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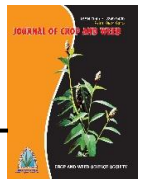

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Performance of cherry tomato (*Solanum lycopersicum* var. *cerasiformae*) for biochemical quality traits under hydroponics

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ABSTRACT

Globally, hydroponics technology has been accepted as sustainable technology with potential for increasing productivity and maintains quality of vegetables. Hydroponics not only offers safe food but also ensures vertical utilization of space with higher water use efficiency. This experiment was conducted during 2021-22 at DIBER, DRDO, Haldwani, Nainital (Uttarakhand). The objective of this study was to evaluate the performance of cherry tomato cultivars under hydroponics culture. The nursery of tomato was raised in the portrays by using soilless media (cocopeat: vermiculite: perlite) during the month of September 2021 and 30 days old seedlings were transplanted under plastic trays size 45cm to 30cm and depth 10cm and covered by thermacol sheet which can accommodate 4 plants tray $^{-1}$. The pH of hydroponicas nutrient solution was maintained between 6 to 7 during entire growth stages of the crop. Performance of cherry tomato cultivar Serina and Esterina differed significantly for various growth or yield traits under study. Esterina cultivar exhibited the highest value for plant height (370 cm), number of fruitcluster^{-1} (22), number of cluster plant^{-1} (18.66), total yield plant $^{-1}$ (4680.00g), Tannin (7.49 mg 100 g $^{-1}$), total phenol (394.66 mg100 g $^{-1}$), Flavonoid (4.91 mg100g. $^{-1}$). Serina cultivar exhibited the highest value for Number of branch/plant (3.66), fruit girth (3.42 cm), fruit length (3.03 cm), pericarp thickness (4.16 mm), Carbohydrate (6.33 g100g $^{-1}$), protein (1.78 g100g $^{-1}$), ascorbic acid (18.68 mg100g $^{-1}$.). The results revealed that both the cherry tomato hybrids can be grown under hydroponics successfully with better quality fruits as cash crops for better returns.

***Keywords*:** Biochemical quality, cherry tomato, growth, hydroponic and yield

Hydroponics is a method of growing the crops without soil with the help of nutrient solution. With increasing scarcity of water availability, increased levels of residual toxicity in vegetables and rapid growth rate of urban population has attracted the global attention towards the use of intensive cropping systems and paved the way for new technologies such as soilless culture and hydroponics (Sambo *et al*., 2019; Pant *et al*., 2018 and Agarwal et *al*., 2019**).** The advantages of hydroponic are that it requires small space with provision to vertical space utilization, higher nutrients use efficiency. Hydroponics techniques also facilitate roof farming and indoor farming. Hydroponics system also play an important role towards the precision farming by supporting the principle of "right time, right input, right quantity and right location". Globally, tomato tomato is regarded as "protective food" and grown all over the world as a very good source of income and cash earning crop. Cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) is a good source of vitamins A and C, and antioxidant compounds. Golden yellow cherry tomatoes can be marketed @ 7-8 US dollars per kg in premium market (Singh *et al.*, 2021). In recent years, cherry tomato demand is increasing due to higher antioxidant activity, higher yield which play an important role as growth engine in horticulture sector. With the increasing urbanization and increasing opportunity for self-employment, various start-ups are coming up near urban areas with hydroponics and

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commercial nursery (Patil *et al*., 2017) as preferred business option. In order to increase the return on investments, high value vegetables including cherry tomatoes are being preferred in these systems. The present investigation was carried out to evaluate the performance of two popular hybrids of cherry tomato under hydroponics for growth, yield and quality related traits.

MATERIALS AND METHODS

An experiment was conducted at DIBER (DRDO) Haldwani, Uttarakhand situated at 243 msl in the central Himalayan zone at 29.2183° N, 79.5130° E during Sep. 2021 to January 2022. The experiment was conducted under customized shade net house with rain protection provision. Shade net used for cladding purpose was of 25% shade. Roof of the structure was covered with 200 gsm UV stabilized polythene sheet. Light intensity observed during the experimentation was 6,000 to 50,000 lux varying from cloudy to sunny day during the experiment. During the study period, the maximum and minimum temperature of the field and low-cost shade net recorded was 28-34°C and 16 -18 °C, respectively. Under present experiment complete randomized design was used with three replications comprising two treatments (two cultivars).

Esterina- Yellow cherry and Serina- Red cherry were chosen for the experiment. Nursery of cherry tomato was grown using soilless media (cocopeat: perlite: vermiculite) and application of nutrients solution which given below was applied during the month of Sep. 2021 and 30 days old seedlings were transplanted under tray system (NFT) hydroponic. NFT system used for growing the crop comprised plastic trays (size 45cm x 30cm and depth 10 cm) and covered by thermacol sheet, which can accommodate 4 plants $tray^{-1}$. DIBER has developed the hydroponics nutrient solution as given by Hoagland and Arnon (1950) with desired modifications. The nutrient application is important for growth, yield and quality of various vegetables crops. Standard protocols need to be followed while preparing nutrient solution and necessary measures to be taken to avoid chances of precipitation. Presence of cations (positively charged $^{+}$) and anions (negatively charged $^{-}$) of all the essential macro and micro nutrients decides the electrical conductivity in the solution. Usually, three categories of stock solutions are prepared for hydroponics nutrient solutions. Among them category A consists KNO_3 (Nitrogen $_{+}$ potassium 250 to 300 ppm, respectively) , KH_2PO_4 (36 ppm), Na_2MoO_4 (less than 1 ppm) from hi- media while category B consists 200 ppm Ca (NO_3), H_3BO_3 (4 ppm), $MnCl_2$ (less than 1 ppm) , Boric acid (less than 1 ppm) of Molychem to be dissolved in hot water then boil after it dissolved and make the volume 1 liter by addition of 10 ml of this stock solution/100 Liter of water. In category C, iron stock solution prepared separately, firstly weighing chelating agent 66.6 g EDTA and dissolved in 600 ml distilled water and weighing 8 g NAOH (Pellets) which dissolved in 200 ml of water than warm up to 72^{o}C than weighing 50 g $FeSO_4$ and dissolved the prescribed quantity in 600 ml distilled water and add 1% N H_2SO_4 and than warm up to 75-80^{o}c , then mix both the solution and expose to aeration overnight to get ready to use (l ml^{-1}) iron solution .The hydroponic nutrient solution prepared at DIBER, Haldwani has good availability of all necessary nutrients according to their concentration and ions reactions. Under hydroponics cultivation maintaining EC is very important because excessive level of nitrates accumulates in plant leaves and excessive phosphorus gives impact on growth. Thus, the use of recommended dose of nutrients in solution must be necessary to maintain EC concentration. Nutrient solutions supplied to grow the plants through irrigation pump. pH of irrigation water after addition of hydroponics nutrient solution ranged from 6 to 7.0 during the experiment and electrical conductivity (EC) 1800±100 ppm. Electrical conductivity (EC) and pH of nutrient solution were checked by using hand held pH and EC Meter (MCP and HANNA, respectively). Harvesting was done 70- 95 days after transplanting. Generally, tomatoes are harvested at mature green to turning stage for distant marketing. For fresh consumption, orange to light red tomatoes are preferred. The observations were recorded on plant height, number of fruits $clusters^{-1}$, number of cluster $plants^{-1}$, number of branch $plants^{-1}$, fruit girth, fruit length, pericarp thickness, total yield, carbohydrate content, protein content, Vit. C (mg 100g.), tannin content (mg 100 g^{-1}.), phenol (mg 100 g^{-1}), flavonoid content (mg $100g^{-1}$). Data were recorded randomly on five plants $replicate^{-1}$ and mean values for each of the variable were calculated.

Determination of total phenols

The concentration of total phenols in the samples was estimated through Folin–Ciocalteu method (Malik and Singh, 1980). Catechol was used as standard. Cherry tomato was crushed in 0.2 ml ethanolic (80%) extract (4 mg ml^{-1}) and 0.2 ml Folin –Ciocalteu reagent was added and mixed thoroughly. A 60 µl sample was taken for analysis. After 4 min, 1 ml of 15 % sodium carbonate was added and the mixture was allowed to stand for 2 h at room temperature. The absorbance was measured at 760 nm. The concentration of total phenols was measured

against standard calibration curve which was drawn using equivalent to catechol.

Determination of tannins

Folin–Denis method was used for total tannin estimation in plant extract as reported by Schanderi (1970). Fresh cherry tomato was crushed by using mortar and pestle. And transferred into centrifuged tube and centrifuged at 2000 rpm for 20 min and supernatant was collected in 100 ml volumetric flask and the volume was made up with double distilled water. 1 ml of this solution was then transferred to a volumetric flask (100 ml) already containing water (75 ml) with Folin–Denis reagent (5 ml). Ten ml of sodium carbonate solution was added and diluted up to 100 ml with water. After shaking the flask was kept for 30 min and then the absorbance was read at 700 nm. Blank solution using distilled water was prepared. Standard graph was prepared by using 0-100 µg tannic acid. Total tannin content of the sample was measured equivalent to tannic acid by standard graph (Meena *et al*., 2021).

Determination of ascorbic acid content

Total ascorbic acid content in plant extract was determined by 2, 6-dichlorophenolindophenol method **(**Sadasivam and Balasubraminan, 1987). Two ml sample was extracted with 4 % oxalic acid and the volume was made up to 100 ml. It was centrifuged at 10,000 rpm for 10 min. 5 ml supernatant liquid was transferred to a conical flask and 10 ml of 4 % oxalic acid was added. It was titrated against standard dye solution (2, 6-dichlorophenolindophenol) to a pink end point. The procedure was repeated with a blank solution (without adding sample). 5 ml ascorbic acid of 100 ppm was used as standard.

Ascorbic acid content was calculated using the formula: Ascorbic acid (mg 100 g^{-1}) = [0.5 mg × titer vol against test × 100 ml titer vol^{-1}. against ref. × 5 ml × weight of sample] × 10

Determination of total flavonoids

Total flavonoids in plant extract was determined by aluminium chloride method was modified from the procedure given by (Meena *et al*., 2022). Quercetin (Sigma) was used as standard.100-250 mg of the sample was weighed and was crushed with a pestle and mortar in methanol. Then the sample was centrifuged at 10,000 rpm for 20min and supernatant was collected. 0.5ml of solution extract was taken and 1.5ml of methanol, 0.1ml of potassium acetate (1M), 0.1ml of aluminum chloride and 2.8ml of distilled water were added. The reaction mixture was incubated at room temperature for 30 minutes and absorbance was measured 415 nm against the reagent blank. Blank, prepared with water, was used. Calibration curve was prepared by using quercetin (1mg/ml) and standard graph was plotted against concentration and absorbance. Standard curve was used to calculate the amount of flavonoids equivalent to quercetin present in the sample.

Determination of total carbohydrates content

Total carbohydrates were determined by Anthrone method (Sadasivam and Balasubraminan, 1987). The sample 120 mg was weighed and crushed by using mortar and pestle, then hydrolyzing by keeping it in a boiling water bath for three hours with 5 mL of 2.5N HCL, and cool at room temperature, after neutralize it with solid sodium carbonate until the effervescence ceases, then make up the volume to 100 mL and centrifuging it, after centrifuged collect the supernatant and take 0.5 and 1mL for analysis by using standard glucose (Sigma). In all tubes including sample tubes volume was made up to 1 ml by adding distilled water, then 4 mL Anthrone reagent was added, followed by heating for 8 minutes in a boiling water bath, cool rapidly and finally read the absorbance at 630 nm., standard curve was used to calculate the amount of carbohydrates

Determination of total protein content

Total protein content was determined by Lowry method (Sadasivam and Balasubraminan, 1987**)** the amount of protein present in the sample was calculated by using the standard graph. The bovine serum albumin (BSA) was used as standard. For the estimation of protein four reagents were prepared. Reagent A was prepared using 2% sodium carbonate in 0.1N sodium hydroxide. For the preparation of reagent B 0.5% copper sulphate in (1%) potassium sodium tartrate solution and for the preparation of reagent C mix 50 ml of reagent A and 1ml of reagent B prior to use. Folin-Ciocoilteau was the fourth reagent. Protein solution (stock standard) 50mg of Bovine serum albumin was weighed and 50ml distilled water was added to make up a standard solution. Working standard preparation 10ml of the stock solution was diluted with 50ml with distilled water in a standard flask. 1ml of this solution contains 200mg protein. Preparation of sample for protein analysis extraction buffer was prepared using Tris. 100mg of sample was weighed and triturated with 3ml of tris buffer of pH 7.4, triturated samples were centrifuged at 10.000rpm for 15min. Supernatant was used for protein analysis. Then the procedure followed by the Lowry's method. The amount was calculated the protein mg g^{-1} or 100g of sample.

Statistical analysis was done by using. The Randomized Block Desigh (RBD) following the procedure described by (Gomez and Gomez 1984). The significance of variation among the treatments was observed by applying analysis of variance (ANOVA) and critical difference (C.D.) at 5% level of significance for each character was worked out.

RESULTS AND DISCUSSION

The results (Table 1) revealed that both the cultivars exhibited variation for morphological traits viz., plant height, fruit colour and fruit size and days to first picking. In general both the cultivars exhibited the indeterminate growth habit. Similar fimding has been also reported by Khan *et al. (2017)* for cherry tomato grown under hydroponics.

Yield, being the polygenic trait, is the most important trait to decide the popularity and acceptance of cultivar among the farmers. Various traits which directly influence the yield are fruit weight, number of fruits per cluster, number of clusters per vine, fruit size. Results presented in table 2 revealed that cultivar Esterina exhibited the taller plants with higher number of fruit cluster plant^{-1} (18.66) and number of fruits cluster^{-1} (22.0). Hybrid Serina exhibited better fruit size and pericarp thickness (4.16mm). Hydroponics cultivation is significantly effects on fruit size due to proper application of nutrients solution as compared to conventional farming and there was a better provision for protection from soil borne diseases and weed growth as compared to traditional farming. The results also revealed that Esterina exhibited better fruit yield (4.68 kg/plant) almost 36% higher over Serina (3.76 kg/plant) under hydroponics. Better performance of Esterina may be attributed to the comparatively higher number of fruit cluster per plant with higher fruit weight. Fruit yield of 4.95 to 6.11 kg plant^{-1} among three cherry cultivars under greenhouse conditions was observed by Singh *et al.* (2021). Khan *et al.* (2017) has also reported yield from 2.9 – 23.09 kg per plant in cherry tomato cultivars under hydroponics.

Quality parameters such as carbohydrate, protein, ascorbic acid, phenol, tannins and flavonoids were estimated and both the cultivars exhibited significant difference for all quality traits under study except protein content (Table 3). Total carbohydrate and protein content were higher in Serina (6.33g, 1.78g per100g, respectively). These two parameters contribute for the TSS (total soluble solids) and thus decides the canning quality of these cultivars. Overall flavor of the tomato is commonly linked with TSS. Sugar and organic acids are important flavor components in tomato fruits (Saltveit, 2005). TSS of cherry tomato was reported 2- 4% under hydroponics (Khan *et al*, 2017). Ascorbic acid plays an important role in human diet as antioxidant, and protects against stress and vitamin deficiency. Ascorbic acid was higher in Esterina (18.68 mg 100g^{-1}**).** Csambalik *et al.* (2014) has reported ascorbic acid content in cherry tomato up to 16.7 mg 100g^{-1}. Khan et al. (2017) has reported ascorbic acid content in cherry tomato from 20.56 to 23.24 mg 100g^{-1} among four cultivars. Total phenol content was higher in Esterina (394.66 mg 100g^{-1}) almost 2.5 time higher over Serina. High phenolic content in cherry tomato has been linked to superior antioxidant activity of these tomatoes. Tannin and flavonoid content were also higher in Esterina (7.49 mg 100g^{-1} and 4.91 mg g^{-1}, respectively). Prasanna *et al.* (2020) and Khan *et al.* (2017) have also reported similar range for various traits in cherry tomato. The results revealed that both the cherry tomato hybrids can be grown under hydroponics successfully with better quality fruits as cash crops for better returns from hydroponics venture.

Table 1: Performance of cherry tomato under Hydroponics for morphological traits

Crop cultivars	Plant height (cm)	No. of branch plant $^{-1}$	Growth habit	Fruit colour	Fruit shape	Days to first picking	fruiting habit
Esterina	370.00	3.33	Ind	Yellow	Round	80.2	bunch
Serina	248.33	3.66	Ind	Red	Round	75.2	bunch
SEm (±)	16.37	0.88					
LSD (0.05)	66.00	NS					

Ind: Indeterminate

Table 2: Performance of cherry tomato under Hydroponics for yield attributing traits

Crop cultivars	No. of fruits cluster^{-1}	No. of cluster plant^{-1}	Average fruit wt. (g)	Fruit girth (cm)	Fruit length (cm)	Pericarp thickness (mm)	Yield plant^{-1} (g)
Esterina	22.00	18.66	15.33	1.93	2.50	2.13	4,680.00
Serina	16.00	14.00	11.33	3.40	3.03	4.16	3,784.00
SEm (±)	1.15	1.02	0.66	0.33	0.04	0.19	163.56
LSD (0.05)	4.65	4.14	2.68	1.36	0.17	0.78	659.44

Table. 3: Performance of cherry tomato under Hydroponics for biochemical quality attributes

Crop cultivars	Carbohydrates (g 100^{-1} g)	Protein (g 100^{-1} g)	Ascorbic acid (mg100^{-1} g)	Tannin (Tannic acid equivalent) (mg100^{-1} g)	Phenol (mg100^{-1} g)	Flavonoid (mg g^{-1})
Serina	6.33	1.78	18.68	4.74	148.43	2.57
Esterina	4.90	1.56	14.50	7.49	394.66	4.91
SEm (±)	0.239	0.21	0.55	0.39	4.31	0.15
LSD (0.05)	0.965	NS	2.23	1.57	17.37	0.60

CONCLUSION

Result revealed that high value cherry tomato (hybrids Esterina and Serina) can be cultivated successfully under hydroponics at an EC of 1800±100 ppm with pH ranging between 6.0 to 7.0 without compromising the antioxidant properties of fruits and yield. Utilization of this technology will be beneficial for farmers and entrepreneur to modernize the technology with the support of modified nutrient solution which was used under this study.

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