack plus intensive input use. Chitosan offers a sustainable option by initiating growth, increasing tolerance to stresses, and cleaner production systems. The integration of protected vegetable farming will make it realize the productivity targets with reduced chemical load towards safe food and sustainable agriculture.

Keywords: Chitosan, Foliar spray, Protected cultivation, Stress tolerance, Vegetable productivity

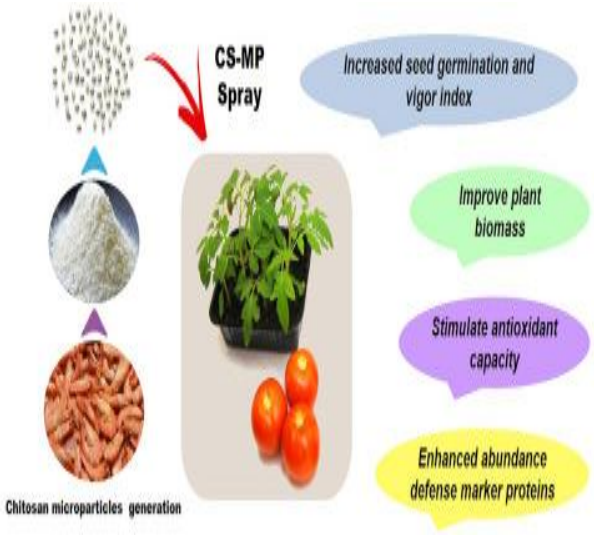
1. Introduction

Vegetables are a crucial component of our diet, supplying us with vital vitamins, minerals, fiber, and other beneficial compounds. In India, the appetite for high-quality vegetables is on the rise, driven by lifestyle changes, urban growth, and a greater awareness of nutrition. Protected cultivation methods, such as polyhouses and net houses, have become effective ways to ensure vegetables can be grown year-round. These structures allow farmers to sidestep the ups and downs of seasonal growing, maintain consistent quality, and boost their harvests.

However, there are still obstacles to overcome, including issues with pests and diseases, nutrient deficiencies, and practices that require a lot of resources, which can hinder both productivity and profits. In this scenario, chitosan a natural biopolymer derived from chitin found in shrimp and crab shells has emerged as a promising solution. When applied as a foliar spray, chitosan helps to stimulate growth, enhance the quality of crops, and improve their ability to withstand stress in a variety of vegetables. Unlike synthetic fertilizers and pesticides, chitosan is biodegradable, safe for the environment, and poses no harm, making it an appealing choice for sustainable vegetable farming within protected cultivation systems.

Sources of Chitosan

Chitosan is a natural biopolymer that comes primarily from chitin, which is abundant in the shells of various crustaceans like shrimp, crabs, prawns, and lobsters. India is a leading producer of seafood, there's a significant opportunity to create chitosan from the waste produced during seafood processing. In addition to its marine sources, chitosan can also be sourced from the cell walls of certain fungi. When compared to synthetic agrochemicals, chitosan stands out as biodegradable, renewable, and environmentally friendly, making it an excellent choice for sustainable agriculture.



2. Chitosan: Properties and Mode of Action

Chitosan is well known for its multifunctional role in plants. It acts as:

- **Growth promoter:** It boosts cell division, enhances leaf expansion, and increases photosynthetic activity.
- **Defense inducer:** This compound triggers the production of defense enzymes and secondary metabolites, which are crucial in fighting off fungal and bacterial infections.
- **Stress alleviator**: Chitosan helps mitigate oxidative stress resulting from drought, high salinity, or temperature changes by enhancing antioxidant activity.
- **Post-harvest improver:** It slows down the aging process, keeps fruits firm, and extends their shelf life.

The effectiveness of chitosan is influenced by various factors, including its concentration, the type of crop, and the method used for application. The most common and effective way to apply it is through foliar spraying, particularly in environments like polyhouses and net houses, where the microclimate is ideal for absorption and effectiveness.

3. Effect of Chitosan Foliar Spray on Vegetable Crops

Various studies have highlighted the beneficial effects of chitosan sprays on plants. These benefits can be categorized into four main areas: growth, yield, quality, and stress management.

- **Growth Improvement:** In crops such as spinach and cucumber, the application of chitosan is shown to boost chlorophyll levels, increase leaf area, and enhance overall plant health.
- **Yield Enhancement:** When tomato and capsicum plants are treated with chitosan, they tend to produce more fruit, with greater fruit weight and overall yield.
- **Quality Traits:** Chitosan not only elevates the levels of lycopene in tomatoes but also enhances antioxidant content in spinach and extends the shelf life of cucumbers.
- **Stress Tolerance:** This natural substance aids plants in coping with challenges like salinity, water scarcity, and fluctuating temperatures, all of which are common in controlled growing environments.

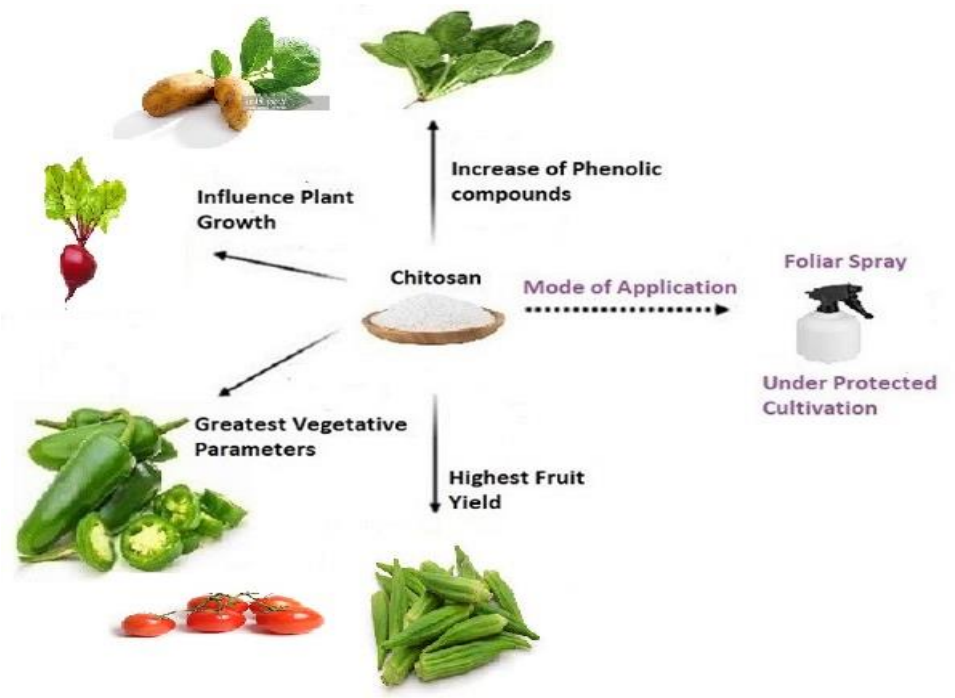


Table 1. Effect of chitosan foliar application on vegetable crops under protected cultivation

Crop	Growth Condition	Dose & Methodology	Major Functions/Traits Improved	Reference
Chilli	Greenhouse	Chitosan 20 ppm, foliar spraying	↑ Plant height, canopy diameter, leaf traits, chlorophyll content, fruit number & weight, seed yield	El-Tantawy et al. (2009)
Tomato	Glasshouse	Chitosan 0, 50, 100, 150 mL/L foliar spray	↑ Plant height, leaf number & area, chlorophyll, water content	El-Miniawy et al. (2013)
Okra	Greenhouse	Chitosan 0.5–0.75%, Potassium salt 1–2%, Potassium bicarbonate 2–3%, foliar spray	↑ Plant height, branches, pod yield, ↓ Powdery mildew	Mondal et al. (2012)
Cucumber	Greenhouse	Chitosan 1–4 mL/L, Yeast 1–4 mL/L, foliar spray	↑ Leaf number, biomass, fruit length, fruit weight, TSS, total yield	Abdel-Mawgoud et al. (2010)
Spinach	Greenhouse	Chitosan 0.1–0.001 mL, foliar spraying	↑ Phenolics, flavonoids, proteins, peroxidase & catalase activity	Xu et al. (2011)
Potato	Greenhouse	Chitosan 1–0.0001 mL/L, foliar spraying	↑ Fresh & dry weight, shoot length, tuber number & yield	Khalil & Badawy (2012)

4. Chitosan in Protected Cultivation: Indian Perspective

India is making significant steps in protected cultivation, particularly in states like Maharashtra, Karnataka, Himachal Pradesh, and Uttarakhand. These innovative systems empower farmers to cultivate valuable vegetables, including capsicum, tomato, cucumber, and leafy greens, even during off-seasons. However, the humid and enclosed conditions that come with protected cultivation can sometimes lead to a swift rise in pests and diseases due to the lack of airflow. This is where chitosan comes into play. Its application on leaves helps reduce reliance on synthetic fungicides and pesticides, which is essential for growing clean, residue-free vegetables that are suitable for both local markets and exports.

Moreover, since chitosan is accepted in organic farming, it fits perfectly with India's increasing commitment to safe and sustainable vegetable production. Numerous ICAR institutes and agricultural universities have begun trials that demonstrate its ability to enhance yield and quality while also cutting down on input costs.

5. Future Prospects

The position for chitosan uses in India is quite encouraging. By combining it with biofertilizers, biocontrol agents, and modern growing techniques like hydroponics and vertical farming, we can really boost efficiency. As researchers delve deeper into developing climate-resistant and pest-resistant crop varieties, chitosan has the potential to play a vital role in minimizing our reliance on chemicals while promoting sustainability in vegetable farming.

To achieve broader acceptance, it will be essential to enhance extension services, provide effective training for farmers, and foster collaborations within the industry.

6. Conclusion

Using chitosan as a foliar spray presents a green and sustainable way to tackle various challenges in vegetable farming, especially in protected environments. This approach not only boosts growth and yield but also enhances the quality and resilience of the crops, resulting in healthier and more appealing vegetables. In India, where the appetite for premium vegetables is on the rise, chitosan could significantly contribute to increasing farmers' earnings, ensuring food safety, and supporting eco-friendly farming practices.

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