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RESEARCH PAPER

Morphological and physio-biochemical screening of rose (*Rosa indica* L.) cultivars against salt stress

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Key Message: Screening of rose cultivars was conducted for salinity tolerance at different levels of salinity stress. The Blue Moon cultivar performed better in term of morphological and physio-biochemical attributes, therefore it may be used as a potential cultivar for saline soil.

Abstract: The present study was undertaken to examine the effect of exogenous application of NaCl on growth, associated biochemical characters, and ionic compositions in rose genotypes grown under different levels of salt stress. In pot experiment, salt concentrations 0, 2, 4, 6, 8, and 10 dS m^{-1} were applied through foliar spray on rose cultivars i.e. Sunset, Golden Giant, Fragrant, Blue Moon, Paradise, Superstar, Happiness, Gladiator, Avon, Sea Shell, Double Delight, Sterling Silver, Mischief, King's Ransom and First Prize . Morphological and physiological growth attributes (shoot length, root length, leaf area, fresh and dry weight), chlorophyll contents, photosynthesis, transpiration rate, stomatal conductance and biochemical attributes i.e. proline and glycine betaine and ions sodium and chloride were recorded to study the effects of these treatments. Salt stress significantly reduced morphological and biochemical attributes. However, proline, glycine betaine, and both ions Na and Cl significantly increased with the increase in salinity level. In this study, cv. Blue Moon was found more salt-tolerant variety as it showed maximum shoot length (27.47 cm), plant fresh weight (61.68 g), plant dry weight (15.42 g) and plant leaf area (18.85 cm^2). Plant chlorophyll contents (51.80%), plant photosynthesis rate (44.31%), transpiration rate (44.68%), stomatal conductance (35.15%) were reduced in salt-treated plants as compared to control. However, proline contents (34.02%), glycine betaine (93.88 %), Na^+ (345.22 %) and Cl ions (171.39 %) increased with the increase in salinity level. The Sterling Silver cultivar was found to be the salt sensitive which showed maximum reduction in morphological and biochemical attributes out of 15 cultivars. Results suggested that cv. Blue Moon is a salt-tolerant cultivar and can be grown in the salinity affected areas without marked effects on aesthetic appearance and productions.

Keywords: Chlorophyll contents, NaCl, Photosynthesis, Proline, Rose, Transpiration rate

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Introduction

Roses (*Rosa indica* L.) is the most important ornamental flower and is thought to be a major ornamental crop due to its economic importance (Leus et al., 2018). It is considered a popular garden shrub among most frequently sold flowers in markets. Furthermore, it is used in parks, houses, and gardens as ornamental plants and mainly cultivated for perfume, food industry, and medicinal purposes (Stewart, 2005). Rose is an efficient aromatic plant that is cultivated for the production of volatile oil (Ma et al., 2019). It has various pharmacological properties e.g., anti-HIV, anti-bacterial anti-diabetic, hypnotic, antioxidant, and relaxing effect on the tracheal chains (Boskabady et al., 2011; Akram et al., 2020).

Salinity is one of the major problems affecting seed germination, plant growth and photosynthetic efficiency in most species in both controlled and field environments (Nedjimi, 2013; Acosta-Motos et al., 2017; Tian et al., 2020). Studies of stress on plants are becoming increasingly important as the amount of cultivated land considered to have saline conditions is increasing yearly around the globe. Nearly 45 million ha of irrigated land in the world is saline, which causes an estimated loss of US$ 273 billion per year for the agribusiness sector (Qadir et al., 2014). Most of the commercially valuable crops are salt sensitive and salinity has reduced the growth and productivity of such crops (Flowers, 2004). Those plants which grow in saline soils accumulate high concentrations of sodium ions which alter plasma membranes as well as inhibit enzymes that ultimately scavenge ROS (reactive oxygen species). This ultimately leads to plant death (Shavrukov et al., 2013). Due to accumulation of sodium ions, absorption of major nutrients, such as K^+, is inhibited by plant root and also ratio of K^+/Na^+ is reduced (Almeida et al., 2017; Assaha et al., 2017; Ami et al., 2020). Moreover, salinity affects plant physiological processes by two ways: one to reduce availability of water to the roots and other to accumulate ions to toxic levels in some plant tissues (Munns et al., 2006).

However, salt tolerance levels of most rose species are unknown. Therefore, expanding our knowledge of responses and tolerance levels to salinity in rose species and cultivars is essential to provide consistent yield and quality as salinity is increasing in agricultural lands around the world. The objectives of this study were to screen 15 genotypes for salt tolerance by applying different concentrations (0 to10 dSm^{-1}) of NaCl and also, to check its possible effects on the physiological functioning of the rose plant. With an increasing global population, the need for high quality crops is also increasing. Therefore, it is necessary to cultivate salt-tolerant crops using cost-effective strategies.

Materials and Methods

Rose (*Rosa indica* L.) was used as an experimental material to conduct this study. Fifteen different varieties of rose were subjected to six different NaCl salinity levels i.e. 0, 2, 4, 6, 8, and 10 dS m^{-1}. Cuttings were planted in plastic pots placed in the nursery area of the Department of Horticulture, College of Agriculture, University of Sargodha (Latitude: 32°5'1.47"N; Longitude: 72°40'18.69" E), Pakistan One cutting per pot was sown and three replications were maintained that comprised of three pots. The pots were kept open field and watered according to the need of plants by observing the moisture of the media. The description of the treatments is shown in Table 1. Potting media having fine sand as a growth medium and Hoagland solution (Table 2) was applied under the non-saline condition. Salinity stress was executed 60 days after sowing. Salinity solutions were prepared in a mixture of salt and double distilled water to final concentration of 0 to 10 dS m^{-1} (NaCl). To avoid the osmotic shock, salinity was created in 2 dS m^{-1} increments after a one-day interval until final concentration was reached. Rose seedlings were grown 60 days under stressed conditions. Irrigation along with Hoagland solution was applied according to the need of the plants.

Table 2 Half strength of Hoagland's solution stock per 200 L

Nutrient name	Quantity (g)
Macro Nutrients	
KH_2PO_4	100 g
KNO_3	500 g
$Ca(NO_3)_2 .4H_2O$	500 g
$MgSO_4.7H_2O$	200 g
Macro Nutrients	
H_3BO_3	100 g
$MnCl_2. 4H_2O$	100 g
$ZnSO_4.7H_2O$	100 g
$CuSO_4.5H_2O$	100 g
$H_2 MoO_4. H_2O$	100 g
Fe. EDTA	100 g
pH	6.0-6.5

Measurement of the shoot and root lengths

After two months, the seedlings were uprooted and washed with distilled water to remove sand particles. The seedling length was measured in cm by using a meter rod (tip of the shoot to the base of hypocotyl) from five seedlings per replicate. A similar method was adopted to measure the root length.

Measurement of plant fresh and dry weight

After the measurement of plant fresh and dry weight, shoots were separated from the root and wrapped with the filter paper to remove excess moisture. The digital balance was used to measure the fresh weight of shoot and root, separately, and readings of each replication were noted down for further calculations. To measure dry weight of root and shoot of rose plants, three randomly selected seedlings were taken in paper bags and placed in an oven for drying of excess moisture for a week at 70°C. The digital balance was used to measure the dry weight of both shoot and root and the average dry weight of each replicate was taken for the calculation.

Leaf area per plant

Two plants per replication were selected and six leaves were separated randomly from each plant. Leaf area per plant (cm^2) was calculated by placing separated leaves on an electronic leaf area meter. The average of the leaf area was calculated.

Measurement of physiological attributes

Infrared Gas Analyzer (IRGA) (Analytical Development Company, Hoddesdon, England) was used to measure the gaseous exchange characteristics (Model CI 340-Photosynthetic Made in U.S.A) i.e. photosynthesis rate**,** transpiration rate and stomatal conductance. For this purpose, three leaves from each plant were used. All the readings of the above mentioned physiological attributes were taken at day time from 10 to 12 a.m. with the molar flow of air per unit area 403.3 mmol m^{-2} s^{-1}, atmospheric pressure 99.9 kPa, water vapor pressure into chamber ranged from 6.0 to 89 mbar and maximum PAR 1711 µmol m^{-2} s^{-1} recorded from the surface of the leaf. Leaf temperature ranged from 28.4 to 32.4 °C and the ambient temperature ranged from 22.4 to 27.9 °C, ambient CO_2 concentration was 352 µmol mol^{-1} (Zekri, 1999; Moya, 2003). The method of Arnon (1949) was used for the calculation of chlorophyll contents. Absorbance was taken at 645 and 663 nm using a double beam spectrophotometer (Hitachi-120, Japan). Total chlorophyll was calculated using the following formula:

$$Total\ Chl = [20.2(OD\ 645) + 8.02(OD\ 663)]X \frac{V}{1000}\ X\ W$$

Where

v = volume of extract; w = weight of a sample

Biochemical parameters

Proline contents and glycine betaine

The method described by Bates et al. (1973) was used for the calculation of proline. Proline concentrates were estimated from a standard curve and calculated on a fresh weight basis by formula as:

$$Mole\ proline\ per\ g\ fresh\ weight = (\ g\ proline\ m-1\ X\ mL\ of \frac{toluene}{115.5})/(g\ of \frac{sample}{5})$$

Glycine betaine was determined by following the method described by Grieve & Gratan (1983). The concentrate of glycine betaine was measured against the standard curve.

Ionic analysis (Na^+ and Cl^{-1} ions)

Na^+ ions were determined by following the method described by Wolf (1991). A standard curve was drawn based on a graded series of standards (ranging from 10 to 100 mg per L) of Na^+. The actual ratio was calculated by comparing values with the standard curve. For the determination of chloride ions, dried roots and leaves were ground to form a powder. From this fine plant material, one gram was heated overnight in distilled water (20 mL) in the test tube at 65°C in an oven. Whatman 40 filter paper was used to filter the overnight heating plant extract and chloride ions were estimated from this extract by using 614 Na+/K+ Analyzers (Ciba Corning Diagnostics Limited England).

Experimental design and statistical analysis

Complete Randomized Design (CRD) with three-factor factorial arrangements were applied to the experiment. Data were collected two months after the induction of NaCl stress to rose plants. The experimental units were arranged in Completely Randomized Design (CRD) with three replications. Data collected were statistically analysed by using computer software "Statistix 8.1" (Steel, 1997). The Analysis of Variance (ANOVA) and the means were compared with Duncan's multiple range test ($P < 0.05$).

Results

Shoot and root length

In present investigation, plants treated with salt exhibited significant differences ($P \leq 0.05$) under all the concentrations of salt applied. The decrease in shoot length, root length, fresh and dry weight, leaf area per plant was observed as compared to non-treated plants (Table 2). According to results, shoot length (cm) of rose varieties reduced after the treatment of NaCl as compared to control (Table 2). Blue Moon was found more salt-tolerant variety as it showed maximum shoot length (27.47 cm) in control which was reduced to (14.53cm) with the increase of salt concentration from 0 to 10 dSm^{-1} followed by King's Ransom (17.84 cm) which showed maximum shoot length (24.02 cm) under control and least shoot length depicted (14.50 cm) under 10 dS m^{-1} salt concentration. Whereas, Sterling Silver variety was found salt-sensitive as it showed maximum shoot length (23.21 cm) in control and minimum (13.17cm) with 10 dS m^{-1} salt concentration. Results revealed that with the increase of salinity, root length decreased. Under salinity level of 2 dS m^{-1}, Blue Moon (23.5 cm) and First Prize (22.59 cm), Happiness (16.56 cm) and Paradise (16.22 cm) had maximum root length (Table 2). While genotype Mischief showed that it is sensitive in saline conditions with minimum root length (8.45 cm) under 10 dS m^{-1} salt stress following as Sunset (8.89 cm) and Paradise (9.2 cm).

Plant fresh and dry weight

Plant fresh weight (60 days after sowing) in all the rose genotypes was significantly ($P \leq 0.05$) influenced by different salt stress levels (Table 2). The highest plant fresh weight (61.68 g) was recorded in plants growing under control and decreased with the increase in salt stress as 58.21, 52.00, 43.1, 37.1 and 35.4 g, respectively, in Blue Moon. Whereas, minimum plant fresh weight was recorded in Sterling Silver (53.02; 45.23; 40.10; 37.20; 35.10; 32.29 g) at different salinity levels. Moreover, genotype King's Ransom showed minimum (30.98 g) plant fresh weight under control and it decreased with the increase of salt levels. From the results, it can be concluded that the genotypes Blue Moon and Happiness showed excellent performance by maintaining the highest plant fresh weight under saline conditions than others while genotypes Sterling Silver, Fragrant and King's Ransom were observed to be highly salt-sensitive as they maintained the lowest under saline condition. Seedling dry weight (SDW) decreased due to salt stress in (Table 2) among the genotypes minimum percent reduction was exhibited by Blue Moon (14.00 g) followed by genotype First Prize and Double Delight depicted 13.25 g and whereas it was maximum (10.20 g) in Sterling Silver with respect to non-saline control. While under the highest salinity level 10dSm^{-1} Blue Moon (9.65 g) showed maximum SDW as compared to control but minimum in genotype Sterling Silver (7.36 g).

Plant leaf area

Leaf area represents a measure of plant growth, which can be affected by different stresses, including salt stress. Plant leaf area (PLA) decreased in all genotypes because of all salt treatments (Table 2). Under 2dSm^{-1} salt stress minimum percent reduction was found in Fragrant Gold (13.12 cm^2) and Sterling Silver (14.23 cm^2), while it was maximum in Blue Moon (18 cm^2) with respect to non-saline control. Whereas, in 10dSm^{-1} Fragrant Gold (8.64 cm^2), showed minimum LA as compared to control while maximum in the First Prize (10.99 cm^2) followed by Blue Moon (10.81 cm^2).

Photosynthesis rate (µmol CO_2 m^{-2} s^{-1})

Photosynthesis rate decreased in all genotypes because of salt treatment. Double Delight (10.88) showed maximum photosynthesis rate in control whereas Sterling Silver (8.12) showed minimum while it was reduced with a salt concentration in Double Delight (9.2;7.7;7.51;6.75;6.21 µmol CO_2 m^{-2} s^{-1}) and Sterling Silver (6.65; 6.3; 5.5; 4.95; 5.23 µmol CO_2 m^{-2} s^{-1}), respectively. Under the lowest level of salt stress (2dSm^{-1}) maximum percent reduction in photosynthesis rate was found in Sterling Silver (6.65) while it was minimum in the Blue Moon (10) with respect to non-saline control (Table 3). Whereas, in the highest salt stress level (10 dSm^{-1}) Fragrant Gold (5.06) showed a minimum Photosynthesis rate as compared to control while maximum in Mischief (6.33).

Table 2 Effect of salinity on the percentage reduction in morphological characters of various rose genotypes subjected to NaCl (0, 2, 4, 6,8,10 dS m^{-1}) after 60 days of sowing

Rose Varieties	Treatments	Morphological parameters				
		Shoot length (cm)	Root length (cm)	Plant fresh weight (g)	Plant dry weight (g)	Plant leaf area (cm^2)
Sunset	Control	21.25 ± 0.89^a	17.25 ± 0.72^a	55.55 ± 2.34^a	13.88 ± 0.58^a	17.25± 0.72^a
	2 dSm^{-1}	18.7 ± 0.78^{ab}	14.5 ± 0.61^b	50.88 ± 2.14^{ab}	12.72 ± 0.53^{ab}	15.19±0.64^a
	4 dSm^{-1}	18.22 ± 0.76^b	13.21 ± 0.55^b	45.78 ± 1.93^{bc}	11.44 ± 0.48^{bc}	12.99±0.54^b
	6 dSm^{-1}	16.42 ± 0.69^{bc}	10.74 ± 0.45^c	40.43 ± 1.70^{cd}	10.1 ± 0.42^{cd}	11.23±0.47^{bc}
	8 dSm^{-1}	14.77 ± 0.62^{cd}	9.66 ± 0.40^c	36.38 ± 1.53^d	9.09 ± 0.38^d	10.10 ± 0.42^c
	10 dSm^{-1}	13.60 ± 0.57^d	8.89 ± 0.37^c	33.47 ± 1.41^d	8.36 ± 0.35^d	9.29 ± 0.39^c
Golden Giant	Control	22.34 ± 0.94^a	17.25 ± 0.68 ^{a}	56.89 ± 2.40 ^{a}	14.22 ± 0.60^a	16.25±0.68^a
	2 dSm^{-1}	20.85 ± 0.87^{ab}	14.21 ± 0.59^b	50.21 ± 2.11^{ab}	12.55 ± 0.52^{ab}	15.02±0.63^{ab}
	4 dSm^{-1}	18.85 ± 0.79^{bc}	12.23 ± 0.51^{bc}	45.11 ± 1.90^{bc}	11.27 ± 0.47^{bc}	13.58±0.57^{bc}
	6 dSm^{-1}	17.31 ± 0.73^{cd}	11.56 ± 0.48^{cd}	42.03 ± 1.77^{cd}	10.05 ± 0.42^{cd}	12.56±0.52^{cd}
	8 dSm^{-1}	15.58 ± 0.65^{de}	10.40 ± 0.43^{cd}	37.82 ± 1.59^{de}	9.04 ± 0.38^d	11.30±0.47^{de}
	10 dSm^{-1}	14.33 ± 0.60^e	9.57 ± 0.40^d	34.80 ± 1.46^e	8.32 ± 0.35^d	9.60±0. 40^e
Fragrant	Control	23.65 ± 0.99^a	17.25 ± 0.85^a	57.25 ± 2.41^a	14.31 ± 0.60^a	15.98±0.67^a
	2 dSm^{-1}	21.81 ± 0.92^a	14.5 ± 0.61^b	51.11 ± 2.15^{ab}	12.06 ± 0.50^b	13.12±0.55^b
	4 dSm^{-1}	18.5 ± 0.78^b	14.12 ± 0.59^{bc}	47.54 ± 2.00^{bc}	11.88 ± 0.50^b	11.07±0.46^c
	6 dSm^{-1}	16.55 ± 0.69^{bc}	13.35 ± 0.56^{bcd}	42.76 ± 1.80^c	10.96 ± 0.46^{bc}	10.44±0.44^{cd}
	8 dSm^{-1}	14.89 ± 0.62^c	12.015 ± 0.50^{cd}	35.1 ± 1.48^d	9.86 ± 0.41^{cd}	9.39±0.39^{cd}
	10 dSm^{-1}	13.70 ± 0.57^c	11.05 ± 0.46^d	32.29 ± 1.36^d	9.07 ± 0.38^d	8.64±0.36^d
Blue Moon	Control	27.47 ± 1.15^a	17.25 ± 1.01^a	61.68 ± 2.60^a	15.42 ± 0.65^a	18.85±0.79^a
	2 dSm^{-1}	24.17 ± 1.09^b	23.5 ± 0.99^a	58.21 ± 2.45^{ab}	14.00 ± 0.59^{ab}	18.00±0.75^a
	4 dSm^{-1}	21.21 ± 0.89^b	21.56 ± 0.90^{ab}	52 .00 ± 2.19^b	13.00 ± 0.54^{bc}	16.54±0.69^a
	6 dSm^{-1}	17.55 ± 0.74^c	20.89 ± 0.88^{ab}	43.1 ± 1.81^c	11.12± 0.46^{cd}	13.56±0.57^b
	8 dSm^{-1}	15.79 ± 0.66^c	19.52 ± 0.82^b	37.1 ± 1.56^c	10.55 ± 0.44^d	11.75±0.49^{bc}
	10 dSm^{-1}	14.53 ± 0.61^c	18.5 ± 0.78^b	35.4 ± 1.49^c	9.65 ± 0.40^d	10.81±0.45^c
Paradise	Control	25.57 ± 1.07^a	17.25 ± 0.89^a	58.36 ± 2.46^a	14.59 ± 0.65^a	16.8±0.70^a
	2 dSm^{-1}	24.01 ± 1.02^a	16.22 ± 0.68 ^{b}	49.23 ± 2.07^b	12.90 ± 0.54^{ab}	13.96±0.58^b
	4 dSm^{-1}	19.01 ± 0.80^b	15.2 ± 0.64^{bc}	48.26 ± 2.03^{bc}	12.06 ± 0.50^b	12.55±0.52^{bc}
	6 dSm^{-1}	16.95 ± 0.71^{bc}	14.21 ± 0.59^{bc}	41.23 ± 1.73^{cd}	11.23 ± 0.47^{bc}	11.65±0.49^{cd}
	8 dSm^{-1}	15.25 ± 0.64^c	12.78 ± 0.53^c	37.10 ± 1.56^d	10.10 ± 0.42^{cd}	10.48 ± 0.44^d
	10 dSm^{-1}	14.03 ± 0.59^c	9.2 ± 0.38^d	34.13 ± 1.44^d	9.29 ± 0.39^d	9.64 ± 0.40^d
Superstar	Control	26.09 ± 1.10^a	17.25 ± 0.94^a	59.66 ± 2.51^a	14.91 ± 0.61^a	18.25 ± 0.76^a
	2 dSm^{-1}	23.95 ± 1.01^a	15.15 ± 0.63^b	54.55 ± 2.30^{ab}	13.66 ± 0.57^{ab}	16.66±0.70^{ab}
	4 dSm^{-1}	18.41 ± 0.77^b	14.52 ± 0.61^b	49.91 ± 2.10^{bc}	12.85 ± 0.54^{bc}	15.65 ± 0.66^b
	6 dSm^{-1}	16.05 ± 0.67^{bc}	14.35 ± 0.60^{bc}	42.51 ± 1.79^{cd}	11.02 ± 0.46^{cd}	12.09 ± 0.51^c
	8 dSm^{-1}	14.44 ± 0.60^c	12.91 ± 0.54^{bc}	38.25 ± 1.61^d	9.91 ± 0.41^d	10.88 ± 0.45^c
	10 dSm^{-1}	13.28 ± 0.56^c	11.88 ± 0.50^c	35.19 ± 1.48^d	9.12 ± 0.38^d	10.01 ± 0.42^c
Happiness	Control	24.09 ± 1.01^a	17.25 ± 0.98^a	58.44 ± 2.46^a	14.91 ± 0.62^a	18.28 ± 0.77^a
	2 dSm^{-1}	22.85 ± 0.96^a	16.56 ± 0.69^b	51.86 ± 2.18^{ab}	12.96 ± 0.54^{ab}	17.91 ± 0.75^a

	4 dSm^{-1}	17.23 ± 0.72^{b}	13.26 ± 0.55^{c}	47.21 ± 1.99^{bc}	11.80 ± 0.49^{bc}	15.5 ± 0.65^{b}
	6 dSm^{-1}	16.75 ± 0.70^{bc}	13.68 ± 0.57^{c}	42.73 ± 1.80^{cd}	11.4 ± 0.48^{bc}	12.49 ± 0.52^{c}
	8 dSm^{-1}	15.07 ± 0.63^{bc}	12.31 ± 0.51^{c}	38.45 ± 1.62^{d}	10.26 ± 0.43^{cd}	11.24 ± 0.47^{c}
	10 dSm^{-1}	13.86 ± 0.58^{c}	11.32 ± 0.47^{c}	35.38 ± 1.49^{d}	8.44 ± 0.35^{d}	10.34 ± 0.43^{c}
Gladiator	Control	22.31 ± 0.94^{a}	17.25 ± 0.85^{a}	57.63 ± 2.43^{a}	14.915 ± 0.61^{a}	18.55±0.78^{a}
	2 dSm^{-1}	20.02 ± 0.84^{ac}	15.23 ± 0.64^{b}	51.97 ± 2.19^{ab}	12.99 ± 0.54^{ab}	17.22±0.72^{ab}
	4 dSm^{-1}	18.91 ± 0.79^{b}	14.35 ± 0.60^{b}	47.55 ± 2.00^{bc}	11.91 ± 0.50^{bc}	15.02±0.63^{b}
	6 dSm^{-1}	17.25 ± 0.72^{bc}	13.2 ± 0.55^{bc}	42.05 ± 1.77^{cd}	10.25 ± 0.43^{cd}	12.24±0.51^{c}
	8 dSm^{-1}	15.53 ± 0.68^{cd}	11.93 ± 0.50^{c}	37.84 ± 1.59^{d}	9.22 ± 0.38^{d}	11.01±0.46^{c}
	10 dSm^{-1}	14.28 ± 0.63^{d}	10.97 ± 0.46^{c}	34.81 ± 1.46^{d}	8.48 ± 0.35^{d}	10.13±0.42^{c}
Avon	Control	23.09 ± 0.97^{a}	17.25 ± 0.73^{a}	58.02 ± 2.44^{a}	14.91 ± 0.60^{a}	17.36± 0.73^{a}
	2 dSm^{-1}	21.11 ± 0.89^{ab}	14.66 ± 0.61^{b}	52.55 ± 2.21^{ab}	13.02 ± 0.54^{ab}	15.88±0.66^{ab}
	4 dSm^{-1}	19.87 ± 0.83^{b}	13.49 ± 0.56^{b}	46.00 ± 1.94^{bc}	11.55 ± 0.48^{bc}	14.33±0.60^{bc}
	6 dSm^{-1}	16.85 ± 0.71^{c}	10.23 ± 0.43^{c}	42.65 ± 1.79^{cd}	10.56 ± 0.44^{cd}	12.18±0.51^{cd}
	8 dSm^{-1}	15.16 ± 0.63^{c}	9.20 ± 0.38^{c}	38.38 ± 1.61^{d}	9.50 ± 0.40^{d}	10.96±0.46^{d}
	10 dSm^{-1}	13.95 ± 0.57^{c}	8.47 ± 0.35^{c}	35.31 ± 1.48^{d}	8.74 ± 0.36^{d}	10.08±0.42^{d}
Sea Shell	Control	26.85 ±1.13^{a}	17.25 ± 0.72^{a}	59.09 ± 2.49^{a}	14.91 ± 0.61^{a}	18.03±0.76^{a}
	2 dSm^{-1}	24.62 ± 1.03^{a}	15.22 ± 0.64^{ab}	51.75 ± 2.18^{ab}	12.93 ± 0.54^{ab}	16.66±0.70^{ab}
	4 dSm^{-1}	17.55 ± 0.74^{b}	14.23 ± 0.60^{bc}	48.43 ± 2.04^{bc}	12.10 ± 0.51^{b}	15.02±0.63^{b}
	6 dSm^{-1}	17.46 ± 0.73^{b}	12.45 ± 0.52^{cd}	42.72 ± 1.80^{cd}	11.18 ± 0.47^{bc}	12.56±0.52^{c}
	8 dSm^{-1}	15.71 ± 0.66^{b}	11.20 ± 0.47^{d}	38.44 ± 1.62^{d}	10.06 ± 0.42^{cd}	11.30±0.47^{c}
	10 dSm^{-1}	14.45 ± 0.7^{b}	10.30 ± 0.43^{d}	35.37 ± 1.49^{d}	9.25 ± 0.39^{d}	10.39±0.43^{c}
Double Delight	Control	27.02 ± 1.13^{a}	17.25 ± 0.81^{a}	60.05 ± 2.53^{a}	14.91 ± 0.63^{a}	18.16±0.76^{a}
	2 dSm^{-1}	24.93 ± 1.05^{a}	15.12 ± 0.63^{b}	53.88 ± 2.17^{ab}	13.25 ± 0.55^{ab}	17.02±0.71^{ab}
	4 dSm^{-1}	18.56 ± 0.78^{b}	13.41 ± 0.56^{bc}	48.93 ± 2.06^{bc}	12.23 ± 0.51^{b}	15.49±0.65^{b}
	6 dSm^{-1}	17.34 ± 0.73^{bc}	13.25 ± 0.55^{bc}	42.11 ± 1.77^{cd}	11.38 ± 0.48^{bc}	12.22±0.51^{c}
	8 dSm^{-1}	15.60 ± 0.65^{bc}	11.92 ± 0.50^{cd}	37.89 ± 1.59^{d}	10.24 ± 0.43^{cd}	10.99 ± 0.46^{c}
	10 dSm^{-1}	14.35 ± 0.60^{c}	10.97 ± 0.46^{d}	34.86 ± 1.47^{d}	9.42 ± 0.39^{d}	10.11 ± 0.42^{c}
Sterling Silver	Control	23.21 ± 0.97^{a}	17.25 ± 0.72^{a}	53.02 ± 2.23^{a}	14.91 ± 0.55^{a}	16.36 ± 0.69^{a}
	2 dSm^{-1}	19.08 ± 0.80^{b}	14.21 ± 0.59^{b}	45.23 ± 2.90^{b}	10.2 ± 0.43^{b}	14.23 ± 0.60^{b}
	4 dSm^{-1}	17.97 ± 0.75^{bc}	11.12 ± 0.46^{c}	40.1 ± 1.69^{bc}	10.02 ± 0.42^{b}	12.23 ± 0.51^{c}
	6 dSm^{-1}	15.9 ± 0.67^{cd}	10.23 ± 0.43^{c}	37.2 ± 1.56^{cd}	9.2 ± 0.38^{bc}	10.12 ± 0.42^{d}
	8 dSm^{-1}	14.31 ± 0.66^{d}	11.01 ± 0.46^{c}	35.1 ± 1.48^{cd}	8.01 ± 0.33^{cd}	9.56 ± 0.40^{d}
	10 dSm^{-1}	13.17 ± 0.58^{d}	10.12 ± 0.42^{c}	32.29 ± 1.36^{d}	7.36 ± 0.31^{d}	8.35 ± 0.35^{d}
Mischief	Control	26.01 ± 1.09^{a}	17.25 ± 0.71^{a}	59.83 ± 2.52^{a}	14.91 ± 0.63^{a}	18.65 ± 0.78^{a}
	2 dSm^{-1}	23.45 ± 0.98^{a}	14.85 ± 0.62^{b}	51.63 ± 2.17^{b}	13.04 ± 0.55^{b}	17.2 ± 0.72^{a}
	4 dSm^{-1}	18.54 ± 0.78^{b}	13.56 ± 0.57^{b}	47.62 ± 2.00^{bc}	12.01 ± 0.50^{bc}	14.2 ± 0.59^{b}
	6 dSm^{-1}	17.45 ± 0.73^{bc}	10.21 ± 0.43^{c}	42.19 ± 1.78^{cd}	11.4 ± 0.48^{bc}	12.33±0.52^{bc}
	8 dSm^{-1}	15.71 ± 0.66^{bc}	9.18 ± 0.38^{c}	37.97 ± 1.60^{d}	10.26 ± 0.43^{cd}	11.09±0.46^{c}
	10 dSm^{-1}	14.45 ± 0.60^{c}	8.45 ± 0.35^{c}	34.93 ± 1.47^{d}	9.43 ± 0.39^{d}	10.20±0.43^{c}
King's Ransom	Control	24.02 ± 0.88^{a}	17.25 ± 0.73^{a}	57.36 ± 2.11^{a}	14.91 ± 0.52^{a}	17.85±0.65^{a}
	2 dSm^{-1}	21.82 ± 0.78^{a}	15.77 ± 0.56^{b}	52.01 ± 1.86^{a}	13.18 ± 0.47^{ab}	16.15±0.57^{a}
	4 dSm^{-1}	17.84 ± 0.65^{b}	13.43 ± 0.49^{c}	40.87 ± 1.50^{b}	11.88 ± 0.43^{bc}	14.11±0.51^{b}
	6 dSm^{-1}	17.51 ± 0.57^{b}	11.61 ± 0.38^{cd}	37.42 ± 1.23^{bc}	11.36 ± 0.37^{cd}	12.10±0.39^{c}
	8 dSm^{-1}	15.55 ± 0.57^{bc}	10.31 ± 0.38^{de}	33.23 ± 1.22^{cd}	10.09 ± 0.37^{de}	10.16±0.37^{d}
	10 dSm^{-1}	14.50 ± 0.47^{c}	9.62 ± 0.31^{e}	30.98 ± 1.02^{d}	9.41 ± 0.31^{e}	9.01±0.29^{d}
First Prize	Control	26.01 ± 0.95^{a}	17.25 ± 0.86^{a}	58.56 ± 2.15^{a}	14.91 ± 0.52^{a}	16.19±0.59^{a}
	2 dSm^{-1}	23.04 ± 0.82^{b}	22.59 ± 0.80^{ab}	53.02 ± 1.89^{ab}	13.25 ± 0.47^{ab}	15.28±0.54^{ab}
	4 dSm^{-1}	20.39 ± 0.75^{b}	20.85 ± 0.76^{bc}	47.42 ± 1.74^{bc}	11.85 ± 0.43^{bc}	14.28±0.52^{bc}
	6 dSm^{-1}	17.17 ± 0.56^{c}	18.29 ± 0.60^{cd}	42.49 ± 1.39^{cd}	11.37 ± 0.37^{cd}	13.27±0.43^{cd}
	8 dSm^{-1}	15.25 ± 0.56^{cd}	16.24 ± 0.59^{de}	37.73 ± 1.39^{de}	10.10 ± 0.37^{de}	11.79±0.43^{de}
	10 dSm^{-1}	14.22 ± 0.46^{d}	15.14 ± 0.49^{e}	35.18 ± 1.15^{e}	9.42 ± 0.31^{e}	10.99±0.43^{e}

Table shows the mean square values of three replicates per treatment; ± S.E (Standard error); Values followed by the same letter do not differ ($P \leq 0.05$) using the LSD test. dSm^{-1} = Deci siemens per meter

Plant transpiration rate (mmol H_2 Om^{-2} s^{-1})

Rose genotypes have a significant difference in terms of plant transpiration rate, and it decreased in all genotypes because of salt treatments. In control, maximum plant transpiration rate was observed in Blue Moon (24.55); Superstar (24.50) which was reduced to (22.58, 19.5, 16.67, 14.55, and 11.39 mmol H_2 Om^{-2} s^{-}). However, the minimum plant transpiration rate was observed in Sterling Silver (20.12). Under 2dSm^{-1} salt stress, maximum percent reduction was found in the Sunset (18.04) while it was minimum Sea Shell (22.69); Superstar (22.58) to non-saline control (Table 3).

While at the highest level of salt stress $10dSm^{-1}$ genotype Sterling Silver (10.23) showed a minimum plant transpiration rate as compared to control while maximum in Happiness (14.39 mmol $H_2 Om^{-2} s^{-}$).

Stomatal conductance (mmol H_2 Om^{-2} s^{-1})

Stomatal conductance always declined with increasing salinity concentration. The interaction between genotype and salt concentration were significant in terms of plant stomatal conductance. Stomatal conductance significantly decreased with the increase of salt concentration (Table 3). In control maximum plant stomatal conductance was observed in Blue Moon (80.54) which was reduced to (64.55, 60.77, 58.56, 52.23, and 48.05 mmol $H_2 Om^{-2} s^{-1}$). However, minimum plant stomatal conductance was observed in Happiness (70.12) which was reduced with the increase of salt concentration (60.14, 50.13, 49.1, 44.19, and 40.65 mmol $H_2 Om^{-2} s^{-1}$).

Chlorophyll contents (mg g^{-1})

Chlorophyll contents (60 days after sowing) in all the rose genotypes were significantly ($p \leq 0.05$) influenced by different salt stress levels (Table 3). The highest chlorophyll contents (29.51 mg g^{-1}) were recorded in plants growing under control and decreased with the increase in salt stress as (26.34; 24.1; 17.18; 15.46 and 14.42 mg g^{-1}) respectively in a Blue Moon. Whereas, minimum in Happiness (25.02) which was further reduced to (22.56; 21.19; 17.1515.44 and 14.20 mg g^{-1}) among the salinity levels. Overall comparison among the genotypes at the lowest level (2 dSm^{-1}) of salinity regarding the chlorophyll contents revealed that the highest contents were recorded in the Blue Moon (26.34 mg g^{-1}) and the lowest in Sterling Silver (21.09 mg g^{-1}), respectively (Table 3). While under the highest level of salinity stress condition (10 dSm^{-1}), the comparison among genotypes showed that a minimum decrease in chlorophyll contents was recorded in Paradise (14.79 mg g^{-1}) but maximum in Sterling Silver (11.78 mg g^{-1}) as compared to control.

Table 3 Effect of salinity on the percentage reduction in biochemical characters of various rose genotypes subjected to NaCl (0, 2, 4, 6,8,10 dS m^{-1}) after 60 days of sowing

Rose Varieties	Treatments	Physiological parameters			
		Photosynthesis rate (µmol CO_2 m^{-2} s^{-1})	Transpiration rate (mmol H_2 Om^{-2} s^{-1})	Stomatal conductance (mmol H_2 Om^{-2} s^{-1})	Chlorophyll contents (mg g^{-1})
Sunset	Control	9.23 ± 0.38^{a}	20.36 ± 0.85^{a}	77.6 ± 3.27^{a}	26.73 ± 1.12^{a}
	2 dSm^{-1}	8.44 ± 0.35^{ab}	18.04 ± 0.76^{ab}	63.21 ± 2.66^{b}	21.2 ± 0.89^{b}
	4 dSm^{-1}	7.45 ± 0.31^{bc}	15.73 ± 0.66^{bc}	60.00 ± 2.53^{b}	20.12 ± 0.84^{bc}
	6 dSm^{-1}	6.66 ± 0.28^{cd}	13.79 ± 0.58^{cd}	55.4 ± 2.33^{bc}	17.66 ± 0.74^{cd}
	8 dSm^{-1}	5.99 ± 0.25^{d}	12.41 ± 0.52^{de}	49.86 ± 2.10^{cd}	15.90 ± 0.76^{d}
	10 dSm^{-1}	5.51 ± 0.23^{d}	10.42 ± 0.43^{e}	45.87 ± 1.93^{d}	14.62 ± 0.61^{d}
Golden Giant	Control	9.86 ± 0.41^{a}	22.81 ± 0.95^{a}	72.29 ± 3.04^{a}	27.66 ± 1.16^{a}
	2 dSm^{-1}	8.9 ± 0.37^{ab}	20.77 ± 0.87^{ab}	63.54 ± 2.68^{ab}	22.27 ± 0.93^{b}
	4 dSm^{-1}	8.45 ± 0.35^{bc}	18.77 ± 0.79^{b}	58.24 ± 2.45^{bc}	22.1 ± 0.93^{b}
	6 dSm^{-1}	7.53 ± 0.31^{cd}	15.39 ± 0.64^{c}	53.12 ± 2.24^{cd}	17.15 ± 0.72^{c}
	8 dSm^{-1}	6.77 ± 0.28^{de}	13.85 ± 0.58^{c}	47.80 ± 2.01^{de}	15.43 ± 0.65^{c}
	10 dSm^{-1}	6.23 ± 0.26^{e}	12.74 ± 0.53^{c}	43.98 ± 1.85^{d}	14.20 ± 0.59^{c}
Fragrant	Control	8.33 ± 0.35^{a}	20.18 ± 0.85^{a}	76.05 ± 3.20^{a}	25.84 ± 1.09^{a}
	2 dSm^{-1}	7.6 ± 0.32^{ab}	19.62 ± 0.82^{a}	64.2 ± 2.70^{b}	21.1 ± 0.89^{b}
	4 dSm^{-1}	6.78 ± 0.28^{ab}	16.49 ± 0.69^{b}	60.45 ± 2.55^{bc}	20.2 ± 0.85^{b}
	6 dSm^{-1}	6.12 ± 0.25^{cd}	13.80 ± 0.58^{c}	56.12 ± 2.36^{bc}	15.1 ± 0.63^{c}
	8 dSm^{-1}	5.50 ± 0.23^{d}	12.42 ± 0.52^{c}	50.50 ± 2.13^{cd}	13.59 ± 0.57^{c}
	10 dSm^{-1}	5.06 ± 0.21^{d}	11.42 ± 0.48^{c}	46.46 ± 1.96^{d}	12.50 ± 0.52^{c}
Blue Moon	Control	10.75 ± 0.45^{a}	24.55 ± 1.03^{a}	80.54 ± 3.39^{a}	29.5 ± 1.24^{a}
	2 dSm^{-1}	10.00 ± 0.42^{ab}	19.41 ± 0.81^{b}	64.55 ± 2.72^{b}	26.34 ± 1.11^{ab}
	4 dSm^{-1}	9.25 ± 0.39^{b}	18.21 ± 0.76^{bc}	60.77 ± 2.56^{bc}	24.1 ± 1.01^{b}
	6 dSm^{-1}	7.23 ± 0.30^{c}	17.13 ± 0.72^{bc}	58.56 ± 2.47^{bc}	17.18 ± 0.72^{c}
	8 dSm^{-1}	6.50 ± 0.27^{c}	15.41 ± 0.65^{cd}	52.23 ± 2.20^{cd}	15.46 ± 0.65^{c}
	10 dSm^{-1}	5.98 ± 0.25^{c}	14.18 ± 0.59^{d}	48.05 ± 2.02^{d}	14.22 ± 0.60^{c}
Paradise	Control	9.14 ± 0.38^{a}	22.58 ± 0.99^{a}	74.1 ± 3.12^{a}	26.98 ± 1.13^{a}
	2 dSm^{-1}	8.55 ± 0.36^{ab}	21.12 ± 0.89^{a}	62.1 ± 2.62^{b}	23.63 ± 0.99^{b}
	4 dSm^{-1}	7.67 ± 0.32^{bc}	20.28 ± 0.85^{a}	55.21 ± 2.32^{bc}	22.34 ± 0.94^{b}
	6 dSm^{-1}	6.7 ± 0.28^{cd}	13.94 ± 0.58^{b}	48.21 ± 2.03^{cd}	17.86 ± 0.75^{c}
	8 dSm^{-1}	6.03 ± 0.25^{d}	12.55 ± 0.52^{bc}	43.38 ± 1.83^{d}	16.07 ± 0.67^{c}
	10 dSm^{-1}	5.54 ± 0.23^{d}	10.55 ± 0.44^{c}	39.91 ± 1.68^{d}	14.79 ± 0.62^{c}
Superstar	Control	10.23 ± 0.43^{a}	24.50 ± 0.95^{a}	71.41 ± 3.01^{a}	26.74 ± 1.12^{a}
	2 dSm^{-1}	9.45 ± 0.39^{ab}	22.58 ± 0.95^{a}	68.23 ± 2.86^{ab}	25.40 ± 1.07^{ab}

	4 dSm^{-1}	8.79 ± 0.37^{b}	19.5 ± 0.82^{b}	60.27 ± 2.54^{b}	23.13 ± 0.97^{b}
	6 dSm^{-1}	7.02 ± 0.29^{c}	16.67 ± 0.70^{bc}	50.11 ± 2.11^{c}	17.50 ± 0.73^{c}
	8 dSm^{-1}	6.31 ± 0.26^{c}	14.55 ± 0.61^{c}	45.09 ± 1.90^{c}	15.75 ± 0.66^{c}
	10 dSm^{-1}	5.81 ± 0.24^{c}	11.39 ± 0.48^{d}	41.49 ± 1.75^{c}	14.49 ± 0.61^{c}
Happiness	Control	10.55 ± 0.44^{a}	23.69 ± 0.99^{a}	70.12 ± 2.95^{a}	25.02 ± 1.05^{a}
	2 dSm^{-1}	9.65 ± 0.40^{ab}	20.12 ± 0.84^{b}	60.14 ± 2.53^{b}	22.56 ± 0.95^{ab}
	4 dSm^{-1}	8.45 ± 0.35^{bc}	18.5 ± 0.78^{bc}	50.13 ± 2.11^{c}	21.19 ± 0.89^{b}
	6 dSm^{-1}	7.84 ± 0.33^{cd}	17.39 ± 0.73^{bc}	49.1 ± 2.07^{cd}	17.15 ± 0.72^{c}
	8 dSm^{-1}	7.05 ± 0.29^{de}	15.65 ± 0.66^{cd}	44.19 ± 1.86^{cd}	15.44 ± 0.65^{c}
	10 dSm^{-1}	6.49 ± 0.27^{e}	14.39 ± 0.60^{d}	40.65 ± 1.71^{d}	14.20 ± 0.59^{c}
Gladiator	Control	9.96 ± 0.42^{a}	22.54 ± 1.00^{a}	80.38 ± 3.39^{a}	25.45 ± 1.07^{a}
	2 dSm^{-1}	8.9 ± 0.37^{ab}	21.41 ± 0.90^{ab}	65.23 ± 2.75^{b}	22.17 ± 0.93^{ab}
	4 dSm^{-1}	8.44 ± 0.35^{bc}	18.65 ± 0.78^{bc}	52.26 ± 2.20^{c}	22.96 ± 0.96^{b}
	6 dSm^{-1}	7.33 ± 0.30^{cd}	16.26 ± 0.68^{cd}	55.12 ± 2.32^{cd}	16.98 ± 0.71^{c}
	8 dSm^{-1}	6.59 ± 0.27^{d}	14.63 ± 0.61^{d}	49.60 ± 2.09^{cd}	15.28 ± 0.64^{c}
	10 dSm^{-1}	6.06 ± 0.25^{d}	13.46 ± 0.56^{d}	45.63 ± 1.92^{d}	14.06 ± 0.59^{c}
Avon	Control	8.86 ± 0.37^{a}	23.55 ± 0.97^{a}	73.72 ± 3.11^{a}	27.45 ± 1.15^{a}
	2 dSm^{-1}	7.98 ± 0.33^{ab}	19.5 ± 0.82^{b}	65.31 ± 2.75^{a}	23.07 ± 0.97^{b}
	4 dSm^{-1}	7.44 ± 0.31^{bc}	18.5 ± 0.78^{b}	53.45 ± 2.25^{b}	23.77 ± 1.00^{b}
	6 dSm^{-1}	6.99 ± 0.29^{bc}	15.39 ± 0.64^{c}	55.74 ± 2.35^{bc}	17.15 ± 0.72^{c}
	8 dSm^{-1}	6.29 ± 0.26^{cd}	13.85 ± 0.58^{c}	50.16 ± 2.11^{bc}	15.44 ± 0.65^{c}
	10 dSm^{-1}	5.78 ± 0.24^{d}	12.74 ± 0.53^{c}	46.15 ± 1.94^{c}	14.20 ± 0.59^{c}
Sea Shell	Control	10.36 ± 0.43^{a}	23.89 ± 0.84^{a}	68.53 ± 2.89^{a}	25.67 ± 1.08^{a}
	2 dSm^{-1}	9.22 ± 0.38^{ab}	22.69 ± 0.95^{a}	62.3 ± 2.62^{ab}	22.38 ± 0.94^{b}
	4 dSm^{-1}	8.59 ± 0.36^{bc}	17.54 ± 0.74^{b}	56.42 ± 2.38^{b}	20.16 ± 0.85^{bc}
	6 dSm^{-1}	7.5 ± 0.31^{cd}	17.23 ± 0.72^{b}	42.3 ± 1.78^{c}	17.32 ± 0.73^{cd}
	8 dSm^{-1}	6.75 ± 0.28^{d}	15.50 ± 0.65^{bc}	35.22 ± 1.48^{cd}	15.59 ± 0.65^{d}
	10 dSm^{-1}	6.21 ± 0.26^{d}	13.27 ± 0.55^{c}	32.40 ± 1.36^{d}	14.34 ± 0.60^{d}
Double Delight	Control	10.88 ± 0.45^{a}	23.10 ± 0.95^{a}	78.29 ± 3.30^{a}	27.11 ± 1.14^{a}
	2 dSm^{-1}	9.2 ± 0.38^{b}	21.95 ± 0.92^{a}	71.11 ± 3.00^{a}	23.75 ± 1.00^{b}
	4 dSm^{-1}	7.7 ± 0.32^{c}	20.85 ± 0.87^{a}	58.23 ± 2.45^{b}	21.46 ± 0.90^{b}
	6 dSm^{-1}	7.51 ± 0.31^{cd}	17.66 ± 0.74^{b}	54.1 ± 2.28^{bc}	17.50 ± 0.73^{c}
	8 dSm^{-1}	6.75 ± 0.28^{cd}	15.89 ± 0.67^{bc}	48.69 ± 2.05^{bc}	15.75 ± 0.66^{c}
	10 dSm^{-1}	6.21 ± 0.26^{d}	13.65 ± 0.55^{c}	44.79 ± 1.88^{c}	14.49 ± 0.61^{c}
Sterling Silver	Control	8.12 ± 0.34^{a}	20.12 ± 0.84^{a}	70.84 ± 2.98^{a}	26.52 ± 1.11^{a}
	2 dSm^{-1}	6.65 ± 0.28^{b}	18.96 ± 0.79^{a}	58.88 ± 2.48^{b}	21.09 ± 0.88^{b}
	4 dSm^{-1}	6.3 ± 0.26^{bc}	17.87 ± 0.75^{a}	46.35 ± 1.95^{c}	15.73 ± 0.66^{c}
	6 dSm^{-1}	5.5 ± 0.23^{cd}	14.23 ± 0.60^{b}	40.1 ± 1.69^{c}	14.23 ± 0.60^{cd}
	8 dSm^{-1}	4.95 ± 0.20^{d}	12.80 ± 0.54^{b}	36.09 ± 1.52^{d}	12.80 ± 0.54^{d}
	10 dSm^{-1}	5.23 ± 0.22^{d}	10.23 ± 0.43^{c}	33.20 ± 1.40^{d}	11.78 ± 0.49^{d}
Mischief	Control	10.56 ± 0.44^{a}	22.41 ± 0.94^{a}	77.66 ± 3.27^{a}	26.05 ± 1.09^{a}
	2 dSm^{-1}	9.81 ± 0.41^{a}	19.25 ± 0.81^{b}	72.34 ± 3.05^{a}	23.64 ± 0.99^{a}
	4 dSm^{-1}	8.3 ± 0.35^{b}	18.26 ± 0.77^{b}	60.45 ± 2.55^{b}	20.31 ± 0.85^{b}
	6 dSm^{-1}	7.65 ± 0.32^{bc}	13.26 ± 0.55^{c}	56.24 ± 2.37^{bc}	16.34 ± 0.68^{c}
	8 dSm^{-1}	6.88 ± 0.29^{c}	11.93 ± 0.50^{c}	50.61 ± 2.13^{c}	14.70 ± 0.62^{c}
	10 dSm^{-1}	6.33 ± 0.26^{c}	10.98 ± 0.46^{c}	46.56 ± 1.96^{c}	13.53 ± 0.57^{c}
King's Ransom	Control	9.76 ± 0.35^{a}	23.10 ± 0.85^{a}	73.80 ± 3.71^{a}	28.32 ± 1.04^{a}
	2 dSm^{-1}	9.15 ± 0.32^{a}	20.45 ± 0.73^{b}	68.66 ± 2.45^{a}	23.53 ± 0.84^{b}
	4 dSm^{-1}	8.05 ± 0.29^{b}	18.08 ± 0.66^{c}	57.30 ± 2.11^{b}	22.58 ± 0.83^{b}
	6 dSm^{-1}	6.97 ± 0.22^{c}	13.20 ± 0.43^{d}	52.30 ± 1.72^{bc}	16.59 ± 0.54^{c}
	8 dSm^{-1}	6.19 ± 0.22^{cd}	11.72 ± 0.43^{d}	46.45 ± 1.71^{cd}	14.73 ± 0.54^{cd}
	10 dSm^{-1}	5.77 ± 0.19^{d}	10.93 ± 0.36^{d}	43.31 ± 1.42^{d}	13.73 ± 0.45^{d}
First Prize	Control	8.80 ± 0.32^{a}	20.85 ± 0.76^{a}	80.76 ± 2.97^{a}	26.76 ± 0.98^{a}
	2 dSm^{-1}	8.03 ± 0.28^{ab}	19.74 ± 0.70^{ab}	72.91 ± 2.61^{a}	26.09 ± 0.93^{a}
	4 dSm^{-1}	7.38 ± 0.27^{bc}	17.97 ± 0.66^{b}	64.04 ± 2.35^{b}	23.16 ± 0.85^{b}
	6 dSm^{-1}	6.52 ± 0.21^{cd}	13.59 ± 0.44^{c}	57.31 ± 1.88^{bc}	16.75 ± 0.55^{c}
	8 dSm^{-1}	5.79 ± 0.21^{de}	12.07 ± 0.44^{cd}	50.89 ± 1.87^{cd}	14.87 ± 0.54^{cd}
	10 dSm^{-1}	5.40 ± 0.17^{e}	11.25 ± 0.37^{d}	47.45 ± 1.56^{d}	13.87 ± 0.45^{d}

Table shows the mean square values of three replicates per treatment; ± S.E (Standard error); Values followed by the same letter do not differ ($P \leq 0.05$) using the LSD test; dSm^{-1} = Deci siemens per meter

Proline contents and glycine betaine (mg^{-1} protein)

Proline accumulation is one of the most often described changes induced by water and salt stress in plants and is frequently considered to be involved in stress resistance mechanisms. Proline contents (60 days after sowing) in all the rose genotypes were significantly ($P \leq 0.05$) influenced by different salt stress levels (Table 4). The highest production of proline contents (0.97) was recorded in plants growing under control and increased with the increase in salt stress levels as 1.15; 1.45; 1.46; 1.35 and 1.3 mg^{-1} protein respectively in Blue Moon. The following as Sunset and Double Delight showed a maximum of 1.36 and 1.25 proline contents under the highest level of salt stress (10 dS m^{-1}).Whereas, minimum in genotype Avon (0.66; 0.77; 0.84; 1.35; 1.32 and 1.12 mg^{-1} protein) among the different salinity levels. Salt stress and Glycine betaine exhibited significant results, with an increase in salt concentration GB more concentration. Highest glycine betaine (1.96) was recorded in plants growing under control and enhanced with the increase in salt stress as (1.96, 2.94, 3.81, 4.1, 3.99, and 3.8 mg^{-1} protein) respectively in Blue Moon, followed by Sea Shell genotype (1.74, 3.09, 3.35, 3.65, 3.55, 3.36 mg^{-1} protein). Whereas, minimum in Mischief (1.26, 2.49, 2.69, 3.48, 3.4, and 3.21 mg^{-1} protein) among the salinity levels (Table 4).

Effect of salt concentration on sodium and chloride ions of 15 rose varieties

Results regarding the sodium ions revealed that lowest sodium ions (1.63) were recorded in plants growing under control (Table 4) and enhanced with the increase in salt stress as 3.09, 5.88, 8.34, 9.01, and 9.55 mg g^{-1} dry wt respectively in Sunset. Afterward, Blue Moon revealed 1.57 sodium ions under control, and it increased (6.99) under 10dSm^{-1} salt stress level. Whereas, minimum in Golden Giant (1.28, 2.44, 4.64, 8.1, 8.74, and 9.27 mg g^{-1} Dry wt) among the different salinity levels. Lowest chloride ions (4.73) was recorded in plants growing under control and enhanced with the increase in salt stress as an observed minimum in Blue Moon (6.21, 7.02, 12.21, 12.11, and 12.83 mg g^{-1} dry wt) respectively (Table 4). Whereas, maximum in Sterling Silver (3.23, 10.88, 15.65, 15.8, 17.21 and 17.98 mg g^{-1} dry wt) among the salinity levels. Under the highest (10 dS m^{-1}) level of salt-stressed condition, the comparison among genotypes showed that the maximum increase in chloride ions was recorded in Avon (18.15), but the minimum in Blue Moon (12.83 mg g^{-1} dry wt).

Table 4 Effect of salinity on the percentage reduction in biochemical characters of various rose genotypes subjected to NaCl (0, 2, 4, 6,8,10 dS m^{-1}) after 60 days of sowing

Rose Varieties	Treatments	Biochemical characters		Ion contents	
		Proline contents (mg^{-1} protein)	Glycine betaine (mg^{-1} protein)	Na+ ions	Cl^{-1} ions (mg g^{-1} dry wt)
Sunset	Control	0.95 ± 0.04^{c}	1.65 ± 0.06^{d}	1.63 ± 0.06^{e}	4.13 ± 0.17^{d}
	2 dSm^{-1}	1.1 ± 0.04^{bc}	1.89 ± 0.07^{cd}	3.09 ± 0.13^{d}	10.66 ± 0.44^{c}
	4 dSm^{-1}	1.22 ± 0.05^{ab}	2.09 ± 0.08^{c}	5.88 ± 0.24^{c}	11.23 ± 0.47^{c}
	6 dSm^{-1}	1.38 ± 0.05^{a}	3.3 ± 0.13^{a}	8.34 ± 0.35^{b}	13.65 ± 0.57^{b}
	8 dSm^{-1}	1.37 ± 0.05^{a}	3.1 ± 0.13^{a}	9.01 ± 0.38^{ab}	14.74 ± 0.62^{ab}
	10 dSm^{-1}	1.36 ± 0.05^{a}	2.5 ± 0.10^{b}	9.55 ± 0.40^{a}	15.62 ± 0.65^{a}
Golden Giant	Control	0.81 ± 0.03^{d}	1.83 ± 0.07^{b}	1.28 ± 0.05^{e}	4.1 ± 0.17^{e}
	2 dSm^{-1}	0.95 ± 0.04^{cd}	2.17 ± 0.09^{b}	2.44 ± 0.10^{d}	9.56 ± 0.40^{d}
	4 dSm^{-1}	1.11 ± 0.04^{bc}	3.48 ± 0.14^{a}	4.64 ± 0.16^{c}	12.23 ± 0.51^{c}
	6 dSm^{-1}	1.31 ± 0.05^{a}	3.85 ± 0.16^{a}	8.1 ± 0.34^{b}	14.41 ± 0.60^{b}
	8 dSm^{-1}	1.32 ± 0.05^{a}	3.56 ± 0.15^{a}	8.74 ± 0.36^{ab}	15.56 ± 0.65^{ab}
	10 dSm^{-1}	1.2 ± 0.05^{ab}	3.54 ± 0.14^{a}	9.27 ± 0.39^{a}	16.49 ± 0.69^{a}
Fragrant	Control	0.76 ± 0.03^{b}	1.43 ± 0.06^{c}	1.47 ± 0.06^{e}	4.23 ± 0.17^{e}
	2 dSm^{-1}	0.88 ± 0.03^{b}	1.58 ± 0.06^{c}	2.79 ± 0.11^{d}	10.12 ± 0.42^{d}
	4 dSm^{-1}	0.92 ± 0.03^{b}	1.83 ± 0.07^{c}	5.31 ± 0.22^{c}	12.66 ± 0.53^{c}
	6 dSm^{-1}	1.32 ± 0.05^{a}	3.5 ± 0.14^{a}	7.9 ± 0.33^{b}	14.64 ± 0.61^{bc}
	8 dSm^{-1}	1.41 ± 0.05^{a}	3.25 ± 0.13^{ab}	8.53 ± 0.35^{ab}	15.81 ± 0.66^{ab}
	10 dSm^{-1}	1.3 ± 0.05^{a}	2.86 ± 0.12^{b}	9.04 ± 0.38^{a}	16.75 ± 0.70^{a}
Blue moon	Control	0.97 ± 0.04^{c}	1.96 ± 0.08^{c}	1.57 ± 0.06^{e}	4.73 ± 0.19^{c}
	2 dSm^{-1}	1.15 ± 0.04^{bc}	2.94 ± 0.12^{b}	2.98 ± 0.12^{d}	6.21 ± 0.26^{bc}
	4 dSm^{-1}	1.45 ± 0.06^{a}	3.81 ± 0.16^{a}	4.4 ± 0.18^{c}	7.02 ± 0.29^{b}
	6 dSm^{-1}	1.46 ± 0.06^{a}	4.1 ± 0.17^{a}	5.98 ± 0.25^{b}	12.21 ± 0.51^{a}
	8 dSm^{-1}	1.35 ± 0.05^{ab}	3.99 ± 0.16^{a}	6.89 ± 0.29^{a}	12.11 ± 0.51^{a}
	10 dSm^{-1}	1.3 ± 0.05^{ab}	3.8 ± 0.16^{a}	6.99 ± 0.29^{a}	12.83 ± 0.54^{a}
Paradise	Control	0.71 ± 0.02^{c}	1.64 ± 0.06^{c}	1.45 ± 0.06^{e}	4.08 ± 0.17^{e}
	2 dSm^{-1}	0.81 ± 0.03^{bc}	1.89 ± 0.07^{c}	2.77 ± 0.11^{d}	11.27 ± 0.47^{d}
	4 dSm^{-1}	0.88 ± 0.03^{b}	2.08 ± 0.08^{c}	5.26 ± 0.22^{c}	13.16 ± 0.55^{cd}
	6 dSm^{-1}	1.3 ± 0.05^{a}	3.27 ± 0.13^{b}	8.00 ± 0.33^{b}	15.23 ± 0.64^{bc}
	8 dSm^{-1}	1.27 ± 0.05^{a}	3.53 ± 0.14^{ab}	8.64 ± 0.36^{ab}	16.44 ± 0.69^{ab}

	10 dSm^{-1}	1.21 ± 0.05^{a}	3.74 ± 0.15^{a}	9.15 ± 0.38^{a}	17.43 ± 0.73^{a}
Superstar	Control	0.71 ± 0.02^{c}	1.66 ± 0.07^{b}	1.51 ± 0.06^{e}	4.01 ± 0.16^{d}
	2 dSm^{-1}	0.81 ± 0.03^{c}	1.8 ± 0.07^{b}	2.88 ± 0.12^{d}	10.44 ± 0.44^{c}
	4 dSm^{-1}	0.88 ± 0.03^{b}	1.95 ± 0.08^{b}	5.47±0.23^{c}	11.89±0.50^{c}
	6 dSm^{-1}	1.3 ± 0.05^{a}	3.36 ± 0.14^{a}	8.6 ± 0.36^{b}	14.91 ± 0.62^{b}
	8 dSm^{-1}	1.27 ± 0.05^{ab}	3.25 ± 0.13^{a}	9.28 ± 0.39^{ab}	16.10 ± 0.67^{ab}
	10 dSm^{-1}	1.21 ± 0.05^{ab}	3.01 ± 0.12^{a}	9.84 ± 0.41^{a}	17.06 ± 0.72^{a}
Happiness	Control	0.71 ± 0.02^{c}	1.74 ± 0.07^{b}	1.46 ± 0.06^{e}	3.8 ± 0.16^{e}
	2 dSm^{-1}	0.81 ± 0.03^{c}	1.94 ± 0.08^{b}	2.78 ± 0.12^{d}	10.26 ± 0.43^{d}
	4 dSm^{-1}	0.88 ± 0.03^{b}	2.11 ± 0.08^{b}	5.29 ± 0.22^{c}	12.75 ± 0.56^{c}
	6 dSm^{-1}	1.3 ± 0.05^{a}	3.42 ± 0.14^{a}	8.42 ± 0.35^{b}	14.96 ± 0.63^{b}
	8 dSm^{-1}	1.27 ± 0.05^{a}	3.35 ± 0.14^{a}	9.10 ± 0.38^{ab}	16.15 ± 0.68^{ab}
	10 dSm^{-1}	1.21 ± 0.05^{a}	3.2 ± 0.13^{a}	9.64 ± 0.40^{a}	17.12 ± 0.72^{a}
Gladiator	Control	0.83 ± 0.03^{c}	1.53 ± 0.06^{b}	1.39 ± 0.05^{e}	3.56 ± 0.15^{e}
	2 dSm^{-1}	0.93 ± 0.03^{bc}	1.69 ± 0.07^{b}	2.64 ± 0.11^{d}	11.66 ± 0.49^{d}
	4 dSm^{-1}	1.05 ± 0.04^{b}	1.83 ± 0.07^{b}	5.03 ± 0.21^{c}	13.38 ± 0.59^{cd}
	6 dSm^{-1}	1.35 ± 0.05^{a}	3.61 ± 0.15^{a}	8.34 ± 0.35^{b}	15.47 ± 0.65^{bc}
	8 dSm^{-1}	1.25 ± 0.05^{a}	3.5 ± 0.14^{a}	9.01 ± 0.38^{ab}	16.70 ± 0.70^{ab}
	10 dSm^{-1}	1.24 ± 0.05^{a}	3.21 ± 0.13^{a}	9.55 ± 0.40^{a}	17.71 ± 0.73^{a}
Avon	Control	0.66 ± 0.02^{d}	1.37 ± 0.05^{d}	1.42 ± 01^{e}	4.1 ± 0.17^{e}
	2 dSm^{-1}	0.77 ± 0.03^{cd}	2.6 ± 0.10^{c}	2.70 ± 0.11^{d}	11.58 ± 0.48^{d}
	4 dSm^{-1}	0.84 ± 0.03^{c}	2.85 ± 0.12^{bc}	5.13 ± 0.21^{c}	14.12 ± 0.56^{c}
	6 dSm^{-1}	1.35 ± 0.05^{a}	3.55 ± 0.14^{a}	8.42 ± 0.35^{b}	15.86 ± 0.66^{bc}
	8 dSm^{-1}	1.32 ± 0.05^{a}	3.45 ± 0.14^{a}	9.10 ± 0.38^{ab}	17.12 ± 0.72^{ab}
	10 dSm^{-1}	1.12 ± 0.04^{b}	3.21 ± 0.13^{ab}	9.64 ± 0.40^{a}	18.15 ± 0.76^{a}
Sea shell	Control	0.76 ± 0.03^{c}	1.74 ± 0.07^{c}	1.47 ± 0.06^{d}	3.56 ± 0.15^{d}
	2 dSm^{-1}	0.86 ± 0.03^{bc}	3.09 ± 0.13^{b}	2.80 ± 0.11^{c}	10.92 ± 0.46^{c}
	4 dSm^{-1}	0.96 ± 0.04^{b}	3.35 ± 0.14^{ab}	5.33 ± 0.22^{b}	13.36 ± 0.61^{b}
	6 dSm^{-1}	1.2 ± 0.05^{a}	3.65 ± 0.15^{a}	8.9 ± 0.37^{a}	15.68 ± 0.66^{a}
	8 dSm^{-1}	1.25 ± 0.05^{a}	3.55 ± 0.14^{ab}	9.61 ± 0.40^{a}	16.93 ± 0.71^{a}
	10 dSm^{-1}	1.21 ± 0.05^{a}	3.36 ± 0.14^{ab}	9.51 ± 0.40^{a}	17.21 ± 0.72^{a}
Double Delight	Control	0.82 ± 0.03^{b}	1.95 ± 0.08^{d}	1.42 ± 0.06^{d}	4.43 ± 0.18^{d}
	2 dSm^{-1}	0.96 ± 0.04^{b}	2.21 ± 0.09^{cd}	2.71 ± 0.11^{c}	11.93 ± 0.50^{c}
	4 dSm^{-1}	1.25 ± 0.05^{a}	2.47 ± 0.10^{c}	5.15 ± 0.21^{b}	14.66 ± 0.66^{b}
	6 dSm^{-1}	1.23 ± 0.05^{a}	3.69 ± 0.15^{a}	8.98 ± 0.37^{a}	16.23 ± 0.68^{ab}
	8 dSm^{-1}	1.32 ± 0.05^{a}	3.54 ± 0.14^{ab}	9.70 ± 0.40^{a}	17.01 ± 0.71^{a}
	10 dSm^{-1}	1.25 ± 0.05^{a}	3.21 ± 0.13^{b}	9.8 ± 0.41^{a}	17.45 ± 0.73^{a}
Sterling Silver	Control	0.72 ± 0.03^{b}	1.51 ± 0.06^{b}	1.43 ± 0.06^{a}	3.23 ± 0.13^{d}
	2 dSm^{-1}	0.73 ± 0.03^{b}	1.55 ± 0.06^{b}	2.71 ± 0.11^{ab}	10.88 ± 0.45^{c}
	4 dSm^{-1}	0.82 ± 0.03^{b}	1.64 ± 0.06^{b}	5.16 ± 0.21^{b}	15.65 ± 0.66^{b}
	6 dSm^{-1}	1.1 ± 0.04^{a}	3.21 ± 0.13^{a}	7.82 ± 0.32^{c}	15.8 ± 0.66^{ab}
	8 dSm^{-1}	1.06 ± 0.04^{a}	3.11 ± 0.13^{a}	8.44 ± 0.35^{d}	17.21 ± 0.72^{ab}
	10 dSm^{-1}	1.05 ± 0.04^{a}	2.9 ± 0.12^{a}	8.95 ± 0.37^{e}	17.98 ± 0.75^{a}
Mischief	Control	0.91 ± 0.03^{d}	1.26 ± 0.05^{c}	1.38 ± 0.05^{d}	3.26 ± 0.13^{d}
	2 dSm^{-1}	1.01 ± 0.04^{cd}	2.49 ± 0.10^{b}	2.63 ± 0.11^{a}	12.02 ± 0.50^{c}
	4 dSm^{-1}	1.12 ± 0.04^{abc}	2.69 ± 0.11^{b}	5.00 ± 0.21^{a}	14.23 ± 0.60^{b}
	6 dSm^{-1}	1.3 ± 0.05^{a}	3.48 ± 0.14^{a}	9.00 ± 0.37^{b}	14.01 ± 0.59^{bc}
	8 dSm^{-1}	1.2 ± 0.05^{ab}	3.4 ± 0.14^{a}	9.72 ± 0.41^{c}	15.13 ± 0.63^{ab}
	10 dSm^{-1}	1.11 ± 0.04^{bc}	3.21 ± 0.13^{a}	9.7 ± 0.40^{a}	17.21 ± 0.72^{a}
King’s Ransom	Control	0.86 ± 0.03^{d}	1.35 ± 0.05^{c}	1.42 ± 0.05^{d}	4.62 ± 0.17^{d}
	2 dSm^{-1}	1.00 ± 0.03^{cd}	2.71 ± 0.09^{b}	2.78 ± 0.09^{c}	11.73 ± 0.42^{c}
	4 dSm^{-1}	1.10 ± 0.04^{bc}	2.94 ± 0.10^{ab}	6.69 ± 0.24^{b}	13.87 ± 0.51^{b}
	6 dSm^{-1}	1.35 ± 0.04^{a}	3.30 ± 0.10^{a}	10.04 ± 0.33^{a}	14.27 ± 0.33^{b}
	8 dSm^{-1}	1.2 ± 0.04^{ab}	3.27 ± 0.12^{a}	9.92 ± 0.36^{a}	15.20 ± 0.56^{ab}
	10 dSm^{-1}	1.10 ± 0.03^{bc}	3.21 ± 0.10^{a}	10.66 ± 0.35^{a}	16.34 ± 0.53^{a}
First Prize	Control	0.83 ± 0.03^{d}	1.62 ± 0.05^{c}	1.38 ± 0.05^{e}	3.81 ± 0.14^{e}
	2 dSm^{-1}	0.97 ± 0.03^{cd}	3.00 ± 0.10^{b}	2.69 ± 0.09^{d}	11.10 ± 0.39^{d}
	4 dSm^{-1}	1.04 ± 0.03^{c}	3.16 ± 0.11^{ab}	4.98 ± 0.18^{c}	13.30 ± 0.49^{c}
	6 dSm^{-1}	1.35 ± 0.04^{a}	3.49 ± 0.11^{a}	9.14 ± 0.30^{b}	15.49 ± 0.51^{b}
	8 dSm^{-1}	1.19 ± 0.04^{b}	3.37 ± 0.12^{ab}	9.74 ± 0.35^{ab}	16.51 ± 0.60^{ab}
	10 dSm^{-1}	1.11 ± 0.03^{bc}	3.36 ± 0.11^{ab}	10.47 ± 0.34^{a}	17.74 ± 0.58^{a}

Table shows the mean square values of three replicates per treatment; ± S.E (Standard error); Values followed by the same letter do not differ ($P \leq 0.05$) using the LSD test; dSm^{-1} = Deci siemens per meter

Discussion

Salinity is a problem in arid and semiarid areas worldwide. Plants growing under salt-stress conditions exhibit water deficiencies, photosynthetic declines and growth reductions when compared with growth under normal conditions. Here, fifteen rose genotypes named as (Sunset, Golden Giant, Fragrant Gold, Blue Moon, Paradise, Superstar, Happiness, Gladiator, Avon, Sea Shell, Double Delight, Sterling Silver, Mischief, King's Ransom, First Prize) were selected to screen them for salt tolerance based on growth and physiological characteristics. In this study, four concentrations of NaCl (0, 2, 4, 6,8,10 dSm^{-1}) were applied to the rose genotypes under controlled conditions to check their effects on plant growth and physiological functioning.

In this study, significant decrease in root/ shoot length, plant fresh and dry biomass, leaf area per plant were found in response to salinity. It is a well-known fact that Na is a toxic element whose higher concentration disturbs the different metabolic activities of plants. The varieties which were successful in holding the Na^+ in the root were considered tolerant (Akram et al., 2007). Our results are in line with Khodarahmpour (2012) who described that different rose genotypes showed different shoot lengths at various salinity levels. Reduction in plant height with increase of salt stress may be due to toxic ion accumulation in the plant cells which ultimately leads to a decrease in cell division and expansion (Munns, 1993). The root is an important part of the plant that absorbs water and nutrients from the soil. Therefore, the length of root gives clear information about the reaction of the plant under salinity stress conditions (Khodarahmpour, 2012). In our experiment, results revealed that with the increase of salinity, root length decreased. Same results were defined by Ibrahim et al. (2007) who reported decreasing trend of root length due to increase in salt stress. In the case of cotton crop root, shoot, and leaf biomass was reduced with the increase of salt stress (Meloni et al., 2001). Plant dry biomass was reduced with high salt concentration which ultimately delayed cell wall maturity (Taleisnik et al., 2009). Similar findings were observed by Hakim et al. (2014) on the root/shoot dry biomass of rice which significantly decreased with the increase in the salinity. This decrease of dry weight might be due to certain reasons as follows (a) reduction in photosynthesis per unit leaf area which results in less supply of sugars needed for the growth of shoots, (b) decrease of turgor pressure in plants that reduced the water potential (c) hindrance in mineral supply could be responsible for inhibited growth. Also, salt stress affected the cell size, or cell production rate, hence reduced shoot and root dry weight occur. Our outcomes are strongly in agreement with Mathur et al. (2006); Jamil et al. (2007) who stated that bean plant and sugarcane significantly decreased leaf area in the response of salt concentrations.

According to our findings biochemical characters chlorophyll, photosynthesis, transpiration rate, stomatal conductance reduced in salt-treated plants as compared to control. However, proline, glycine betaine, and both ions Na^+ and Cl^- increased with the increase of salinity level. It is a well-known fact that photosynthetic efficiency depends on chlorophyll which plays an important role in photochemical reactions of photosynthesis (Taiz et al., 2006). This change in leaf chlorophyll contents might be due to decrease of biosynthesis or increase in degradation of chlorophyll molecule under salinity. It is also reported that breakdown of the ultrastructure of chloroplast comprising plastid envelope and thylakoids occur in saline conditions or might be photosynthetic aperture rupture due to sodium toxicity or salt-induced oxidative damage (Mittler, 2002). On the other hand, reduction in chlorophyll contents may be due to the formation of proteolytic enzymes such as chlorophyllase, which is accountable for chlorophyll degradation (Sabater & Rodriguez, 1978). Chlorophyll content can be taken as a biochemical marker to screen salt tolerant plants (Ashraf et al., 2013). Stepien et al. (2009) found that salt-tolerant genotypes indicate more or unchanged chlorophyll content under salinity stress, while chlorophyll contents decrease in salt-sensitive genotype. Our findings are in agreement with results obtained by Khattab (2007); Amirjani (2010); Sadak et al. (2010); Taie et al. (2013). The results of our research are analogous with the earlier found outcomes in sunflower (Akram & Ashraf, 2011), okra (Saleem et al., 2011), wheat (Kanwal et al., 2011), turnip (Noreen et al., 2010), and eggplant (Abbas et al., 2010) in which it was reported that different saline regimes significantly decreased the stomatal conductance (gs) of plants. It has been reported that proline contents in salt stress improved plants increase because proline protects plants against various stress mechanisms (Khaled et al., 2003; Liu et al., 2020). Therefore, improvement of plant tolerance to salinity stress is important for good yield and production. Sakamoto and Murata (2002) described that in their research glycinebetaine (GB) depicted maximum accumulation in response to salinity. In root 5- fold and in leaves 6.8 fold increase CB at NaCl @ 300 mmol L^{-1}, as compared with the control.

According to Chavan and Karadge (1986); Turan et al. (2007), increasing levels of salts encouraged absorption of Na and Cl in both shoot and root. Accumulation of Cl in root tissue is disruptive to membrane uptake mechanisms which results in increased translocation of Cl to the shoots (Yousif et al., 1972). Though Cl^- ion is an main essential micronutrient and plays a very important role in regulation of stomata, photosynthesis, and control of cytoplasmic activities (Franco-Navarro et al., 2019), but it is very toxic at higher concentrations and effects metabolic activities going on in cytoplasm of a plant cell (Tavakkoli et al., 2011). Our result are at par with study of Richter et al. (2019) who observed higher concentration of Cl^- ions in root and shoot of *V. faba* L.

Moreover, Pollastri et al. (2018) reported that *Arundo donax* L. plants exhibited excessive accumulation of Cl^- ion under salt stress.

Conclusion

In present study, we investigated the growth, physiological and biochemical responses of fifteen rose cultivars against salt stress. According to results, the salt stress induced diverse changes among all the cultivars studied. However, in absolute terms, the cultivar Blue Moon showed more vigorous growth among the 15 cultivars studied which suggests that Blue Moon could be used in saline soils and good yield can be ensured even under salty conditions.

Author Contribution Statements: Tehseen Ashraf conducted a research experiment and wrote the manuscript. Zahoor Hussain conceived and designed the research project. Tehseen Ashraf and Muhammad Asim contributed in statistical analysis for screening of rose cultivars for salinity tolerance and sensitive attributes of stress. Naveeda Anjum contributed in data interpretation.

Conflict of Interest: The authors declare that they have no conflict of interest.

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