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Effect of Chitosan Salicylic Acid Nano formulations on Growth and Yield of Strawberry cv. Winter Dawn

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ABSTRACT

A field experiment was conducted at horticulture farm Rajasthan College of Agriculture, MPUAT, Udaipur during 2022-23 and 2023-24. The study revealed that the effect of chitosan nano formulations (CS-SA NFs) on the growth and yield of strawberry (Fragaria × ananassa Duch.) cv. Winter Dawn. The study found that the number of leaves per plant and leaf length significantly increased with the application of CS-SA NFs at 800 ppm as compared to other treatments SA (100-300 ppm), BCH (100-1200 ppm) and control. The highest number of leaves was recorded in the 800 ppm CS-SA NFs treatment. Similarly, the maximum leaf length was observed in the same treatment. Flowering duration also increased significantly with CS-SA NFs, with the longest duration at 800 ppm. Yield attributes showed notable improvement, with the number of fruits per plant and yield per hectare highest in the 800 ppm CS-SA NFs treatment, achieving 27.70 fruits per plant and 353.68 q ha^{-1}, respectively, compared to the control. The study demonstrates the potential of CS-SA NFs to enhance strawberry growth and yield.

Key words: *Chitosan, Nano formulations, Strawberry*

Introduction

The cultivated strawberry (*Fragaria × ananassa* Duch.), a member of Rosaceae family (2n = 56), is a highly nutritious soft fruit with 98 per cent of its portion being edible. These stoloniferous plants spread through stolons or runners and have a short, thickened stem called the "crown" with trifoliate leaves. The non-climacteric fruit, which does not ripen after picking, develops from one ovule with multiple achenes. Strawberries thrive in sub-tropical and high-altitude tropical climates, favouring sandy loam soil pH of 5.5-6.5. Ideal day temperatures are around 22 °C, with nights ideally between 7 °C to 13°C. In India, strawberries are commercially grown in Maharashtra, Punjab, Haryana, Karnataka, Madhya Pradesh, Jammu & Kashmir, Himachal Pradesh and Uttarakhand (Thakur *et al.*, 2017). Chitosan, an environmentally friendly biopolymer from seafood industry waste, is easily degraded, non-toxic to humans and elicits natural defence responses in plants to control pre- and post-harvest diseases. Transcriptomic analysis has shown that chitosan induces the expression of genes involved in systemic acquired resistance, the plant immune system, photosynthesis and hormone metabolism (Rahman *et al.*, 2018). Salicylic acid (SA), a plant phenolic, induces plant defence mechanisms under stress and improves photosynthetic rates, gas exchange and osmotic regulation, enhancing plant growth (Aghaeifard *et al.,* 2016).

Previous studies have used chitosan and SA separately to improve strawberry growth, yield, and quality (Rahman *et al.,* 2018; Ahmed *et al.,* 2016; Akter Mukta *et al*., 2017). This study aims to investigate the combined effect of chitosan nano formulations (chitosan + SA) on the growth, yield, and quality of strawberries, potentially providing significant improvements in crop quality and quantity.

Materials and Methods

Five plants were randomly selected and tagged from each plot. Data for growth parameters, such as the number of leaves per plant and leaf length, were recorded from these five randomly selected plants at 60 and 90 days after transplanting. The duration of flowering was noted for the five tagged plants from each plot at the time of flowering, and the average value was calculated. The number of fruits per plant and the total yield per plant were determined from the five randomly selected plants in each plot at the time of harvest.

Results

Evaluation of the Response of Chitosan Nanoformulations on Growth, Yield (*Fragaria* X *Ananassa* Duch.) Cv. Winter Dawn.

Response of Chitosan NFs in Plant Growth of Strawberry cv. Winter Dawn

Table 1 presents the pooled data from two years (2022-23 and 2023-24), showing that the number of leaves per plant (60 & 90 DAT) was increased by CS-SA NFs (800 ppm), CS-SA NFs (1200 ppm) and BCH (1200 ppm) as compared to control. On the basis of pooled data, the highest number of leaves per plant was recorded in 800 ppm CS-SA NFs (11.50 and 17.47 at 60 & 90 DAT respectively) followed by 1200 ppm CS-SA NFs (10.78 and 16.07 at 60 & 90 DAT respectively) and 1200 ppm BCH (10.19 and 16.79 at 60 & 90 DAT respectively) as compared to control (7.02 and 10.85 at 60 & 90 DAT respectively) and other treatments (Table 1). However, maximum leaf length was recorded in treatment CS-SA NFs 800 ppm (5.59 cm and 7.50 cm at 60 & 90 DAT) followed by CS-SA NFs 1200 ppm (5.43 and 7.32 cm at 60 & 90 DAT) as compared to control (3.38 cm and 5.34 cm at 60 & 90 DAT respectively) and rest of all treatments.

The growth parameters were recorded at 60 and 90 days after transplanting (DAT). Each value is mean of triplicate and each replicate consisted of 5 plants. 1st foliar was done at 30 days and 2nd at 60 days after transplanting. Mean ± SE followed by same letter is not significantly different at p = 0.05 as determined by Tukey- Kramer HSD. BCH represents bulk chitosan dissolved in 0.5% acetic acid.

Table 1. Response of Chitosan NFs in number of leaves plant^{-1} and leaf length

Treatment	No. of leaves per plant at 60 DAT	No. of leaves per plant at 90 DAT	Leaf length (cm) at 60 DAT	Leaf length (cm) at 90 DAT
Control (water)	7.02±0.15^{i}	10.85±0.26^{g}	3.38±0.11^{e}	5.34±0.11^{d}
Salicylic acid (SA)				
SA (100 ppm)	8.08±0.005^{h}	11.23±0.12^{fg}	4.38±0.005^{d}	6.30±0.005^{c}
SA (200 ppm)	8.87±0.14^{g}	12.81±0.19^{cde}	4.57±0.17^{cd}	6.51±0.17^{c}
SA (300 ppm)	9.82±0.15^{cde}	13.67±0.02^{cd}	4.60±0.02^{cd}	6.59±0.02^{c}
Bulk chitosan				
BCH (100 ppm)	8.90±0.05^{fg}	12.09±0.05^{efg}	4.41±0.02^{d}	6.30±0.02^{c}
BCH (400 ppm)	9.37±0.10^{efg}	13.99±0.04^{c}	4.65±0.02^{cd}	6.54±0.02^{c}
BCH (800 ppm)	9.65±0.11^{cdef}	14.07±0.24^{c}	4.90±0.11^{bcd}	6.75±0.11^{bc}
BCH (1200 ppm)	10.19±0.03^{bcd}	16.79±0.46^{ab}	5.07±0.19^{abc}	6.87±0.19^{abc}
CS-SA NFs				
CS-SA NF (100 ppm)	9.54±0.02^{defg}	12.43±0.09^{def}	4.54±0.04^{cd}	6.43±0.04^{c}
CS-SA NF (400 ppm)	10.31±0.32^{bc}	15.58±0.51^{b}	4.91±0.22^{bcd}	6.85±0.22^{bc}
CS-SA NF (800 ppm)	11.50±0.26^{a}	17.47±0.40^{a}	5.59±0.17^{a}	7.50±0.17^{a}
CS-SA NF (1200 ppm)	10.78±0.01^{ab}	16.07±0.37^{ab}	5.43±0.09^{ab}	7.32±0.07^{ab}

Table 2. Response of Chitosan NFs in duration of flowering, number of fruit plant^{-1} and yield ha^{-1}

Treatment	Duration of flowering (days)	No. of fruits plant^{-1}	Yield ha^{-1} (Q/ha)
Control (water)	36.38±0.77^{f}	18.08±0.32^{d}	170.15±5.98^{e}
Salicylic acid (SA)			
SA (100 ppm)	38.54±0.02^{ef}	18.96±0.015^{d}	193.41±0.09d^{e}
SA (200 ppm)	40.93±1.09^{cde}	21.26±0.48^{c}	219.17±7.60^{cd}
SA (300 ppm)	41.34±0.17^{cde}	21.36±0.32^{c}	226.66±4.14^{cd}
Bulk chitosan			
BCH (100 ppm)	39.27±0.16^{def}	21.33±0.20^{c}	222.01±5.69^{cd}
BCH (400 ppm)	42.30±0.12^{bcde}	21.49±0.12^{c}	231.96±1.65^{c}
BCH (800 ppm)	42.62±0.73^{abcde}	22.29±0.12^{bc}	244.10±4.88^{bc}
BCH (1200 ppm)	43.34±1.19^{abcd}	22.63±0.33^{bc}	253.79±9.65^{bc}
CS-SA NFs			
CS-SA NF (100 ppm)	40.03±0.30^{cdef}	21.98±0.46^{c}	236.81±5.81^{c}
CS-SA NF (400 ppm)	43.77±1.43^{abc}	23.90±0.68^{b}	277.41±15.55^{b}
CS-SA NF (800 ppm)	46.81±1.07^{a}	27.70±0.027^{a}	353.68±6.74^{a}
CS-SA NF (1200 ppm)	46.42±1.09^{ab}	27.28±0.023^{a}	329.32±6.69^{a}

Response of Chitosan NFs in Flowering Parameters of Strawberry cv. Winter Dawn

Table 2 presents the pooled data of two years (2022-23 and 2023-24), showing that the maximum duration of flowering was found in CS-SA NFs 800 ppm (46.81 days) followed by CS-SA NFs 1200 ppm (46.12 days, 1st and 2nd year pooled data) as compared to control (36.38 days) and rest of other treatment explained in Table 2.

The yield attributes, specifically the number of fruits per plant, were significantly increased by the foliar spray of CS-SA NFs at 800 ppm and 1200 ppm (27.70 fruits, 27.28 fruits respectively), compared to the control (18.08 fruits).

The yield per hectare was observed to be highest in the CS-SA NFs 800 ppm treatment, 353.68 quintals per hectare. This was followed by the CS-SA NFs 1200 ppm treatment at 329.32 quintals per hectare. In comparison, the control treatment exhibited a significantly lower yield of 170.15 quintals per hectare.

The growth parameters were recorded at 60 and 90 days after transplanting (DAT). Each value is mean of triplicate and each replicate consisted of 5 plants. 1st foliar was done at 30 days and 2nd at 60 days after transplanting. Mean ± SE followed by same letter is not significantly different at p = 0.05 as determined by Tukey- Kramer HSD. BCH represents bulk chitosan dissolved in 0.5% acetic acid.

Discussion

Application of CS-SA NFs significantly increased number of leaves and leaf length as compared to control. Earlier this formulation was tested on wheat and maize. In earlier study, salicylic acid-chitosan nanoparticles (SA-CS NPs) were developed where chitosan matrix slowly released the encapsulated SA for its sustained availability to growing plant. Slow release of SA comprehensively stimulated plant antioxidant strength, protected maize crop from disease and improved yield as compared with SA (Kumaraswamy *et al.*, 2019 and Kadam *et al*. 2021).

Conflict of Interest- None

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