Journal Of Research Technology & Engineering
www.jrte.org

Effect of different concentrations of foliar application of chitosan on growth development of tomato (*Solanum lycopersicum* L.) cultivar grown in Sri Lanka.

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Received:05 June 2023; Revised: 23 June 2023; Accepted: 01 July 2023; Available online: 10 July 2023

Abstract: Appropriate nutrients and fertilizers are essential for plant growth and development. Because of the scarcity of chemical fertilizers in Sri Lanka, there is a need to use alternative fertilizers effectively and efficiently. Considering the Current Situation. The aim of this study was to determine the effects of foliar application of different concentrations of chitosan on the physiological growth, yield, and yield components of tomato cultivars (Pathma). The experiment was conducted at the Uva Wellassa University of Sri Lanka. Chitosan was applied to the plants during different growth stages. As a positive treatment, foliar application of chitosan was applied at three different concentrations (70, 80, and 120 ppm). The negative control treatment consisted of plants without treatment. There were significant differences ($p<0.05$) between the treatments in the measured parameters of the tomato cultivar. Foliar application of chitosan affected the plant's vegetative growth, leaf area, plant height, chlorophyll index, and dry weight. Moreover, it affects fruit pH, total soluble solids, single fruit weight, fruit diameter, and yield of tomato cultivars. The results showed that the highest physiological attributes, biochemical parameters, yield components, and yield were obtained at a concentration of 120 ppm compared with the control. Hence, it was concluded that chitosan at an application rate of 120 ppm produced the highest yield and better quality of tomatoes. In this study, chitosan application impact on the growth, and yield of tomato cultivar has been observed and the positive results may extend to other local crops as well.

Keywords: Bio stimulator, Chitosan, Tomato, yield.

1. INTRODUCTION

Chitosan is a linear unbranched polymer of 1,4-d-glucosamine derived from chitin, a copolymer of N-acetyl-d-glucosamine and d-glucosamine, and is the main component of arthropod exoskeletons. Chitin can be extracted from marine crustacean-like shrimps, crabs, prawns, fungi, and algal cell walls. Chitosan is a safe and inexpensive biopolymer. Their chemical structure can be easily transformed to develop polymers suitable for specific applications. Chitosan is an important molecule for a wide range of potential users, from the healthcare to the biotechnology industry. It is biodegradable, environmentally friendly for agriculture, and non-toxic to humans and other organisms. Chitin is insoluble in polar solvents, which inhibits its direct use in plant metabolism.

It can be easily solubilized in weak organic acids, such as acetic acid, and its limited solubility in water can be overcome by chemical modifications such as carboxy methylation. Moreover, chitosan helps improve soil fertility and mineral and nutrient absorption, and today, consumers demand more natural, safe food with high quality, prolonged shelf life, and without any chemical preservatives [1]. Chitosan is treated not only as a promising and economic source for efficient and versatile crop protection materials but also as an environmentally friendly, biocompatible, and biodegradable polymer with various applications [2]. Chitosan has a wide range of applications in various fields of agriculture, including crop production, protection, storage, and nutritional quality. Chitosan has been extensively used as a bioactive fungicide, bactericide and edible coating at the pre-harvest and postharvest stages to preserve the quality of many fruits and vegetables.

Tomato belongs to the Solanaceae family and continues to be the most important vegetable in the world due to its increasing commercial and dietary value. It contains many health-promoting compounds and can be easily incorporated as a nutritious component of a balanced diet . Consumers consume fresh fruits and tomatoes in processed products, such as soups, juices, and sauces [3]. Over the past decade, consumers have become more aware of food as a source of health benefits and its role in preventing several chronic diseases and disorders [4]. Tomatoes are rich in carotenoids, which are the main source of lycopene in the human diet. The specific objectives of the current study were to evaluate the effects of four different doses of chitosan foliar spray on the vegetative growth, yield components, and yield of the selected tomato cultivar Padma.

2. METHODOLOGY

2.1 Experimental site

The experiment was carried out at Uva Wellassa University of Sri Lanka premises from March 14, 2022, to August 30, 2022. Where the climate was warm (24.1^0 C) and humidity 65.7 %. Soil is red Yellow Podzolic and Mountain Regosols with a pH of 5.5 to 6.5. Certified seeds ‘*Padma* ’ was obtained from the seed sales centre in Gannoruwa, Sri Lanka.

2.2 Experimental design layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with four treatments and six replications. A pot experiment was conducted using 128 polyethene bags (diameter of 42 cm and height of 36 cm). A potting mixture consisted of topsoil and compost 1:2 ratio. Certified seeds were sown in the nursery tray for 3 weeks. After three weeks, healthy tomato seedlings were transferred to polythene bags, and only one seedling was allowed to grow in each polythene bag. Agronomic and intercultural operations including fertilizer applications were performed as per the commercial production guide. Data on plant growth parameters viz, leaf area (cm^2), Chlorophyll index, plant height (cm), and dry weight (g) were recorded from every plant and averaged under a treatment at the vegetative stage. Ripe fruits were harvested from the individual plant under each treatment and a single fruit weight, the number of fruits per plant, pH, total soluble solids and yield were statistical analyses.

2.3 Preparation of different concentrations of Chitosan solutions

Chitin extraction from shrimp shells and conversion to chitosan by de-acetylation was done by Referring to a slightly modified chemical method [5]. A 1000 ppm chitosan stock solution was prepared by dissolving 1.039 g of chitosan powder in 0.1 N HCl and diluting it with deionized water, followed by pH adjustment to 6.5 by 0.1 M NaOH [6]. By using 1000 ppm stock solution, 70 ppm, 80 ppm, and 120 ppm of chitosan solutions were prepared, and 100 mL of each solution was applied to each treatment in the late evening during the plant vegetative, reproductive, and harvesting stages. As a control treatment, deionized water (Control) was applied as a foliar application to the plants.

2.4.1 Leaf area

Five leaves were punched and labelled into Petri dishes from each treatment and determined the leaf surface area using a mobile application known as “Petiole”. The mobile application and manual grid method both were able to provide identical results.

2.4.2 Chlorophyll content index

A number of five plants were randomly selected from each replicate of the treatments; the chlorophyll index was measured by using a chlorophyll meter (CCM – 200 Plus).

2.4.3 Plant height

A number of five plants were randomly selected and uprooted from each replicate of treatments on the 45th day of the vegetative stage. The control plants too were selected for the measurement. The plants were uprooted and the roots were washed with tap water, their heights were measured by a ruler.

2.4.4 Plant dry weight

A number of five plants were randomly selected and uprooted from each replicate of treatments on the 45th day of the vegetative stage. The control plants too were selected for the measurement. Plants dry weights were determined by keeping them at 80^{o} C for two days.

2.4.5 pH

Five fruits were randomly selected from replication of the treatment at the harvesting stage.50 g of sample was weighted from each treatment of the replication. The weight fruits were crushed gently by the laboratory mortar and pistil. The pH was taken using the Jenway 3505 pH meter.

2.4.6 Total soluble solid

Total soluble solids (TSS) were determined for each sample fruit in five replications. The samples were gently crushed with the electric blender and 2 drops of the crushed sample was placed on the digital plate of DR-A1 digital refractometer (Atago Co. Ld., Japan) at 20°C and expressed as °Brix.

2.4.7 Number of fruits per plant

Five fruits were randomly selected from each replicate of the treatment and the number of the fruits were counted from each treatment of the replicate.

2.4.8 Fruit weight per plant

Five fruits were randomly selected from each replicate of the treatment at the harvesting stage. Single fruit weight was measured by electronic balance.

2.4.9 Yield

A number of five plants were randomly selected from each replicate of the treatment at the time of the harvesting stage and fruits were collected from each treatment of the replication to determine the yield of plants**.**

2.5 Data Analysis

The data were statistically analyzed and the difference between treatment means was compared using DMRT at a 5% significance level by the SPSS (Statistical Package for Social Sleafnces) version 25.

3. RESULTS AND DISCUSSIONS

Foliar application of chitosan affected the vegetative growth of the tomato plants and significantly ($p<0.05$) influenced leaf area Compared to the control treatment (Table 1). The highest leaf area (11.91 cm^2) was obtained from plants treated with the concentration of 120 ppm solution and the lowest (4.63 cm^2) was obtained in the untreated control plants. Effect of chitosan on physiological processes and enhanced transference of nitrogen in the functional leaves that improve vegetative growth and development [7].

At a concentration of 120 ppm, the maximum chlorophyll content index (33.5) was recorded, whereas the lowest (18.22) was recorded in untreated plants (Table 1). As a result, when compared to control plants, the usage of chitosan improves photosynthetic pigment by improving photosynthesis [8]. Another study found that applying chitosan to the leaves of diverse plant species improved the efficiency of light use, the stability of chlorophyll, and the diameter of chloroplasts. Chitosan treatment also had an effective and significant effect on tomato plant height (Table 1). At 120 ppm, the highest plant height (27.55 cm) was recorded, while the lowest (12.75 cm) was reported in the untreated control plants. Some studies recently discovered that the stimulating effect of chitosan on plant development could be due to an increase in critical nitrogen metabolism enzyme activities (nitrate reductase, glutamine synthesis, and glutamine synthesis).

Foliar application of chitosan on tomato plants had a positive impact on the dry weight of the plants. Foliar application with a concentration of 120 ppm that had successfully increased the dry weight (Table 1.).The highest dry weight (1.77 g) was obtained from the plant treated with 120 ppm and the lowest dry weight (0.77 g) was obtained from the control treatment. The increment in fresh and dry biomass could be associated with the increment in plant growth and development. On the other hand, previous researchers had confirmed the growth enhancement of chitosan on several crops [9].

Table 1. Effect of foliar application of chitosan on leaf area index, Chlorophyll content index plant height and plant dry weight of selected tomato cultivar during the vegetative stage.

Treatments	Leaf area (cm^2)	Chlorophyll index	Plant height (cm)	Plant dry weight (g)
70 ppm	6.16 c	23.72 c	19.25 b	1.14 b
80 ppm	8.79 b	28.31 b	21.50 b	1.55 a
120 ppm	11.91 a	33.50 a	27.75 a	1.7 a
Control	4.63 c	18.22 d	12.75 c	0.77 c

Means with the same letter(s) are not significantly different from each other according to the Duncan Multiple Range Test (DMRT) 5% significant level.

Different concentrations of foliar application of chitosan effect on pH and total soluble solids of the fruits (Table 2). There was no significant difference between the pH of the fruits. But the highest pH (4.3) was obtained from the plants treated with 120 ppm and the lowest pH (3.9) was obtained from the control treatment. There some other researchers also found that chitosan application has not shown any changes in fruit pH.

There was a substantial variation in total soluble solids between the fruits. The maximum total soluble solid (4.8) was obtained at 120 ppm, and the lowest total soluble solid (3) was obtained from untreated plants (Table 2). This rise in TSS could be attributed to cell wall breakdown [10], a decrease in respiration rate, and an increase in dry matter as a result of water loss [11].

Table 2. Effect of foliar application of chitosan effect on the pH and total soluble solid of the fruits

Treatments	pH	Total soluble solid (^{o}Brix)
70 ppm	4.09 a	3.6 b
80 ppm	4.1 a	3.8 b
120 ppm	4.3 a	4.8 a
Control	3.2 b	3.0 c

Means with the same letter(s) are not significantly different from each other according to the Duncan Multiple Range Test (DMRT) 5% significant level.

The results of the number of fruits per plant (Fig 1). There was a significant ($p<0.05$) difference between the treatment. The highest number of fruits per plant (23) was highest in 120 ppm chitosan treated and the lowest Fruit per plant was (08) found in untreated control plants.

Again, , the number of fruits plant^{-1} increased in chitosan applied plants than control due to the increase in the plant height, resulting from the increase in the fruit bearing nodes.

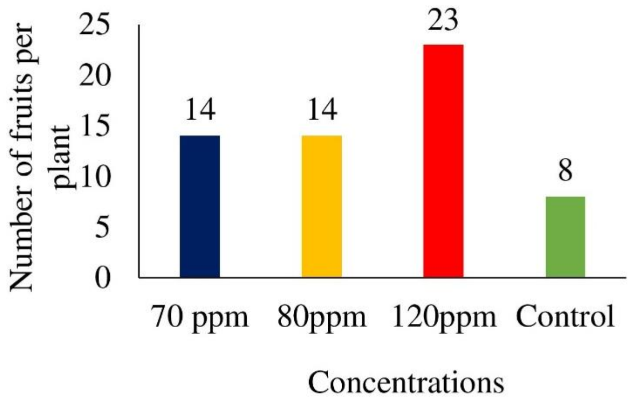

Fig.1. Effect of foliar application of chitosan on the number of fruits per plant of selected tomato

The effect of different chitosan foliar spray concentrations on a single fruit weight (Fig 2). The highest single fruit weight (74.85g) was achieved from the 120 ppm concentration, whereas the lowest single fruit weight (34.39 g) was obtained from the control treatment. Typically, fruit volume and weight are directly connected, with an increase in volume resulting in an increase in weight. The increased fruit volume could be attributed to the high level of starch and plant hormones, particularly cytokines, which play an important role in promoting cell division and expansion, resulting in greater volume. Chitosan may activate gibberellin in the carpel ovary, which is important for cell elongation and hence promotes an increase in size and volume [12].

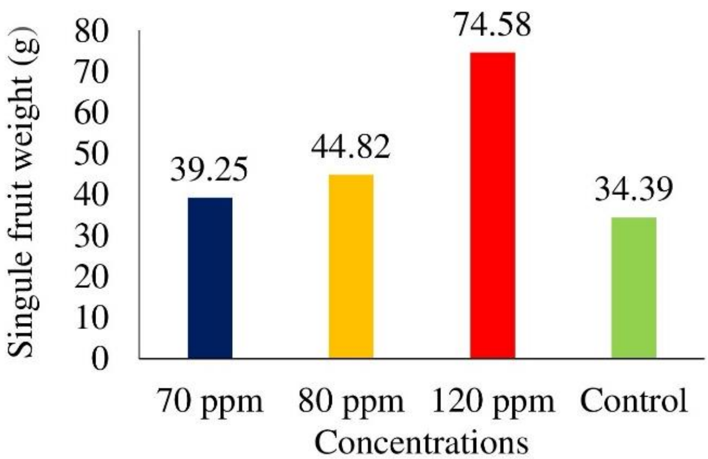

Fig. 2. Effect of foliar application of chitosan on single fruit weight of selected tomato cultivar

The influence of various chitosan concentrations on the yield of the selected tomato cultivar (Fig.3). There is a significant difference between the treatments ($p < 0.05$). At 120 ppm, the highest tomato production (47.64 t ha^{-1}) was obtained, whereas the lowest tomato yield (7.64 t ha^{-1}) was produced at the control treatment. This higher production in treated plants over untreated plants is related to increased plant height, fruit-bearing in nodes, chlorophyll contents, and decreased disease incidence [13].

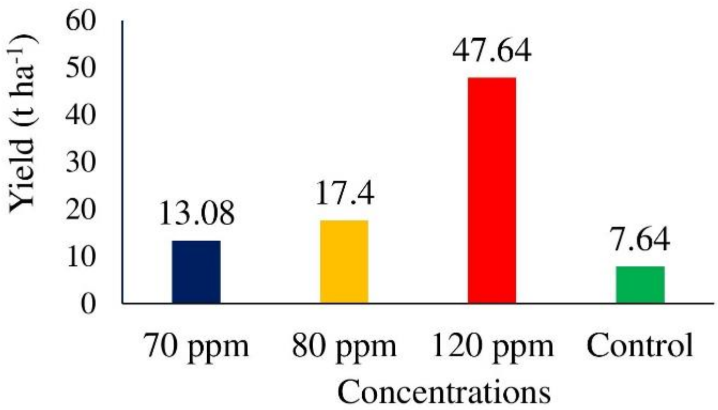

Fig. 3. Effect of foliar application of chitosan on yield of selected tomato cultivar

4. CONCLUSION

It has been determined that foliar application of chitosan at the early growth stage improves plant growth in a selected tomato cultivar. Among the concentrations, 120 ppm performed better than the other concentrations in terms of tomato plant development. Plant growth superiority of tomato plants. Furthermore, 120 ppm had an effect on tomato plant yield and yield components. Foliar treatment of chitosan at 120 ppm may thus be recommended for improving plant development and fruit characteristics.

5. REFERENCES

1. N.B. Gol ,R.P. Pooja R ,T.V Ramana Rao. "Improvement of quality and shelf-life of strawberries with edible coatings enriched with chitosan." *Postharvest Biology and Technology* 85,185-195, 2013.

2. Geisberger, Georg, E. B. Gyenge, H. Doris , A. Käch, C. Maake, R.P. Greta . "Chitosan-thioglycolic acid as a versatile antimicrobial agent." *Biomacromolecules,* 14,(4) ,1010-1017, 2013.

3. S.Krauss, W. H. Schnitzler, J. Grassmann, M. Woitke, The influence of varying electrical conductivity values in a simplified recirculating soilless system on inner and outer fruit quality attributes of tomato, Journal of Agricultural and Food Chemistry, 54(2), 441-448, 2006.

4. P. E. M. Dhandevi, Rajesh Jeewon. "Fruit and vegetable intake: Benefits and progress of nutrition education interventions-narrative review article." *Iranian journal of public health* 44 (10),1309, 2015.

5. Younes, M. Rinaudo, Chitin and chitosan preparation from marine sources. Structure, properties and applications. *Marine drugs*, *13*(3), 1133-1174, 2015.

6. N. Benhamou, J. W. Kloepper, S .Tuzun,. Induction of resistance against Fusarium wilt of tomato by combination of chitosan with an endophytic bacterial strain. Life Sciences, 1, 1998.

7. K.Górnik, M. Grzesik, B. Romanowska-Duda. The influence of chitosan on roots of grapevine cuttings and subsequent plant growth under drought and temperature stress, Fruit and Ornamental Plant Research, vol. 16, pp. 333-343, 2008.

8. El-Tantawy, E. M. "Behavior of tomato plants as affected by spraying with chitosan and aminofort as natural stimulator substances under application of soil organic amendments." *Pakistan Journal of Biological Sciences: PJBS* 12 (17) ,1164-1173, 2009.

9. J. Yan, C. Guo, M. A. O. Dawood, J. Gao, Effects of dietary chitosan on growth, lipid metabolism, immunological response, and antioxidant-related gene expression in Misgurnus anguillicaudatus, 439-449 in Beneficial Microbes, 2017.

10. B.R. Cordenunsi, M.I. Genovese, J. R. O. do Nascimento, N. M.A. Hassimotto, R. J. dos Santos, F. M. Lajolo. "Effects of temperature on the chemical composition and antioxidant activity of three strawberry cultivars." *Food chemistry* 91(1), 113-121, 2005.

11. R. Dris, , R. Niskanen, E . Fallahi. "Relationships between leaf and fruit minerals and fruit quality attributes of apples grown under northern conditions." *Journal of Plant Nutrition* 22(12) 1839-1851, 1999.

12. M. M. Mondal, M. A. Malek, A. B. Puteh, M. R. Ismail, M. Ashrafuzzaman, L. Naher, Effect of foliar chitosan application on okra growth and yield, Australian Journal of Crop Science, 6(5), 918-921, 2012.

13. S. Bautista-Baños, A. N. Hernandez-Lauzardo, M. G. Velazquez-Del Valle, M. Hernández-López, M . Barka, E. Bosquez-Molina, and C. L. Wilson. "Chitosan as a potential natural compound to control pre and postharvest diseases of horticultural commodities." *Crop protection* 25(2),108-118, 2006.