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RESPONSE OF DIFFERENT GENOTYPES OF STRAWBERRIES (*FRAGARIA* × *ANANASSA*) GROWING UNDER SALT STRESS

Harjinder Kaur, Sanjay Singh* and Aditi Thakur

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

Abstract

A study was conducted at the Polyhouse of Lovely Professional University, Phagwara, Punjab during the year 2019-2020 with the title 'Effect of Salt stress in strawberry with genotype using Sodium chloride (NaCl) under the objective of determining the varieties which are tolerant to salinity so that it could be grown in the areas which are prone to salinity. The study involves the effect of different concentration of NaCl with a concentration of 0 mM, 25 mM, 50 mM and100 mM on three different varieties of strawberry *viz*., Rania, Camarosa and Winter dawn in order to observe their response to the stress caused by NaCl 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). Five treatments were applied to the plants of strawberry through irrigation water which were considered as T1 (0 mM -Control), T2 (25 mM), T3 (50 mM), T4 (75 mM) and T5 (100 mM). The results of the present study revealed that both Rania and Camarosa performed better in terms of plant height, shoot length, number of flowers and number of leaves, number of shoots & chlorophyll content, as Rania showed maximum salt tolerance for plant height, shoot length and number of flowers while Camarosa showed maximum salt tolerance index for number of leaves, number of shoots and chlorophyll content. However, Winter dawn only showed minimum salt tolerance index for shoot length and maximum for number of buds. Therefore, it shows that both Rania and Camarosa performed moderately for salinity tolerance, thus they can be used to be cultivated in a region where salinity causes stress to the plants.

Key words: Strawberry, Salinity, CRD (Completely Randomized Design), Salt tolerance index.

Introduction

Strawberry (*Fragaria* × *ananassa*) is a nutritional fruit crop which belong to family Rosaceae. It is the soft fruit crop and mostly cultivated throughout the world. Strawberries are unique fruit crop which contain excellent source of vitamins, potassium, fiber and sugars and highly desirable taste, flavor (Sharma and Sharma, 2003). Itsoriginis France. Strawberry is 98% edibleportion. This crop also has the potential to grown under irrigated Sub-tropical areas like Jammu. Temperate climate is most suitable for growing this crop. However, sub-tropical climate is also suitable for some of cultivars. For the flower bud formation sunlight of 12 hour and moderate temperature are important. For the cultivation of strawberry sandy loam to loamy soil with an ideal pH 5.7-6.5 is required.

Strawberry is commercially propagated by runner or crowns. The time of planting of strawberry runners grown in hilly area. The plant lacks vigorifitis plant too early there fore, they ieldand quality of fruit may also be reduced. The runner develops in march if it is planting time delay. Salt stressed soils may suppress the growth of plants (Shrivastava and Kumar, 2015). It is believed that being in natural environment the Plants with endo-cellular and intracellular microorganisms are easily colonized. (Gray and Smith, 2005). The 33% piece of the water system place that is known for the universe of the flooded land is exceptionally influenced by saltiness in soil and water undermines (Hasegawa *et al.,* 1986). Saltiness is one of the most destructive abiotic stresses since it upsetting the retention of whole some component and water take-up. It likewise may cause aberrant dry season pressure. Salinity is the most serious problem all over the world up to six percent of an agriculture area. (Ghassemi *et al*., 1995). Saltness stress is also responsible for the reduction the chlorophyll and carotenoid content in a strawberry plant (Yaghubi *et al*., 2016). It takes admitted that the salinity conditions may expand take-up of Na+ although diminishing the take-up of calcium and potassium salinity conditions, this can dependon the

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

pressure severity and lead to an incredible decrease in the development and performance related parameters.

Fragaria × *ananassa* is considered as a NaCl saltiness delicate specie however contrasts between cultivars occur (Keutgen and Pawelzik, 2009; Kaya *et al.,* 2003). Higher measure of sodium chloride saltiness legitimately influences the plant development and organic product profitability which have been accounted for by Keutgen and Pawelzik, 2009; D'Anna *et al.,* (2003); Awang and Atherton, (1995b) and Awang *et al.,* (1993).

The production of strawberry during 2016-17 in different states, Haryana ranked No. 1 with a production of 2010 MT (million tons) with an area of 150 Ha (hectare). After this, Mizoram with production of (000MT) and area up to 0.15 (000 Ha). Afterwards, Meghalaya, Maharashtra, Himachal Pradesh, Tamil Nadu, Kerala, Jammu & Kashmir and Madhya Pradesh having production of 1.06, 0.66, 0.11, 0.11, 0.10, 0.06 and 0.01 (000 MT) and area up to 0.14, 0.07, 0.06, 0.01, 0.05, 0.13, 0.01 and 0.07 (000 Ha) (NHB 2017). Among all these states Punjab has an area and production of 88.56 (000Ha) and 1856.92 (000MT) under strawberry, respectively during 2016-17 (NHB2017).

The salt stress condition may prompt the advancement of leaf necrosis and hence diminishing photosynthetic capacity of the plants. Accordingly, adaptation of carbohydrates presented being production of fruit is decrease (Saied *et al*., 2005; Keutgenand Pawelzik, 2007; Giuffrida *et al*., 2001). Salinityen larged the masure of sodium fix at ion in the plant as soon as the salt given to the ethereal piece of plant (Turhanand Atilla, 2004). Kaya *et al.,* (2003) announced then earness of NaCl stress, the concentration of sodium in leaves of two strawberry cultivars. Salt application has expanded the measure of Sodium and chloride substance along with diminished the measure of Mg and K in strawberry plant. (Turhan and Atilla, 2004).

Material and Methods

The present investigation entitled "Response of different genotypes of strawberries (Fragaria × ananassa) growing under salt stress" involved a field experiment conducted during the year 2019-2020 at the Polyhouse of Agriculture Research Farm of the School of Agriculture, Lovely Professional University, Jalandhar, Punjab (India).

List of treatments and concentration of NaCl

Treatments	NaCl concentration
T1	0.00mM NaCl (Control)
T2	25mM
T3	50mM
T4	75mM
T5	100mM

Varieties used

Rania, Camarosa and Winter Dawn

Growth Parameters

Plant height, number of leaves, number of shoots, shoot length, number of flowers, number of buds and chlorophyll content were recorded at 20 DAT (days after treatment) and 90 DAT (days after treatment).

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 response of strawberry plant with different NaCl concentrations, at 20DAT (days after treatment) and 90DAT on plant height, petiole length, number of leaves, number of shoots, number of buds, number of flowers and chlorophyll content are discussed in this result.

Growth parameters

In the present study, the plant height, number of leaves, number of shoots, shoot length, number of buds, number of flowers and chlorophyll content were estimated.

Plant height

The effects of NaCl on plant height in strawberry fruit crop at various concentrations were discussed in table 1. The data was recorded at two stages i.e., at 20DAT and 90 DAT.

The highest plant height in Rania cultivar recorded was 11.42 cm in T1 (control) followed by 11.11 cm in T2(25 mM) and the lowest plant height recorded in T5 (100 mM) with 9.94cm at 20 DAT respectively. However, the highest plant height was recorded 12.68 cm in T1 (control) followed by 10.28 cm in T2 (control) and the lowest plant height recorded 4.24 cm in T5 (100 mM) which were significant at 90 DAT respectively.

Winter dawn was recorded with 12.05cm of highest plant height in

Table 1: Effect of NaCl concentration on plant height.

Varieties	20 DAT					90 DAT				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Rania	11.42	11.11	10.80	9.72	9.94	12.68	10.28	9.90	9.37	4.24
Winter Dawn	12.05	11.32	10.83	10.11	9.70	13.35	9.90	9.30	8.53	2.98
Camarosa	10.34	9.66	9.31	9.25	7.42	13.07	9.85	9.33	7.94	0.00

Table 2: Effect of NaCl concentration on number of leaves.

Varieties	20 DAT					90 DAT				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Rania	16.00	15.42	14.25	13.92	13.00	19.50	16.33	13.50	9.08	0.33
Winter Dawn	17.83	15.92	13.58	13.25	13.00	18.75	16.33	15.25	14.25	0.75
Camarosa	16.17	15.17	14.33	13.50	13.42	19.32	16.08	14.00	13.75	1.50

T1(control) followed by 11.32cm height in T2 (25mM) and lowest was recorded in T5 (100mM) having a plant height of 9.70cm. However, the highest plant height was recorded 13.35 cm in T1(control) followed by 9.90cm in T2 (25 mM) and the lowest plant height recorded 2.98 cm in T5(100 mM) which were significant at 90 DAT respectively.

The highest plant height in Camarosa cultivar recorded was 10.38 cm in T1(control) followed by 9.66 cm in T2 (25 mM) and the lowest plant height recorded in T5 (100 mM) with 7.42cm which were significant at 20 DAT, respectively. The highest plant height at 90 DAT was recorded 13.07 cm in T1 (control) followed by 9.85 cm in T2 (25 mM) and the lowest plant height recorded 0.00 cm in T5 (100 mM) as the plant died due to salinity stress caused by NaCl, respectively.

Our results were supported by Qureshi *et al.,* (2013) where they observed decrease in the plant height as compared to the other treatments when salt with concentration of 0.4% $CaCl_2$ (400 mg/l) was applied to the plants.

Number of leaves

The effect of NaCl on number of leaves in strawberry fruit crop at various concentrations was discussed in table 2. The data was recorded at three stages at 20 DAT and 90 DAT, respectively**.**

It was recorded in cultivar Rania that the highest number of leaves was 16.00 in T1 (control) followed by 15.42 in T2 (25 mM) and the lowest number of leaves recorded was 13.00 in T5 (100 mM) at 20 DAT. However, at 90 DAT, the highest number of leaves recorded was 19.50 in T1 (control) followed by 16.33 in T2 (25 mM) and the lowest number of leaves was recorded to be 0.33 in T5 (100 mM).

The highest number of leaves in Winter dawn cultivar recorded was 17.83 in T1 (control) followed by 15.92 in T2 (25 mM) and the lowest plant height recorded in T5 (100 mM) with 13.00 leaves which were significant at 20 DAT, respectively. The highest number of leaves was recorded 18.75 in T1 (control) followed by 16.33 in T2 (25 mM) and the lowest plant height recorded 0.75 in T5 (100 mM) which were significant at 90 DAT, respectively.

The highest number of leaves in Camarosa cultivar recorded was 16.17 cm in T1 (control) followed by 15.17 in T2 (25 mM) and the lowest number of leaves recorded in T5 (100 mM) with 13.42 which were significant at 20 DAT respectively. However, the highest number of leaves was recorded 19.32 in T1 (control) followed by 16.08 in T2 (25mM) and the lowest number of leaves recorded 1.50 in T5 (100mM) which were significant at 90 DAT respectively.

Among all the treatments highest reduction percentage of number of leaves observed 18.75% and 98.29% in T5 (100 mM) followed by 13.02% and 53.42% in T4 (75mM), 10.94% and 30.77% in T3 (50 mM) and 3.64% & 16.24% in T2 (25 mM) as compared to T1 (control) at 20 DAT and 90 DAT respectively in Rania.

Winter Dawn showed highes treduction percentage of number of leaves in T5 (100mM) having 27.10% and 96.00% followed by 25.70% and 24.00% in T4(75mM), 23.83% and 18.67% in T3(50mM) and 10.74% and 12.89% in T2(25mM) as compared to T1 (control) respectively, at 20 DAT and 90 DAT.

Camarosa was observed with highest reduction percentage of number of leaves was 17.01% and 92.23% in T5 (100mM) followed by 16.50% and 28.82% in T4 (75mM) which is followed by 11.34% and 27.52% in T3 (50mM) and 6.19% and 16.74% T2 (25 mM) respectively, as compared to T1 (control) at 20, 50 and 90 DAT.

Our results were supported by Akbar Mozafari *et al.,* (2018) if a decrease in the number of leaves was observed at a higher concentration of 100mM of NaCl. Similar, Garriga *et al.,* (2015) also supported our results when it was observed that number of leaves decreased at higher concentration of NaCl of 60mM.

Shoot Length

The effects of NaCl on shoot length in strawberry fruit crop at various concentrations were discussed in table 3. The data was recorded at three stages at 20 DAT and 90 DAT.

Table 3: Effect of NaCl concentration on shoot length.

Varieties	20 DAT					90 DAT				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Rania	7.86	7.53	7.45	7.08	7.05	9.07	8.67	8.43	7.70	2.88
Winter Dawn	8.08	7.52	7.74	6.95	6.14	9.38	7.98	7.35	6.46	2.23
Camarosa	6.46	6.24	5.86	5.77	4.23	8.06	7.96	6.29	5.92	3.44

It was recorded in cultivar Rania that the shoot length of plant was 7.86

cm in T1 (control) followed by 7.53cm in T2 (25mM) and the lowest shoot length of plant recorded was 7.05cm in T5 (100 mM) at 20 DAT. Similarly, at 90 DAT, the highest shoot length of plant recorded was 9.07cm in T1 (control) followed by 8.67cm in T2 (25mM) and the lowest shoot length of plant was recorded to be 2.88 cm in T5 (100 mM), respectively.

The highest shoot length of plant in Winter dawn cultivar recorded was 8.08 cm in T1 (control) followed by 7.52 cm in T2 (25 mM) and the lowest shoot length of plant recorded in T3 (3.0 EC) with 6.14 cm which were significant at 20 DAT respectively. The highest shoot length of plant was recorded 9.38cm in T1 (control) followed by 7.98cm in T2 (25 mM) and the lowest shoot length of plant recorded 2.23 cm in T5 (100 mM) which were significant at 90 DAT, respectively.

The highest shoot length of plant in Camarosa cultivar recorded was 6.46 cm in T1 (control) followed by 6.24cm in T2 (25 mM) and the lowest shoot length of plant recorded in T5 (100 mM) with 4.23 cm which were significant at 20 DAT respectively. However, the highest shoot length was recorded 8.06cm in T1 (control) followed by 7.96 cm in T2 (25mM) and the lowest shoot length recorded 3.44 cm in T5 (100 mM) which were significant at 90 DAT respectively.

Among all the treatments highest reduction percentage of shoot length observed 10.34% and 68.20% in T5 (100mM) followed by 9.96% and 15.11% in T4 (75mM), 5.25% and 6.99% in T3 (50 mM) and 4.16% & 4.41% in T2 (25 mM) as compared to T1 (control) at 20DAT and 90 DAT respectively in Rania.

Winter Dawn showed highest reduction percentage of shoot length in T5 (100 mM) having 24.00% and 76.27% followed by 14.05% and 31.15% in T4 (75mM), 4.21% and 21.67% in T3 (50 mM) and 3.45% & 1.20% in T2 (25 mM) as compared to T1 (control) respectively, at 20 DAT and 90 DAT.

Camarosa was observed with highest reduction percentage of shoot length was 34.57% and 57.36% in T5 (100mM) followed by 10.73% and 28.82% in T4 (75mM) which is followed by 9.24% and 22.00% in T3 (50 mM) and 3.45% & 1.20% T2 (25 mM) respectively, as compared to T1 (control) at 20 and 90 DAT.

Number of Shoots

The effects of NaCl on number of shoots in strawberry fruit crop at various concentrations were discussed in Table 4**.**The data was recorded at three stages at 20 DAT and 90DAT.

It was recorded in cultivar Rania that the highest number of shoots was 5.58 in T1 (control) followed by 5.25 in T2 (25mM) and the lowest number of shoots recorded was 4.42 in T5 (100 mM) at 20 DAT. Similarly, at 90 DAT, the highest number of shoots recorded was 5.92 in T1 (control) followed by 4.83 in T2 (25 mM) and the lowest number of shoots was recorded to be 0.00 in T5 (100 mM) because the plants died due to the effect of salinity, respectively.

Winter dawn was recorded with 5.50 of number of shoot in T1 (control) followed by 5.25 in T2 (25mM) and lowest was recorded in T5 (100mM) having a number of shoots of 3.83 while, at 90 DAT, the highest number of shoots recorded was 6.17 in T1 (control) followed by 5.58 in T2 (25mM) and the lowest number of shoots was recorded to be 0.92 in T5 (100mM), respectively.

The highest number of shoots in Camarosa cultivar recorded was 6.17 in T1(control) followed by 5.52 in T2 (25 mM) and the lowest number of shoots recorded in T5 (100mM) with 4.42 which were significant at 20 DAT respectively. The highest number of shoots was recorded 7.08 in T1 (control) followed by 6.58 in T2 (25 mM) and the lowest number of shoots recorded 0.417 in T5 (100 mM) which were significant at 90 DAT respectively.

Among all the treatments highest reduction percentage of shoot length observed 20.88% and 100% in T5 (100 mM) followed by 16.41% and 49.30% in T4 (75mM), 11.93% and 29.58% in T3 (50mM) and 5.96% & 18.32% in T2 (25mM) as compared to T1 (control) at 20 DAT, 50 DAT and 90 DAT respectively in Rania.

Winter Dawn showed highest reduction percentage of shoot length in T5 (100 mM) having 30.31% and 85.13% followed by 22.73% and 50.01% in T4 (75mM), 16.67% and 14.87% in T3 (50mM) and 4.55% & 9.47% in T2 (25mM) as compared to T1 (control) respectively, at 20 DAT, 50 DAT and 90 DAT.

Camarosa was observed with highest reduction percentage of number of shoots was 28.38% and 94.11% in T5 (100mM) followed by 17.58% and 28.24% in T4 (75mM) which is followed by 14.87%, 16.00% and 21.18% in T3 (50 mM) and 10.54%, 13.33% & 7.06% T2 (25 mM) respectively, as compared to T1 (control) at 20 and 90 DAT.

Table 4: Effect of NaCl concentration on number of shoots.

Varieties	20 DAT					90 DAT				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Rania	5.58	5.25	4.92	4.67	4.42	5.92	4.83	4.17	3.00	0.00
Winter Dawn	5.50	5.25	4.58	4.25	3.83	6.17	5.58	5.25	3.08	0.92
Camarosa	6.17	5.52	5.25	5.08	4.42	7.08	6.58	5.58	5.08	0.42

Table 5: Effect of NaCl concentration on number of buds.

Varieties	20 DAT					90 DAT				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
Rania	3.58	3.00	2.73	2.42	2.00	2.33	1.75	1.58	1.25	0.50
Winter Dawn	2.67	2.50	2.00	1.83	1.33	2.42	2.08	1.50	1.42	0.17
Camarosa	2.42	2.25	1.58	1.50	1.25	2.50	2.17	1.42	1.25	0.00

Our results were supported by Akbar Mozafari *et al.,* (2018) when decrease in the number of shoots was observed at higher concentration of 100 mM of NaCl.

Number of buds

The effects of NaCl on number of buds in strawberry fruit crop at various concentrations was discussed in table 5. The data was recorded at three stages at 20 DAT and 90 DAT.

The highest number of buds in Rania cultivar recorded was 3.58 in T1 (control) followed by 3.00 in T2 (25 mM) and the lowest number of buds recorded in T5 (100 mM) with 2.00 which were significant at 20 DAT respectively. The highest number of buds was recorded 2.33cm in T1 (control) followed by 1.75 in T2 (25 mM) and the lowest number of buds recorded 0.50 in T5 (100 mM) which were significant at 90 DAT, respectively.

Winter dawn was recorded with 2.67 of highest number of buds in T1 (control) followed by 2.50 number of buds in T2 (25mM) and lowest was recorded in T5 (100mM) having a number of buds 1.33 which were significant at 20 DAT respectively. However, the highest number of buds was recorded 2.42 in T1 (control) followed by 2.08 in T2 (25 mM) and the lowest number of buds recorded 0.17 in T5 (100 mM) which were significant at 90 DAT respectively.

The highest number of buds in Camarosa cultivar recorded was 2.42 in T1 (control) followed by 2.25 in T2 (25 mM) and the lowest number of buds recorded in T5 (100 mM) with 1.25 which were significant at 20 DAT, respectively. The highest number of buds was recorded 2.50 in T1 (control) followed by 2.17 in T2 (25 mM) and the lowest number of buds recorded 0.00 in T5 (100 mM) which were significant at 90 DAT, respectively.

Among all the treatments highest reduction percentage of number of buds observed 44.18% and 78.57% in T5 (100mM) followed by 32.54% and 46.42% in T4 (75mM), 23.72% and 32.15% in T3 (50 mM) and 16.27% & 24.99% in T2 (25 mM) as compared to T1 (control) at 20 DAT and 90 DAT respectively in Rania.

Winter Dawn showed highest reduction percentage of number of buds in T5 (100 mM) having 50.02% and 93.09% followed by 31.27% and 41.37% in T4(75mM), 25.01% and 37.94% in T3 (50 mM) and 6.26% &13.82% in T2 (25 mM) as compared to T1 (control) respectively, at 20 DAT and 90 DAT.

Camarosa was observed with highest reduction percentage of number of buds was 37.94% and 100% in T5 (100 mM) followed by 34.51% and 50.00% in T4 (75 mM) which is followed by 48.28% and 43.32% in T3 (50 mM) and 6.91% & 13.32% T2 (25mM), respectively, as compared to T1 (control) at 20 and 90 DAT.

Our results were supported by Qureshi *et al*., (2013) where they observed decrease in the number of buds of 1.18 as compared to the other treatments when salt with concentration of 0.4% $CaCl_2$ (400 mg/l) was applied to the plants.

Number of flowers

The effects of NaCl on number of flowers in strawberry fruit crop at various concentrations were discussed in table 6. The data was recorded at three stages at 20 DAT and 90 DAT.

It was recorded in cultivar Rania that the highest number of flowers was 2.17 in T1 (control) followed by 2.00 in T2 (25 mM) and the lowest number of flowers recorded was 1.08 in T5 (100 mM) at 20 DAT. However, at 90DAT, the highest number of flowers recorded was 2.50 in T1 (control) followed by 2.08 in T2 (25 mM) and the lowest number of flowers was recorded to be 1.00 in T4 (75mM).

The highest number of flowers in Winter dawn cultivar recorded was 2.50 in T1 (control) followed by 2.17 in T2 (25 mM) and the lowest number of flowers recorded in T5 (100mM) with 1.08 which were significant at 20 DAT respectively. However, the highest number of flowers was recorded 1.92 in T1 (control) followed by 1.82 in T2 (25 mM) and the lowest number of flowers recorded 0.92 cm in T4 (75mM) which were significant at 90 DAT, respectively.

Table 6: Effect of NaCl concentration on number of flowers.

Varieties	20 DAT					90 DAT			
	T1	T2	T3	T4	T5	T1	T2	T3	T4
Rania	2.17	2.00	1.83	1.08	1.00	2.50	2.08	1.67	1.00
Winter Dawn	2.50	2.17	1.83	1.42	1.08	1.92	1.82	1.00	0.92
Camarosa	2.33	1.50	1.42	1.33	1.17	2.25	1.58	1.25	0.00

The highest number of flowers in Camarosa cultivar recorded was 2.33 in T1 (control) followed by 1.50 in T2 (25mM) and the lowest number of flowers recorded in T5 (100mM) with 1.17cm which were significant at 20

Table 7: Effect of NaCl concentration on chlorophyll content.

Varieties	20 DAT					90 DAT			
	T1	T2	T3	T4	T5	T1	T2	T3	T4
Rania	53.19	52.45	52.22	49.57	48.29	51.83	48.59	46.58	39.46
Winter Dawn	52.67	52.49	52.00	50.17	48.40	51.09	48.32	46.91	46.16
Camarosa	52.91	49.45	48.68	48.35	47.87	46.33	45.63	45.47	43.75

DAT, respectively. The highest number of flowers was recorded 2.25 in T1 (control) followed by 1.58 in T2 (25 mM) and the lowest number of flowers recorded 0.00 in T4 (75 mM) which were significant at 90 DAT respectively.

Among all the treatments highest reduction percentage of number of flowers observed 50.02% in T5 (100mM) followed by 53.85% in T4 (75mM), 15.41% in T3 (50 mM) and 7.71% in T2 (25 mM) at 20 DAT. Also, at 90 DAT the highest reduction percentage of number of flowers observed was 60.00% in T4 (75mM) followed by 33.32% in T3 (50 mM) and 16.68% in T2 (25 mM) respectively as compared to T1 (control) in Rania.

Winter Dawn showed highest reduction percentage of number of flowers in T5 (100 mM) having 56.68% followed by 43.32% in T4 (75mM), 26.68% in T3 (50mM) and 13.32% in T2 (25mM) at 20 DAT. However, at 90 DAT the highest reduction percentage of number of flowers observed was 52.16% in T4 (75 mM) followed by 8.30% in T3 (50 mM) and 5.06% in T2 (25 mM) as compared to T1 (control) respectively, at 20 DAT, 50 DAT and 90 DAT.

Camarosa was observed with highest reduction percentage of number of flowers was 49.98% in T5 (100mM) followed by 42.86% in T4 (75mM) which is followed by 39.26% in T3 (50 mM) and 35.71% in T2 (25 mM) at 20 DAT. However, at 90 DAT the highest reduction percentage of number of flowers observed was 100% in T4 (75 mM) followed by 44.44% in T3 (50 mM) and 29.64% in T2 (25 mM) as compared to T1 (control) respectively, at 20 DAT, 50 DAT and 90 DAT.

Our results were supported by Qureshi *et al.*, (2013) where they concluded that the number of flowers decreased of 2.83 as compared to the other treatments when salt with concentration of 0.4% $CaCl_2$ (400 mg/l) was applied to the plants.

Chlorophyll content

The effect of NaCl on chlorophyll content in strawberry fruit crop at various concentrations were discussed in table 7. The data was recorded at three stages at 20 DAT and 90 DAT.

Rania was recorded with 53.19 mg/g of highest chlorophyll content in T1 (control) followed by 52.45 mg/g chlorophyll content in T2 (25 mM) and lowest was recorded in T4 (75 mM) having a chlorophyll content 48.29 mg/g, which were significant at 20 DAT respectively. However, the highest chlorophyll content was recorded 51.83 mg/g in T1(control) followed by 48.59mg/g in T2 (25mM) and the lowest chlorophyll content recorded 39.46 mg/g in T4 (75 mM) which were significant at 90 DAT, respectively.

The highest chlorophyll content in Winter dawn cultivar recorded was 52.67 mg/g in T1 (control) followed by 52.49 mg/g in T2 (25 mM) and the lowest chlorophyll content recorded in T5 (100 mM) with 48.40 mg/g which were significant at 20 DAT respectively. The highest chlorophyll content was recorded 51.09 mg/g in T1 (control) followed by 48.32mg/g in T2 (25mM) and the lowest chlorophyll content recorded 46.16 mg/g in T4 (75 mM) which were significant at 90 DAT, respectively.

Camarosa was recorded with 52.91 mg/g of highest chlorophyll content in T1 (control) followed by 49.45 mg/g chlorophyll content in T2 (25 mM) and lowest was

Table 8: Salt tolerance index for plant height.

Varieties	20 DAT					90 DAT					Salt Tolerance Index
	RSTI-T2	RSTI-T3	RSTI-T4	RSTI-T5	Average	RSTI-T2	RSTI-T3	RSTI-T4	RSTI-T5	Average	
Rania	97.29	94.54	85.11	87.04	**91.00**	81.07	78.12	73.91	33.47	**66.64**	**78.82**
Winter dawn	93.92	89.88	83.85	80.50	**87.04**	74.17	69.66	63.91	22.30	**57.51**	**72.27**
Camarosa	93.45	90.06	89.48	71.78	**86.20**	71.40	0.00	75.38	60.74	**51.88**	**69.04**

Table 9: Salt tolerance index for number of leaves.

Varieties	20 DAT					90 DAT					Salt Tolerance Index
	RSTI-T2	RSTI-T3	RSTI-T4	RSTI-T5	Average	RSTI-T2	RSTI-T3	RSTI-T4	RSTI-T5	Average	
Rania	96.36	89.06	86.98	81.25	**88.41**	83.76	69.23	46.58	1.71	**50.32**	**69.37**
Winter dawn	89.26	76.17	74.30	72.90	**78.16**	87.11	81.33	76.00	4.00	**62.11**	**70.13**
Camarosa	93.45	90.06	89.48	71.78	**86.20**	71.40	0.00	75.38	60.74	**51.88**	**69.04**

Table 10: Salt tolerance index for number of shoots.

Varieties	20 DAT					90 DAT					Salt Tolerance Index
	RSTI-T2	RSTI-T3	RSTI-T4	RSTI-T5	Average	RSTI-T2	RSTI-T3	RSTI-T4	RSTI-T5	Average	
Rania	94.04	88.07	83.59	79.12	**86.20**	81.68	70.42	50.70	0.00	**50.70**	**68.45**
Winter dawn	95.45	83.33	77.27	69.69	**81.44**	90.53	85.13	49.99	14.87	**60.13**	**70.78**
Camarosa	89.46	85.13	82.42	71.62	**82.16**	92.94	78.82	71.76	5.89	**62.35**	**72.26**

Table 11: Salt tolerance index for shoot length.

Varieties	20 DAT					90 DAT					Salt Tolerance Index
	RSTI-T2	RSTI-T3	RSTI-T4	RSTI-T5	Average	RSTI-T2	RSTI-T3	RSTI-T4	RSTI-T5	Average	
Rania	95.84	94.75	90.04	89.66	**92.57**	95.59	93.01	84.89	31.80	**76.32**	**84.45**
Winter dawn	93.03	95.79	85.95	76.00	**87.69**	85.02	78.33	68.85	23.73	**63.98**	**75.84**
Camarosa	96.55	90.76	89.27	65.43	**85.50**	98.80	78.00	73.45	42.64	**73.22**	**79.36**

Table 12: Salt tolerance index for number of buds.

Varieties	20 DAT					90 DAT					Salt Tolerance Index
	RSTI-T2	RSTI-T3	RSTI-T4	RSTI-T5	Average	RSTI-T2	RSTI-T3	RSTI-T4	RSTI-T5	Average	
Rania	83.73	76.28	67.46	55.82	**70.82**	75.01	67.85	53.58	21.43	**54.47**	**62.64**
Winter dawn	93.74	74.99	68.73	49.98	**71.86**	86.18	62.06	58.63	6.91	**53.44**	**62.65**
Camarosa	93.09	51.72	65.49	62.06	**68.09**	86.68	56.68	50.00	0.00	**48.34**	**58.22**

Table 14: Salt tolerance index for chlorophyll content.

Varieties	20 DAT					90 DAT				Salt Tolerance Index
	RSTI-T2	RSTI-T3	RSTI-T4	RSTI-T5	Average	RSTI-T2	RSTI-T3	RSTI-T4	Average	
Rania	98.61	98.18	93.21	90.79	**95.20**	93.75	89.88	76.13	**86.59**	**90.90**
Winter dawn	96.65	98.72	95.25	91.90	**96.38**	94.58	91.82	90.36	**92.25**	**94.32**
Camarosa	93.46	92.02	91.38	90.49	**91.84**	98.49	98.15	94.44	**97.03**	**94.44**

recorded in T4 (75 mM) having a chlorophyll content 47.87mg/g which were significant at 20DAT, respectively. While, the highest chlorophyll content was recorded mg/g in T1 (control) followed by 45.63 mg/gin T2 (25 mM) and the lowest chlorophyll content recorded 43.75 mg/g in T4 (75 mM) which were significant at 90 DAT, respectively.

Among all the treatments highest reduction percentage of chlorophyll content observed 9.21% in T5 (100 mM) followed by 6.79% in T4 (75 mM), 1.82% in T3 (50mM) and 1.39% in T2 (25mM) at 20DAT. Also, at 90DAT the highest reduction percentage of chlorophyll content observed was 23.87% in T4 (75mM) followed by10.12% in T3(50mM) and 6.25% in T2(25mM) respectively as compared to T1 (control) in Rania.

Winter Dawn showed highest reduction percentage of chlorophyll content in T5 (100 mM) having 8.10% followed by 4.75% in T4 (75 mM), 1.28% in T3 (50 mM) and 0.35% in T2 (25 mM) at 20 DAT. However, at 90 DAT the highest reduction percentage of chlorophyll content observed was 9.64% in T4 (75 mM) followed by 8.18% in T3 (50mM) and 5.42% in T2 (25mM) as compared to T1 (control) respectively, at 20 DAT, 50 DAT and 90DAT.

Camarosa was observed with highest reduction percentage of chlorophyll content was 9.51% in T5 (100mM) followed by 8.62% in T4 (75mM) which is followed by 7.98% in T3 (50 mM) and 6.54% in T2 (25 mM) at 20 DAT. However, at 90 DAT the highest reduction percentage of chlorophyll content observed was 5.56% in T4 (75 mM) followed by 1.85% in T3 (50mM) and 1.51% in T2 (25mM) as compared to T1(control) respectively.

Our results were supported by Garriga *et al.,* (2014) where they concluded that the content of chlorophyll decreased from 13.43 mg/g to 10.83 mg/g under higher concentration of 60 mM of NaCl.

Salt tolerance index

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

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

Based on the salt tolerance index the varieties were categorized as tolerant or susceptible to salinity, respectively. Salt tolerance index for the varieties for the growth parameters is mentioned below in the tables (Table 8- Table 14).

According to the tables of salt tolerance index for the parameters of growth it was observed that Rania performed better for plant height, shoot length and number of leaves having a maximum salt tolerance index of 78.82, 84.45 and 65.79. However, it also showed minimum salt tolerance index of 69.37, 68.45 and 90.90 for number of leaves, number of shoots and chlorophyll content, respectively. Simultaneously, Camarosa performed better for parameters of number of leaves, number of shoots and chlorophyll content having a maximum salt tolerance index of 72.71, 72.26 and 94.44, however it also showed minimum salt tolerance index of 69.04, 58.22 and 50.01 for plant height, number of buds and number of flowers.

Conclusions

The results of the present study demonstrated that NaCl 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 plant height, number of leaves, shoot length, number of shoots, number of buds, number of flowers and also content of chlorophyll. We can conclude from the results of the present study that both Rania and Camarosa performed better in terms of plant height, shoot length, number of flowers and number of leaves, number of shoots &chlorophyll content, as Rania showed maximum salt tolerance for plant height, shoot length and number of flowers while Camarosa showed maximum salt tolerance index for number of leaves, number of shoots and chlorophyll content. However, Winter dawn only showed minimum salt tolerance index for shoot length and maximum for number of buds. Therefore, it shows that both Rania and Camarosa performed moderately for salinity tolerance, thus they can be used to be cultivated in a region where salinity causes stress to the plants.

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