Plant Archives Volume 20 No. 2, 2020 pp. 5575-5582 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

CHARACTERIZATION OF STRAWBERRIES (*FRAGARIA × ANANASSA*) GENOTYPES UNDER DIFFERENT SALT STRESS CONDITION

Aditi Thakur and Sanjay Singh*

School of Agriculture, Lovely Professional University, Punjab, India.

Abstract

Strawberry is known as one of the most salt-delicate yields with variable degrees of resistance concerning the various cultivars & times of introduction to high NaCl concentration. A study was conducted at the Polyhouse of Lovely Professional University, Phagwara, Punjab during the year 2019-2020 with title 'Characterization of strawberries (*Fragaria × ananassa*) genotypes under different salt stress conditions under the objective of determining a salt tolerant cultivar of strawberry so that it can be grown in the areas which are affected to salt. This study involves the effect of different concentration of salt (NaCl: Na_2SO_4: $CaCl_2$) in the ratio 7: 1: 2 on three different cultivars of strawberry which were Capri, Winter Star and Camarosa in order to observe their response to the stress caused by salinity. CRD (Completely Randomized Design) has been used and the results for each treatment were recorded time to time at 20, 50 and 90 DAT (days after treatment). In this study, three different salts such as NaCl, Na_2SO_4 and $CaCl_2$ were utilized as one in the ratio of 7: 1: 2. Three treatments were applied to the plants of the strawberry cultivars which were T1 (0.0 EC- Control), T2 (1.5 EC) and T3 (3.0 EC). The results of the present study indicated that Camarosa showed maximum salt tolerance for the growth parameters such as number of leaves, number of shoots, leaf length and chlorophyll content, which shows that it is tolerant to salinity while, cv. Capri showed minimum salt tolerance for growth parameters performing inferior amongst the cultivars, being susceptible towards salinity.

Key words: Strawberry, Salinity, Salt tolerance index, Growth Parameters, Tolerant, Susceptible.

Introduction

Strawberry (*Fragaria ×ananassa* Duch.) being a member of family Rosaceae (Zebrawora and Horlynski, 2002) is one of the most aromatic sweet flavoured and most delicious fruits of the world which makes it very popular in many countries (Sharma and Sharma, 2003). Commercially Strawberry (*Fragaria ×ananassa* Duch.) is broadly cultivated & is highly demanded berry species on world basis. aroma, flavour, colour and texture are some of the organoleptic properties and represents the physical appearance of strawberries are the centre of attraction not only these properties but the attractiveness is also due to their high nutritive value, contents of vitamin & mineral (Aharoni *et al*., 2002) and properties of their antioxidants obtained from the different complexes such as phenolics, anthocyanins & flavonoids (Olsson *et al*., 2004; Simirgiotis *et al*., 2009). *Fragaria ×ananassa* is believed to be originated by crossing American *Fragaria virginiana* Mill. with *Fragaria chiloensis*; which signifies that both of the species are related genetically (Hancock, 1999).

***Author for correspondence :** E-mail: sanjaydbtster@gmail.com

Strawberry fruit is rich source of vitamins and minerals having Vitamin C in higher amounts than the other vitamins. The flavour of fruit consists of three compounds i.e. sugar, acids and aromatic compounds. The major volatile compound which is responsible for the flavour of the fruit is Ethyl esters e.g. Ethyl butanoate and ethyl hexanoate. Ellagic acid which is an antimutagenic and anti-carcinogenic phenol is present in the leaf tissues and red achenes of the strawberry fruit. Due to presence of more oleic acid and less linoleic acid ripe fruit contains more lipids than unripe fruits (Chattopadhyay, 2013).

Strawberry covers around 9.2 lakh hectare area (73 countries) and the annual production of strawberry is estimated to be 45.9 lakh in the world. Total area under strawberry cultivation in India is 1 lakh hectare. The annual production is nearly about 5000 million tons (NHB 2017). India is exporting strawberry fruit is being exported to different countries such as Austria, Bangladesh, Germany, Jordan from India.

Strawberry is known as one of the most salt-delicate yields with variable degrees of resistance concerning the various cultivars & times of introduction to high NaCl concentration (Maas, 1990; Martinez Barroso and Alvarez, 1997; Turhan and Eris, 2005; Yilmaz and Kina, 2008). Strawberry (*Fragaria* × *ananassa* Duch.) pursues the common two-stage reaction to stress caused by salt, displaying development concealment well formerly the leaves give a little indications of salt damage (Ehlig and Bernstein, 1958). Suppression of growth is ordinarily a vague salt reaction, which depends more on the pressure caused due to osmosis made by the complete centralization of solvent salts than on the degree of explicit solutes (Hoffman, 1981).

In a study of Pirlak and Esitken, (2004) the cultivars Fern and Camarosa showed reduction in the number of leaves, fresh weight and dry weight of roots, number of crowns and runner length as the concentration of salt increased from 2.0 mS/cm to 7.5 mS/cm. Saied *et al.,* (2005) in their two year study observed no reduction in the number of leaves in Camarosaat 8.5 mM NaCl concentration however, reduction in the area of leaf by 13% was observed in cv. Korona and 34% of Elsanta with respect to the controlled plants. Sun *et al.,* (2015) in their study of seven cultivars of strawberry under salinity with an electrical conductivity (EC) from 1.1 to 4.4 dS m^{-1} observed reduction in the growth and yield of the plants of cv. "Albion", "Benicia", "Camarosa", "Camino Real", "Chandler", "Radiance" and "San Andreas". The results demonstrated that "Albion", "Camarosa" and "San Andreas" were tolerant to salt, while "Camino Real", "Benicia", "Chandler" and "Radiance" were tolerant to salt but with a very less amount. Hussein *et al.,* (2017), evaluated the effect of salinity stress on two cultivars of strawberry (Fortuna and Festival) throughout their regeneration under *in vitro* conditions. The culture media were supplemented with NaCl with concentrations of 0, 500, 750 and 1000 mg L^{-1} for up to 3 weeks. The results showed reduction in the chlorophyll content from 15.33 to 10.13 mg/g, length of the shoot from 5.40 to 2.10 cm, biomass of dry shoot from 2.51 to 0.96 mg whereas an increase in the contents of proline, catalase and peroxidase from 0.53, 1.86 and 20.42 in the plants which were kept under control to 3.95, 4.75 and 20.42 µg/g in the plants. This showed that cultivar Festival exhibits same behaviour as of Fortuna in response to salt stress. In a study conducted by Abbas *et al.,* (2018) on cv. Festival of strawberry showed reduction in the number of shoots to up to 1.00 from 26.00, plant height from 14.07 cm to 10.00 cm, at higher concentration of NaCl (45 mM) when compared to the plants in control. Akbar Mozafari *et al.,* (2018) in their study observed the response of cv. Queen Elisa to salinity. A reduction in the number of leaves was observed at concentration of 100 mM of NaCl.

The above studies have indicated variation to salt tolerance among the cultivars of strawberry and the importance of cultivar selection when soil or water salinity is too high. The objective of the study was to characterize the three strawberry cultivars grown commercially by irrigating the plants with a solution of nutrients or saline solution at particular levels of salinity. Salt tolerance index of the cultivars were also determined to check whether which cultivar is tolerant to salinity and which one is susceptible.

Materials and Methods

Plant materials

The healthy plants of strawberry cv. Capri, Winter star and Camarosa free from insect, pest and diseases and injuries were imported from District Solan, Himachal Pradesh from the nursery of M.K. Biotech to the Lovely Professional University. The plants were transplanted in the month of November into 1 kg black polybags filled with a mixture of soil, vermicompost and cocopeat. The plants were trimmed off from runners, dead leaves and/or flowers at the time of transplanting. The plants were grown in the Polyhouse of Lovely Professional University. The plants were applied with normal irrigation water until the treatment of salts were provided. The salt solution prepared by mixing NaCl, Na_2SO_4 and $CaCl_2$ in the ratio of 7:1:2 (Singh *et al.,* 2015) having a concentration of EC 1.5 dS/m and 3.0 dS/m considered as T2 and T3 and T1 was just an application of normal irrigation water considered to be as controlled.

Growth Parameters

Number of leaves, number of shoots, plant height, petiole length, leaf length and chlorophyll content were recorded at 20 DAT (Days After Treatment), 50 DAT (Days After Treatment) and 90 DAT (Days After Treatment). The number of leaves and number of shoots were measured and their mean was recorded on the basis of per plant and was expressed in numbers. The plant height, petiole length and leaf length were measured with the help of meter scale and was expressed in centimetres (cm). The content of chlorophyll was recorded using SPAD meter and was termed in the units of mg/g.

Salt Tolerance Index (STI)

Salt tolerance trait indices (STTI) for each of the studied trait were calculated according to the formula of Ali *et al*., (2007).

$$\text{STTI} = \frac{\text{Value of trait under stress condition}}{\text{Value of trait under control condition}} \times 100$$

Results and Discussion

The characterization of strawberry genotypes under the conditions of salt stress at 20, 50 and 90 DAT (Days After Treatment) for the different parameters of growth is discussed further.

Growth parameters

In the present study, the number of leaves, number of shoots, plant height, petiole length, leaf length and chlorophyll content were different significantly within the treatments of salt & amongst the cultivars. The number of leaves decreased gradually with the increase in the concentration of salt. The variation in the number of leaves due to different concentration of salt was significant. It was observed in three cultivars Capri, Winter star and Camarosa that at higher concentration of salt i.e., at EC 3.0 dS/m they showed reduction in the number of leaves, number of shoots, plant height, petiole length, leaf length and chlorophyll content of the plants at 20 DAT, 50 DAT and 90 DAT (days after treatment), respectively. The effect of salinity on different growth parameters have been demonstrated below in the tables regarding each cultivar (Table 1 and 3).

Considering table 1, Capri was recorded with maximum number of leaves at 20 DAT in T1 (control) having 10.09 leaves followed by 8.89 leaves in T2 (1.5 EC) and the minimum number of leaves was recorded to be 8.33 in T3 (3.0 EC). Considerably at 50 DAT and 90 DAT the maximum number of leaves was recorded at T1 (control) having 16.78 leaves and 17.56 leaves times followed by T2 (1.5 EC) having leaf number of 13.78 and 13.33, however the minimum number of leaves was recorded in T3 (3.0 EC) with 12.55 and 10.22 leaves, respectively. Reduction in the number of leaves observed at 90 DAT (Days After Treatment) was from 24.06% to 41.79%, correspondingly.

As for number of shoots, the cultivar was recorded with maximum number of shoots at 20 DAT in T1 (control) having 5.67 shoots followed by 3.78 shoots in T2 (1.5 EC) and the minimum number of shoots was recorded to be 2.67 in T3 (3.0 EC). Considerably at 50 DAT and 90 DAT the maximum number of shoots was recorded at T1 (control) having 8.33 and 7.89 shoots followed by T2 (1.5 EC) having shoot number of 7.00 and 6.44, however the minimum number of shoots was recorded in T3 (3.0 EC) with 6.33 and 5.33 shoots, respectively. At 90 DAT (Days After Treatment) the reduction in the number of shoots was observed from 18.34% at 1.5 EC to 32.41% at 3.0 EC, simultaneously.

The maximum plant height of 6.24 cm in T1 (control) was recorded followed by 5.95 cm in T2 (1.5 EC) and the lowest was recorded 5.33 cm in T3 (3.0 EC) at 20 DAT. However, highest plant height was of 5.76 cm was recorded in T1 (control) followed by 5.52 cm in T2 (1.5 EC) and the lowest was recorded 5.23 cm in T3 (3.0 EC), significantly highest plant height was recorded up to 6.25 cm in T1 (control) followed by 5.76 cm in T2 (1.5 EC) and the lowest plant height was recorded up to 5.18 cm in T3 (3.0 EC) at 50 and 90 DAT, respectively. The plant height was reduced from 5.61% at 1.5 EC to 8.83% at 3.0 EC at 90 DAT (Days After Treatment), simultaneously.

It was recorded with maximum petiole length of 5.30 cm in T1 (control) followed by 3.93 cm in T2 (1.5 EC) and the lowest was recorded 3.12 cm in T3 (3.0 EC) at 20 DAT. However, maximum petiole length was of 4.63 cm was recorded in T1 (control) followed by 3.73 cm in T2 (1.5 EC) and the lowest was recorded 3.03 cm in T3 (3.0 EC), significantly maximum length of petiole was recorded up to 4.94 cm in T1 (control) followed by 4.51 cm in T2 (1.5 EC) and the minimum was recorded up to 3.87 cm in T3 (3.0 EC) at 50 and 90 DAT, respectively. Reduction in the petiole length was observed from 8.70% at 1.5 EC to 21.77% at 3.0 EC at 90 DAT (Days After Treatment).

As considered in table 2, Capri was recorded with maximum leaf length of 1.92 cm in T1 (control) followed by 1.73 cm in T2 (1.5 EC) and the lowest was recorded 1.66 cm in T3 (3.0 EC) at 20 DAT. However, the maximum leaf length was of 1.84 cm was recorded in T1 (control) followed by 1.76 cm in T2 (1.5 EC) and the minimum was recorded 1.68 cm in T3 (3.0 EC), significantly maximum leaf length was recorded up to 3.29 cm in T1 (control) followed by 2.01 cm in T2 (1.5 EC) and the minimum leaf length was recorded up to 1.38 cm in T3 (3.0 EC) at 50 and 90 DAT. Salinity reduced the leaf length from 38.81% at 1.5 EC to 58.15% at 3.0 EC at 90 DAT (Days After Treatment), respectively.

Table 1: Effect of salinity on growth parameters of cultivar Capri at 20, 50 and 90 DAT (DAT = Days After Treatment).

Cultivar →	**CAPRI**								
DAT →	**20 DAT**			**50 DAT**			**90 DAT**		
	T1	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
Number of Leaves	10.09	8.89	8.33	16.78	13.78	12.55	17.56	13.33	10.22
Number of Shoots	5.67	3.78	2.67	8.33	7.00	6.33	7.89	6.44	5.33
Plant Height	6.24	5.95	5.33	5.76	5.52	5.23	6.25	5.76	5.18
Petiole Length	5.30	3.93	3.12	4.63	3.73	3.03	4.94	4.51	3.87
Leaf Length	1.92	1.73	1.66	1.84	1.76	1.68	3.29	2.01	1.38
Chlorophyll Content	51.94	50.18	45.28	53.19	47.65	45.61	53.63	51.80	47.11

Table 2: Effect of salinity on growth parameters of cultivar Winter star at 20, 50 and 90 DAT (DAT = Days After Treatment).

Cultivar →	**Winter Star**								
DAT →	**20 DAT**			**50 DAT**			**90 DAT**		
	T1	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
Number of Leaves	15.61	14.89	14.78	18.33	14.99	14.78	25.56	16.44	16.78
Number of Shoots	6.89	4.44	4.89	6.78	5.11	5.00	7.22	6.67	5.67
Plant Height	9.29	7.68	7.38	9.99	8.88	8.68	9.44	9.38	8.37
Petiole Length	5.79	5.43	5.31	5.77	5.62	5.38	7.06	6.33	5.95
Leaf Length	3.81	3.42	3.06	3.63	3.76	3.18	4.14	3.34	2.78
Chlorophyll Content	54.19	51.82	50.78	55.16	52.11	51.89	53.20	51.19	47.99

It was recorded with highest chlorophyll content at 20 DAT in T1 (control) having content of 51.94 mg/g followed by 50.18 mg/g in T2 (1.5 EC) and the lowest chlorophyll content was recorded to be 45.28 mg/g in T3 (3.0 EC). Considerably at 50 DAT and 90 DAT the highest chlorophyll was recorded at T1 (control) having 53.19 mg/g and 53.63 mg/g followed by T2 (1.5 EC) having content of chlorophyll up to 47.65 mg/g and 51.80 mg/g, however the least chlorophyll content was recorded in T3 (3.0 EC) with 45.61 mg/g and 47.11 mg/g. At 90 DAT (Days After Treatment) salinity reduced the chlorophyll content as 3.78% at 1.5 EC to 9.79% at 3.0 EC, respectively.

The maximum number of leaves in Winter Star was recorded to be 15.61 in T1 (control) afterwards T2 (1.5 EC) was recorded with number of leaves up to 14.89 and the minimum recorded was 14.78 leaves in T3 (3.0 EC) at 20 DAT. Significantly, maximum number of leaves was recorded 18.33 leaves in T1 (control) followed by 15.00 leaves in T2 (1.5 EC) and the minimum was recorded in T3 (3.0 EC) with 14.78 leaves, also maximum number of leaves was recorded to be 25.56 in T1 (control) followed by 16.78 leaves in T2 (1.5 EC) however, the minimum number of leaves was recorded to be 16.44 in T3 (3.0 EC) which were significant in 50 DAT and 90 DAT, respectively.

The maximum number of shoots in Winter Star was recorded to be 6.89 in T1 (control) afterwards T2 (1.5 EC) was recorded with number of shoots up to 4.89 and the minimum recorded was 4.44 shoots in T3 (3.0 EC) at 20 DAT. Significantly, maximum number of shoots was recorded 6.78 shoots in T1 (control) followed by 5.11 shoots in T2 (1.5 EC) and the minimum was recorded in T3 (3.0 EC) with 5.00 shoots, also maximum number of shoots was recorded to be 7.22 in T1 (control) followed by 6.67 shoots in T2 (1.5 EC) however, the minimum number of shoots was recorded to be 5.67 in T3 (3.0 EC) which were significant in 50 DAT and 90 DAT, respectively.

9.29 cm in T1 (control) was recorded to be the maximum height of plant followed by 7.68 cm in T2 (1.5 EC) and lowest was recorded in T3 (3.0 EC) up to 7.38 cm at 20 DAT. However, highest plant height 9.99 cm was recorded in T1 (control) followed by 8.88 cm in T2 (1.5 EC) and lowest was recorded in 8.68 cm in T3 (3.0 EC) while highest plant height was recorded to be 9.44 cm in T1 (control) followed by 9.38 cm in T2 (1.5 EC) and lowest was recorded in T3 (3.0 EC) up to 8.37 cm 50 DAT and 90 DAT, respectively.

The cultivar was recorded with maximum length of petiole of 5.79 cm in T1 (control) followed by 5.43 cm in T2 (1.5 EC) and minimum was recorded in T3 (3.0 EC) up to 5.31 cm at 20 DAT. However, the maximum petiole length 5.77 cm was recorded in T1 (control) followed by 5.62 cm in T2 (1.5 EC) and minimum recorded was 5.38 cm in T3 (3.0 EC) while maximum petiole length was recorded to be 7.06 cm in T1 (control) followed by 6.333 cm in T2 (1.5 EC) and the minimum was recorded in T3 (3.0 EC) up to 5.95 cm at 50 DAT and 90 DAT, respectively.

The maximum leaf length in to be recorded was 3.81 cm in T1 (control) followed by 3.42 cm in T2 (1.5 EC) and minimum was recorded in T3 (3.0 EC) up to 3.06 cm at 20 DAT. However, maximum length of leaf 3.76 cm was recorded in T1 (control) followed by 3.63 cm in T2 (1.5 EC) and the minimum was recorded in 3.18 cm in T3 (3.0 EC) while maximum leaf length was recorded to be 4.14 cm in T1 (control) followed by 3.34 cm in T2 (1.5 EC) and minimum was recorded in T3 (3.0 EC) up to 2.78 cm, respectively.

Considering the table 3, the highest chlorophyll content was recorded to be 54.19 mg/g in T1 (control) afterwards T2 (1.5 EC) was recorded with 51.82 mg/g of chlorophyll content and the minimum recorded was 50.78 mg/g in T3 (3.0 EC) at 20 DAT. Significantly, highest content of chlorophyll was recorded 55.16 mg/g in T1 (control) followed by 52.11 mg/g in T2 (1.5 EC) and the least was recorded in T3 (3.0 EC) having content of 51.89 mg/g, also highest content was recorded to be 53.20 mg/g in T1 (control) followed by 51.19 mg/g in T2 (1.5 EC) however, the lowest chlorophyll content was recorded to be 47.99 mg/g in T3 (3.0 EC) which were significant in 50 DAT and 90 DAT, respectively.

According to table 3, Camarosa was recorded with the maximum number of leaves in T1 (control) with 21 leaves followed by T2 (1.5 EC) having 18.33 leaves and

Table 3: Effect of salinity on growth parameters of cultivar Camarosa at 20, 50 and 90 DAT (DAT = Days After Treatment).

Cultivar →	Winter Star								
DAT →	20 DAT			50 DAT			90 DAT		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
Number of Leaves	21.00	18.33	16.44	21.67	18.66	17.11	22.44	21.11	18.56
Number of Shoots	7.11	6.11	5.67	6.44	6.33	6.00	10.67	9.22	8.11
Plant Height	10.61	9.85	8.68	10.03	9.53	9.17	10.24	9.83	8.14
Petiole Length	6.34	5.49	5.26	6.34	5.64	5.03	6.19	5.60	4.90
Leaf Length	4.60	4.32	4.05	4.28	3.89	3.79	4.51	4.06	3.86
Chlorophyll Content	48.29	47.32	44.69	49.69	47.78	46.16	50.95	49.69	47.09

the minimum leaf number was recorded with 16.44 leaves in T3 (3.0 EC) also, maximum leaf number was recorded in T1 (control) with 21.67 leaves followed by 18.66 in T2 (1.5 EC) and the minimum number of leaves was recorded in T3 (3.0 EC) with 17.11 leaves which were significant at 20 DAT and 50 DAT. Similarly, at 90 DAT the maximum number of leaves observed was 22.44 in T1 (control) followed by T2 (1.5 EC) with 21.11 leaves and the minimum number of leaves was recorded in T3 (3.0 EC) with 18.56 leaves, respectively.

Apparently, Camarosa was recorded with the maximum number of shoots in T1 (control) with 7.11 shoots followed by in T2 (1.5 EC) having 6.11 shoots and the minimum shoot number was recorded with 5.67 shoots in T3 (3.0 EC) also, maximum shoot number was recorded in T1 (control) with 6.44 shoots followed by 6.33 in T2 (1.5 EC) and the minimum number of shoots was recorded in T3 (3.0 EC) with 6.00 shoots which were significant at 20 DAT and 50 DAT. Similarly, at 90 DAT the maximum number of shoots observed was 10.67 in T1 (control) followed by T2 (1.5 EC) with 9.22 shoots and the minimum number of shoots was recorded in T3 (3.0 EC) with 8.11 shoots, respectively.

Maximum plant height recorded was Camarosa 10.61 cm in T1 (control) followed by 9.85 cm height in T2 (1.5 EC) and lowest was recorded in T3 (3.0 EC) having a plant height of 8.68 cm while, highest plant height 10.03 cm was recorded in T1 (control) followed by 9.53 cm in T2 (1.5 EC) and the lowest was recorded in T3 (3.0 EC) having a plant height of 9.17 cm, which were significant at 20 and 50 DAT. Similarly, at 90 DAT, the highest plant height recorded was 10.24 cm in T1 (control) followed by 9.88 cm in T2 (1.5 EC) and the lowest plant height was recorded to be 8.14 cm in T3 (3.0 EC), respectively.

It was also recorded with 6.34 cm of maximum petiole length in T1 (control) followed by 5.49 cm length in T2 (1.5 EC) and the minimum was recorded in T3 (3.0 EC) having a petiole length of 5.26 cm while, maximum petiole length 6.34 cm was recorded in T1 (control) followed by 5.64 cm in T2 (1.5 EC) and the minimum was recorded in T3 (3.0 EC) having a petiole length of 5.03 cm, which were significant at 20 and 50 DAT. Similarly, at 90 DAT, the maximum length of petiole was 6.19 cm in T1 (control) followed by 5.60 cm in T2 (1.5 EC) and the minimum petiole length was recorded to be 4.90 cm in T3 (3.0 EC), respectively.

Apparently, Camarosa was recorded with 4.60 cm of maximum leaf length in T1 (control) followed by 4.32 cm length in T2 (1.5 EC) and the minimum was recorded in T3 (3.0 EC) having a leaf length of 4.05 cm while, maximum length of leaf 4.28 cm was recorded in T1 (control) followed by 3.89 cm in T2 (1.5 EC) and the lowest was recorded in T3 (3.0 EC) having a length of 3.79 cm, which were significant at 20 and 50 DAT. Similarly, at 90 DAT, the maximum length recorded was 4.51 cm in T1 (control) followed by 3.28 cm in T2 (1.5 EC) and the minimum leaf length was recorded to be 3.12 cm in T3 (3.0 EC), respectively.

Also, maximum chlorophyll content was observed in T1 (control) with 48.29 mg/g followed by in T2 (1.5 EC) having 47.32 mg/g and the least content of chlorophyll was recorded with 44.69 mg/g in T3 (3.0 EC) also, the highest chlorophyll content was recorded in T1 (control) with 49.69 mg/g of chlorophyll followed by 47.78 mol/mg in T2 (1.5 EC) and the lowest was recorded in T3 (3.0 EC) having 46.16 mg/g of chlorophyll which were significant at 20 DAT and 50 DAT. Similarly, at 90 DAT the highest chlorophyll content observed was 50.95 mg/g in T1 (control) followed by T2 (1.5 EC) with 49.69 mg/g and the lowest content of chlorophyll was recorded in T3 (3.0 EC) with 47.09 mg/g of content, respectively.

In cultivar Capri, reduction in the number of leaves

Table 4: Salt tolerance index for number of leaves.

Cultivars	20 DAT			50 DAT			90 DAT			Salt Tolerance Index
	RSTI-T2	RSTI-T3	Average	RSTI-T2	RSTI-T3	Average	RSTI-T2	RSTI-T3	Average	
Capri	88.11	82.56	**85.33**	82.12	74.81	**78.47**	75.94	58.21	**67.08**	**76.96**
Winter star	95.39	94.68	**95.04**	81.82	80.62	**81.22**	65.65	64.34	**64.99**	**80.41**
Camarosa	87.29	78.29	**82.79**	86.12	78.96	**82.54**	94.07	82.69	**88.38**	**84.57**

Table 5: Salt tolerance index for number of shoots.

Cultivars	20 DAT			50 DAT			90 DAT			Salt Tolerance Index
	RSTI-T2	RSTI-T3	Average	RSTI-T2	RSTI-T3	Average	RSTI-T2	RSTI-T3	Average	
Capri	66.67	47.04	**56.86**	84.00	76.00	**80.00**	81.66	67.59	**74.63**	**70.49**
Winter star	64.48	70.93	**67.71**	75.37	73.79	**74.58**	92.30	78.46	**85.38**	**75.89**
Camarosa	85.98	79.70	**82.84**	98.29	93.12	**95.71**	86.43	76.03	**81.23**	**86.59**

observed at 90 DAT (Days After Treatment) was from 24.06% at 1.5 EC to 41.79% at 3.0 EC, correspondingly. While, cv. Winter star was observed with reduction in number of leaves from 34.35% at 1.5 EC to 35.66% at 3.0 EC. Accordingly, Camarosa showed reduction in the leaf number from 5.93% at 1.5 EC to 17.31% at 3.0 EC, respectively.Our results were supported by Mozafari *et al.,* (2018) when decrease in the number of leaves was observed at higher concentration of 100 mM of NaCl. Also, Sun *et al.,* (2015) in their study observed that at EC 2.2 the cultivar Camarosa showed fewer number of leaves than the control ones which also supported our results.

For number of shoots the reduction in cv. Capri was observed to be 18.34% at 1.5 EC to 32.41% at 3.0 EC, while in Winter star it was observed to be 7.70% at 1.5 EC to 21.54% at 3.0 EC. Cultivar Camarosa showed reduction in the number of shoots from 13.57% at 1.5 EC to 23.97% at 3.0 EC at 90 DAT (Days After Treatment), respectively. Our results were supported by Abbas *et al.,* (2018) when maximum number of shoots were observed to be 26.00 under the control whereas at higher concentrations of 45 mM NaCl showed only 1.00 shoot and failed to produce more.

Capri showed reduction in the plant height from 5.61% at 1.5 EC to 8.83% at 3.0 EC, however, reduction in the plant height in Winter star was observed from 0.69% at 1.5 EC to 11.39% at 3.0 EC. Accordingly, Camarosa was observed with the reduction from 3.45% at 1.5 EC to 6.35% at 3.0 EC at 90 DAT (Days After Treatment), respectively. Our results were supported by Abbas *et al.,* (2018) when highest plant height of 14.07 cm under control and lowest 10.00 cm was observed at higher concentrations (45 mM NaCl).

Reduction in the petiole length, leaf length and chlorophyll content in Capri was observed from 8.70%, 38.81% and 3.78% at 1.5 EC but at 3.0 EC the reduction was observed to be 21.77%, 58.15% and 9.79%. However, Winter star showed reduction in the parameters from 10.26%, 19.45% and 3.78% at 1.5 EC to 15.46%, 32.90% and 9.79% at 3.0 EC. Camarosa was observed with the reduction in the petiole length, leaf length and chlorophyll content from 9.48%, 10.45% and 2.47% at 1.5 EC to 20.48%, 14.48% and 7.58% at 3.0 EC, respectively at 90 DAT (Days After Treatment). Our results were supported by Hussein *et al.,* (2017) where the shoot length was decreased from 5.40 to 2.10 cm at 1000 mg/L when treatment of NaCl was applied to the plants. Also, Hussein *et al.,* (2017) reported in their study that the content of chlorophyll was decreased from 15.33 to 10.13 mg/g at 1000 mg/L when treatment of NaCl was applied to the plants.

Salt tolerance index

The salt tolerance of plant can be determined differently depending on the intended use and value of the plant. The salt tolerance of the crop can be described as complex function of decline in the yield across a range of salt concentrations. Salt tolerance can be adequately described on the basis of two parameters basically the threshold and the electrical conductivity which is expected to cause the initial significant reduction in the maximum yield which is expected and the slope, percentage of expected yield reduction per unit increase in salinity above the threshold value.

The salt tolerance index for the varieties was calculated using the formula described by Ali *et al.,* (2007):

$$\text{STTI} = \frac{\text{Value of trait under stress condition}}{\text{Value of trait under control condition}} \times 100$$

The salt tolerance index for the cultivars for various growth parameters is mentioned below in the tables (Table 4 - Table 9).

Table 6: Salt tolerance index for plant height.

Cultivars	20 DAT			50 DAT			90 DAT			Salt Tolerance Index
	RSTI-T2	RSTI-T3	Average	RSTI-T2	RSTI-T3	Average	RSTI-T2	RSTI-T3	Average	
Capri	95.24	85.42	**90.33**	95.92	90.90	**93.41**	92.16	82.89	**87.53**	**90.42**
Winter star	82.69	79.44	**81.06**	88.86	86.87	**87.87**	99.31	88.61	**93.96**	**87.63**
Camarosa	92.85	81.77	**87.31**	95.05	91.40	**93.23**	96.00	79.51	**87.76**	**89.43**

Table 7: Salt tolerance index for petiole length.

Cultivars	20 DAT			50 DAT			90 DAT			Salt Tolerance Index
	RSTI-T2	RSTI-T3	Average	RSTI-T2	RSTI-T3	Average	RSTI-T2	RSTI-T3	Average	
Capri	74.17	58.89	**66.53**	80.57	65.47	**73.02**	91.30	78.23	**84.77**	**74.77**
Winter star	93.83	91.71	**92.77**	97.50	93.24	**95.37**	89.74	84.36	**87.05**	**91.73**
Camarosa	86.50	82.88	**84.69**	88.96	79.35	**84.16**	90.52	79.16	**84.84**	**84.56**

Table 8: Salt tolerance index for leaf length.

Cultivars	20 DAT			50 DAT			90 DAT			Salt Tolerance Index
	RSTI-T2	RSTI-T3	Average	RSTI-T2	RSTI-T3	Average	RSTI-T2	RSTI-T3	Average	
Capri	90.12	86.17	**88.14**	95.33	90.99	**93.16**	61.19	41.85	**51.52**	**77.61**
Winter star	89.69	80.17	**84.93**	96.62	84.56	**90.59**	80.55	67.10	**73.82**	**83.12**
Camarosa	93.98	87.98	**90.98**	90.89	88.48	**89.68**	89.96	85.52	**87.74**	**89.47**

Table 9: Salt tolerance index for chlorophyll content.

Cultivars	20 DAT			50 DAT			90 DAT			Salt Tolerance Index
	RSTI-T2	RSTI-T3	Average	RSTI-T2	RSTI-T3	Average	RSTI-T2	RSTI-T3	Average	
Capri	96.62	87.18	**91.90**	89.58	85.75	**87.66**	96.59	87.83	**92.21**	**90.59**
Winter star	95.63	93.71	**94.67**	94.47	94.07	**94.27**	96.22	90.21	**93.22**	**94.05**
Camarosa	97.99	92.54	**95.26**	96.15	92.90	**94.52**	97.53	92.42	**94.98**	**94.92**

As depicted in the above tables of salt tolerance index for the growth parameters, it was observed that Camarosa performed better for number leaves having maximum salt tolerance index of 84.57, while Capri performed inferior having minimum salt tolerance index of 76.96. As for number of shoots, Camarosa showed maximum salt tolerance index of 86.59 while Capri was observed with minimum salt tolerance index of 70.49, respectively. Cultivar Capri showed maximum salt tolerance for plant height having an index of 90.42 while, Winter star showed minimum salt tolerance index of 87.63. Maximum salt tolerance index of 91.73 for petiole length was observed in cultivar Winter star, while the minimum was observed in Capri with a salt tolerance index of 74.77. Accordingly, cultivar Camarosa showed maximum salt tolerance index for leaf length and chlorophyll content having an index of 89.47 and 94.94, however cultivar Capri showed minimum salt tolerance index for both parameters having an index of 77.61 and 90.59, respectively.

Conclusion

The results of the present study demonstrated that NaCl, Na_2SO_4 and $CaCl_2$ present in the soil affects the physiological processes of growth and yield of strawberry. The increase in the levels of salinity, decreased the growth in terms of number of leaves, number of shoots, plant height, petiole length, leaf length and also content of chlorophyll. From the present study it can be concluded that cultivar Camarosa performed better in terms of number of leaves, number of shoots, length of leaf and chlorophyll content, however cultivar Capri performed inferior amongst the cultivars showing minimum salt tolerance index for number of leaves, number of shoots, plant height, petiole length, leaf length and chlorophyll content. Thus, it can be concluded from the results that cv. Camarosa is more tolerant to salinity amongst the cultivars and Capri is susceptible to salinity, respectively.

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