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Effect of chitosan application on growth and yield attributes of strawberry (*Fragaria* × *ananassa* Duch.) under naturally ventilated polyhouse

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Abstract
The study was carried out to investigate the effect of foliar application of chitosan with 1, 2 and 3 g l^{-1} concentrations applied at different time (once, twice and three times) on vegetative growth and yield attributing traits of strawberry (*var.* winter dawn) during 2019-20. Results revealed that all tested foliar concentration of chitosan increased vegetative growth characteristics *viz*., (plant height 23-28 cm, number of trifoliate leaves/ plants 22-28, leaf area 92-105.65 cm^2 and plant dry weight 23-33 g) and yield attributes (berry length 3.41-3.96 cm, berry diameter 2.82-3.15 cm, berry weight 16.93-18.55 g and number of berries/ plant16.6-19.74) compared to water spray. Among the chitosan treatment, application of chitosan at 3 g l^{-1} on 45, 90 and 135 days interval recorded maximum yield (366 g $plant^{-1}$) followed by chitosan at 3 g l^{-1} on 45 and 90 (346 g plant g $plant^{-1}$) and chitosan at 2 g l^{-1} on 45 and 90 days (343 g $plant^{-1}$) interval due to higher growth and yield attributing traits. There was no significant effect for the tested treatments on runner production.

Keywords: Berry, chitosan, media, polyhouse and strawberry

Introduction
Strawberry (*Fragaria* × *ananassa* Duch.) regarded as "false fruit", highly appreciated world widefor its unique taste, distinct flavor and tantalative aroma. It is one of the most delicious, refreshing and nutritious soft fruits of the world. It is an herbaceous perennial and short-day plant having short stem known as crown. The edible portion includes the ripened receptacle and achenes (true fruits and seed) and usually propagated through runners. The crop is unique among the cultivated temperate fruits as it is quickest to produce fruit from the time of planting and also the earliest fruit to come to the market (Jackson *et al.*, 2011) [5]. In India, growing conditions and early harvest are of primary importance to the growers, while fruit quality is most important to the consumers. However, strawberries have a short postharvest life with rapid spoilage, reflecting high susceptibility to mechanical injury, excessive texture softening, physiological disorders and infection through several pathogens during production, transport, storage and processing. These lacunas can be overcome by the application of new technology like foliar application of chitosan, which resulted in rapid advances in Indian strawberry industry (Jackson *et al.*, 2011) [5]. Chitosan, a deacetylated biopolymeric derivate of chitin, is a high molecular weight cationic linear polysaccharide composed of randomly distributed β-1,4-linked D-glucosamine (deacetylated unit) and to a lesser extent, N-acetyl-D-glucosamine (acetylated unit). It is a polysaccharide called 2-Amino-2-deoxybeta-D-glucosamine (Peniston and Johnson, 1980) [10]. Chitosan can be extracted from the marine crustacean like shrimps, cramp and pinfish or from the exoskeletons of most insects under the name of chitin which can be transformed into chitosan by extracting the acetyl group and turn it into amino (Sugiyama *et al.*, 2001) [12]. It is considered as an environment-friendly for agricultural uses, as it is easily degraded in the environment and non-toxic to humans. Considering the potential uses of chitosan for enhancing plant growth and yield, the present study was conducted to investigate the performances of varying doses of chitosan on fruit yield of strawberry in field condition.

Material and Methods
The study was conducted in a naturally ventilated polyhouse of the Department of Fruit Science, College of Horticulture, Mudigere, during 2019-20. Mudigere is situated in the Western Ghats, represents the typical climate of hill zone (Zone- 9 and Region- V) of Karnataka.

It is located at 13º7' North latitude and 74º 37' East longitude with an altitude of 980 m above mean sea level (MSL). The Completely Randomized Design (CRD) was employed for the study with twelve treatments replicated thrice. The experiment tested in a flat land with long plastic trays of size 60 ×20 ×15 cm. The trays were filled with growing media consist of Soil: Vermicompost: Vermiculite: Cocopeat in the ratio of 1:1:1:1 on volume (v/v) basis. The test variety was "winter dawn" and the planting was taken up on 7th November 2019.

The different chitosan concentrations and application frequency formed the base for treatment combinations and are as follows: T_1-Water spray at 45 DAP, T_2-Water spray at 45 and 90 DAP, T_3-Water spray at 45, 90 and 135 DAP, T_4-Chitosan spray 1 g l^{-1}at 45 DAP, T_5-Chitosan spray 1 g l^{-1} at 45 and 90 DAP, T_6-Chitosan spray 1 g l^{-1} at 45, 90 and 135 DAP, T_7-Chitosan spray 2 g l^{-1} at 45 DAP, T_8-Chitosan spray 2 g l^{-1} at 45 and 90 DAP, T_9-Chitosan spray 2 g l^{-1} at 45, 90 and 135 DAP, T_{10}-Chitosan spray 3 g l^{-1} at 45 DAP, T_{11}-Chitosan spray 3 g l^{-1} at 45, 90 DAP and T_{12}-Chitosan spray 3 g l^{-1} at 45, 90 and 135 DAP. For each time of chitosan application, fresh solution was prepared. The effect of these treatments was determining by observing different growth parameters like plant height, number of trifoliate leaves/ plants, leaf area, plant spread, number of crowns/ plants, number of runners/ plant and plant dry weight recorded at different intervals of time along with berry characteristics and number of berries as yield attributes. The data subjected to statistical analysis with probability of 5 per cent for drawing valid conclusions as per Fisher and Yates (1963) [4].

Result and Discussion

The data pertaining to the study (Table 1) indicated that foliar application chitosan at different concentrations and application frequencies significantly influenced the vegetative growth of strawberry. Foliar application of different concentrations of chitosan recorded 22-27cm plant height, 22-28 trifoliate leaves, 92-105 cm^2 leaf area and 23-33 g $plant^{-1}$ dry weight against 21-23 cm plant height, 20 -21 trifoliate leaves, 88-90 cm^2 leaf area and 21-23 g $plant^{-1}$ dry weight by water spray. Marginal difference was observed for plant spread, number of crowns per plant and number of runners per plants. The probable reason for increase in vegetative growth parameters may be attributed to an increase in the availability and uptake of water and essential nutrients through adjusting cell osmotic pressure and reducing the accumulation of harmful free radicals by increasing antioxidants and enzyme activities (Guan *et al.*, 2009) [8] or may be attributed to an increase in the key enzyme activities of nitrogen metabolism (nitrate reductase, glutamine synthetase and protease) and improved the transportation of nitrogen (N) in the functional leaves as well as increased photosynthesis which enhanced plant growth and development (Mondal *et al.*, 2012) [9]. The results are in line with the results obtained by Khan *et al.* (2002) [6] and Chibu and Shibayama, (2003) [2].

Water spray at different durations recorded normal berry characteristics (2.09-2.49 cm length, 1.93-2.39 cm diameter, 15.63-17.45 ccvolume and 15.8 to 17.86 g $plant^{-1}$ weight). The tested concentration levels of chitosan improved all the berry characteristics studied compared to water spray (Table 2). Further, as the concentration levels of chitosan increases, there is a marginal improvement in these berry parameters. Berry length rose to 3.41, 3.12 and 3.96 cm respectively for 1, 2 and 3 g l^{-1}concentration as compared to 2.49 cm by water spray. Similarly, berry diameter rose from 2.39 cm for water spray to 2.82, (1g l^{-1}) 3.09 (2g l^{-1}) and 3.15 (3g l^{-1}) cm. There length and diameter variations of berry resulted to get higher weight and volume. Berry weight rose from lowest of 15.08 g $plant^{-1}$ (water spray) to 18.55 g$plant^{-1}$(chitosan 3 g l^{-1}), accordingly volume also rose from 15.65 cc (water spray) to 19.43 cc (chitosan-3 g l^{-1}). The increase in fruit length, diameter and volume might be due to oscillation of physio-chemical status of the plant and production of more photosynthates due to maximum vegetative growth of plants as influenced by the foliar application of chitosan (El-Miniawy *et al.*, 2013) [3]. The current results are in accordance with the findings of Shehata *et al.* (2012) [11] on cucumber, Abdel-Mawgoud *et al.* (2010) [1] on strawberry.

Number of berries per plant is amost important factor controlling yield per plant. Berry number differed due the applied treatments as the number varies from 15-19.Here again, Compared to water treatment, chitosan application performed better, in that highest concentration applied recorded higher (18-19) number. Influence of chitosan treatment on number of berries and berry characteristics as discussed above, the yield obtained by plant also remained high and followed the same trend (Fig 2 and fig 3). As against water spray that yielded 228-273 g$plant^{-1}$, chitosan spray @ 1g $plant^{-1}$ yielded 281-331 g $plant^{-1}$. Further, with increase in concentration of 2 and 3 g l^{-1} yield improvement was to the extent of 301-332 and 313-366 g $plant^{-1}$. Water spray at 45 and 90 days yielded lowest (228.76 g $plant^{-1}$) while chitosan 3 g l^{-1}applied at 45,90 and 135 days recorded maximum (366.17 g $plant^{-1}$) an increase of 60.07 per cent. The results are in line with the results obtained by Gornik*et al.* (2008) [7] and Abdel-Mawgoud *et al.* (2010) [1].

Conclusion

The result of the present study revealed that cultivation of strawberry variety "winter dawn" by foliar application of chitosan @ 3g l^{-1} at 45, 90 and 135 days after planting found better for increasing vegetative growth, yield attributing traits and yield under naturally ventilated polyhouse.

Fig 1: General view of the experimental plot and treatment twelve

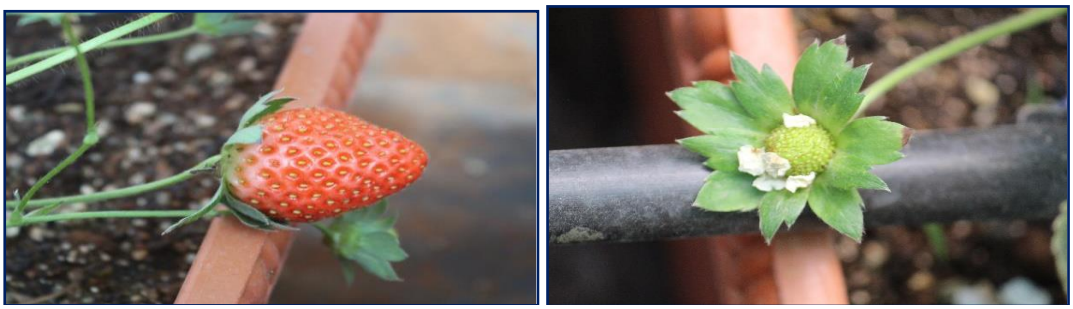

Fig 2: Flowering and fruiting in treatment twelve

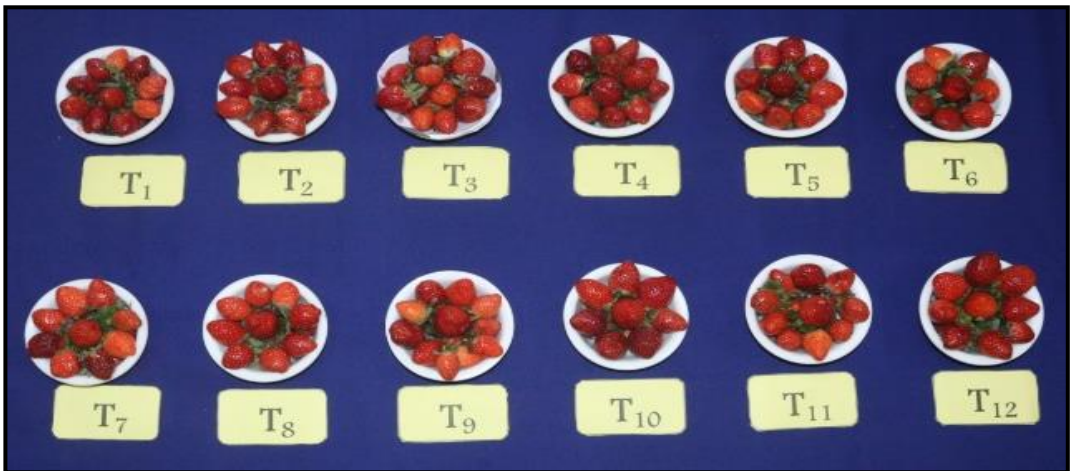

Fig 3: Fruit yield in different treatment

Table 1: Effect of chitosan foliar application on growth parameters of strawberry at harvest under naturally ventilated poly house

Treatment	Plant height (cm)	No. of trifoliate leaves/plants	Leaf area (cm^2)	Plant spread (cm)		No. of crowns/ plant	No. of runners/ plant	Plant dry weight (g)
				N-S	E-W			
T_1	22.98	20.75	88.23	27.26	26.22	2.39	4.85	22.35
T_2	21.23	20.94	89.48	27.46	26.91	1.98	5.35	22.95
T_3	22.15	20.41	90.26	27.39	26.84	2.45	5.68	21.01
T_4	23.51	22.57	92.45	27.78	26.71	2.77	5.48	23.46
T_5	24.94	23.28	93.48	28.17	27.61	2.89	5.55	22.98
T_6	26.64	24.56	96.56	29.75	29.55	3.12	6.10	25.56
T_7	25.32	25.21	94.23	28.15	27.58	3.36	5.23	27.89
T_8	26.78	26.62	95.89	29.84	29.24	3.59	4.56	28.65
T_9	27.96	27.11	99.78	31.23	30.60	4.31	4.26	31.45
T_{10}	26.36	27.49	100.35	32.45	31.80	3.88	5.33	30.78
T_{11}	27.25	27.92	98.56	32.26	32.61	3.98	4.02	29.99
T_{12}	28.73	28.84	105.65	33.32	32.65	4.55	4.56	33.56
S.Em ±	0.38	0.37	0.91	0.45	0.44	0.05	0.08	0.41
CD @ 5%	1.14	1.11	2.71	1.35	1.31	0.15	0.23	1.22

Table 2: Effect of chitosan foliar application on yield parameters and yield of strawberry under naturally ventilated poly house

Treatment	Berry length (cm)	Berry diameter (cm)	Berry weight (g)	Number of berries per plant	Yield per plant (g)
T_1	2.09	1.93	17.86	15.30	273.26
T_2	2.49	2.05	15.08	15.17	228.76
T_3	2.26	2.39	17.24	14.80	255.15
T_4	2.70	2.80	16.93	16.60	281.03
T_5	3.38	2.82	16.86	17.15	289.15
T_6	3.41	2.64	18.04	17.28	311.73
T_7	3.04	2.85	18.34	18.14	332.69
T_8	3.12	3.02	18.11	19.11	346.08
T_9	3.03	3.09	15.88	18.99	301.56
T_{10}	3.82	3.00	17.24	18.21	313.94
T_{11}	3.69	2.76	18.42	18.64	343.34
T_{12}	3.96	3.15	18.55	19.74	366.17
S.Em ±	0.05	0.04	0.26	0.25	1.24
CD @ 5%	0.15	0.12	0.77	0.75	3.71

Legend

T_1- Water spray at 45 DAP
T_2- Water spray at 45 and 90 DAP
T_3- Water spray at 45, 90 and 135 DAP
T_4- Chitosan spray 1 g l^{-1} at 45 DAP
T_5- Chitosan spray 1 g l^{-1} at 45 and 90 DAP
T_6- Chitosan spray 1 g l^{-1} at 45, 90 and 135 DAP
T_7- Chitosan spray 2 gm l^{-1} at 45 DAP
T_8-Chitosan spray 2 gm l^{-1} at 45 and 90 DAP
T_9 -Chitosan spray 2 gm l^{-1} at 45, 90 and 135 DAP
T_{10} -Chitosan spray 3 gm l^{-1} at 45 DAP
T_{11} -Chitosan spray 3 gm l^{-1} at 45 and 90 DAP
T_{12} -Chitosan spray 3 gm l^{-1} at 45, 90 and 135 DAP

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