

Effect of Salt Stress (NaCl) on Growth, Morphology and Physiology of Sunflower (*Helianthus annus* L.)

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Abstract: This experiment was conducted with completely randomized design (CRD) to study the effect of NaCl on morphological and physiological parameters of sunflower. The plants were subjected to different concentrations of NaCl (20, 40 and 60 mM) after 15 days of germination. Salinity affected morphology and physiology aspects of plants. Results showed a significant reduction in morphological parameters (shoot fresh weight, root dry weight, shoot length) and in physiological parameter (transpiration rate), In contrast root fresh weight, shoot dry weight, root length, photosynthetic rate, stomatal conductance of CO₂ and sub- stomatal conductance showed non- significant results.

Key words: NaCl • Sunflower • Growth • Physiology • Morphology

INTRODUCTION

Sunflower (*Helianthus annus* L.) is a very stout and upright plant that grows to heights of over 6 feet. Leaves can be used as cattle feed while the stem contains a fiber which may be used in paper production. Sunflower leaves have a stalk and can measure over 12 inches long [1]. The stem and leaves are covered with sticky hairs that attract many insects. Flowers can measure over 6 inches in diameter with yellow ray flowers (15-30) and purplish-brown disk flowers. The seeds are actually achene (a hard seed-like fruit) which ripens in each of the dozens of disk flowers in the central "head" of the flower [2]. Its seeds were a food source rich in fat (vegetable oil) and protein. Sunflower is native to America and attracts butterflies, other insects, insect-eating birds and seed-eating birds. Oil obtained from its seeds is used to produce biodiesel and margarine. Seeds used as a snack. About 7% of arable lands of world are under salinity pressure [3].

High levels of soil salinity negatively affect productivity of most field crops [4]. Saline soil reduces oil production and oil yield of sunflower [5]. Salinity is also considered a major abiotic stress and significant factor affecting crop production all over the world and especially arid and semiarid regions [6, 7]. Salts in the soil water may inhibit plant growth for two reasons. First, the presence of salt in the soil solution reduces the ability of the plant to take up water and this leads to reductions in the growth rate. This is referred to as the osmotic or water-deficit

effect of salinity. Second, if excessive amounts of salt enter the plant in the transpiration stream there will be injury to cells in the transpiring leaves and this may cause further reductions in growth. This is called the salt-specific or ion-excess effect of salinity [8]. The objective of this study was to determine the effect of NaCl on growth, morphological and physiological attributes of sunflower.

MATERIALS AND METHODS

Experiment was conducted at the botanical garden of University Of Gujrat, Gujrat, Pakistan during April-May 2012. Soil used for this experiment was taken from botanical garden of University of Gujrat. The variety 555.1 of *Helianthus annus* was used. After 10 days of germination plants were thinned and 2 plants per pot were maintained. There were following NaCl treatments:

T₀ = 0 mM (control)
T₁ = 20mM
T₂ = 40mM
T₃ = 60mM

Experimental design was laid down in CRD (Completely Randomized Design) with four replicates. Root length, shoot length, root weight and shoot weight was measured immediately after harvest to evaluate their response to salinity. In order to measure dry weight

of shoot and to analyses ion concentrations in seedling, plant material was dried for 4 days at 60°C. Na concentration was measured using flame photometry following Sulphuric acid (H₂SO₄) digestion. All the data was subjected to analysis of variance.

RESULTS AND DISCUSSION

Results obtained for NaCl stress on sunflower have been presented in Table 1 and Figures 1-15.

Root Fresh Weight (g): There was a significant reduction in root fresh weight of sunflower when compared with control due to salt stress. However, T₃ (60mM) treatment showed relative increase in root fresh weights compared to T₁ (20mM) and T₂ (40mM) treatments (Fig. 1). Maximum fresh root weight was observed in T3 plants which were subjected with 60 mM NaCl when compared with control (0mM).

Shoot Fresh Weight (g): There was a relatively increase in shoot fresh weight of sunflower (*Helianthus annus* L.), when it was subjected with 60 mM of NaCl then it showed greater effect, when compared with control that is 0mM of NaCl. This might be due to lateral growth of plant (Fig. 2).

Root Length (cm): Root length of sunflower subjected to salt stress is decreased when compared with that of control of same plant (Fig. 3). It showed relative increase in root length as compared to control (0mM) of NaCl. But it was observed that T₂ plants which were subjected to 40mM of NaCl showed a relative decrease in root length with reference to T₀ (0mM), T₁ (20mM) and T₃ (60mM) of NaCl.

Shoot Length (cm): A significant increase in shoot length of sunflower (*Helianthus annus* L.) was observed when subjected to 60mM concentration of NaCl as compared with control group (0mM) (Fig. 4). In other words shoot length increases with increase in concentration of NaCl.

Root Dry Weight (g): The dry weight of root showed unusual results when compared with other researcher's work. Root dry weight showed increase in T₂ and T₃ plants which were subjected to (20mM) and (40mM) of NaCl respectively when compared to control (0mM) and T₃ (60mM) plants. It was observed that this parameter of dry root weight for 555.1 variety of sunflower may be tolerant to salinity (Fig. 5).

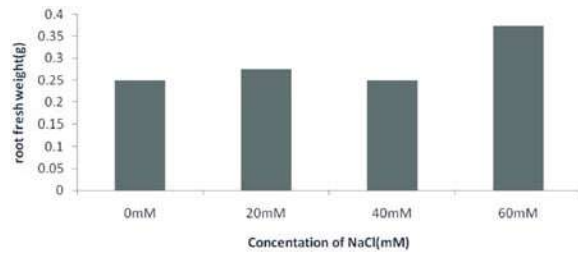


Fig. 1: Effect of NaCl on root fresh weight (g)

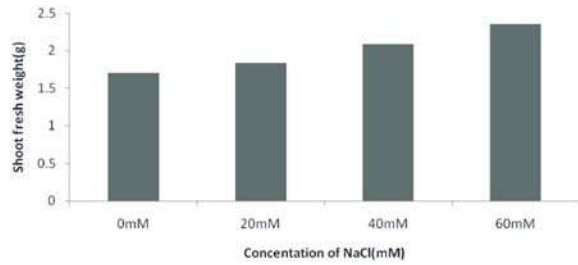


Fig. 2: Effect of NaCl on shoot fresh weigh(g)

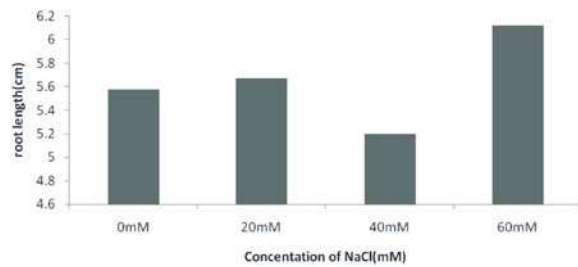


Fig. 3: Effect of NaCl on root length (cm)

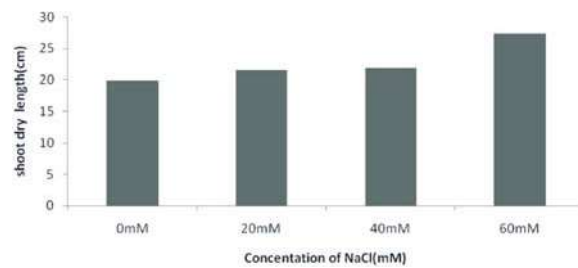


Fig. 4: Effect of NaCl on shoot length (cm)

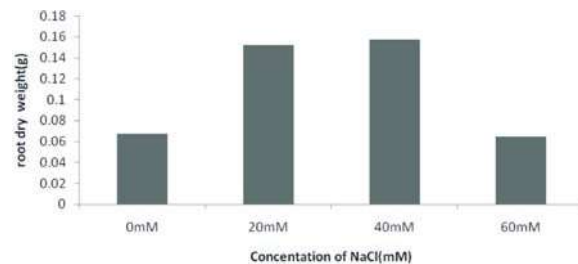


Fig. 5: Effect of NaCl on root dry weight (g)

Shoot Dry Weight (g): It was observed that shoot dry weight of sunflower of variety 555.1 is positively affected by NaCl salt stress (Fig. 6). It was observed that shoot dry

Table 1: Effect of NaCl on morpho-physiological attributes of sunflower

Source	Df	MS of root fresh wt (g)	M.s of shoot fresh wait(g)	M.s of root length (cm)	M.s of shoot length (cm)	M.s of root dry weight	M.s of shoot dry weight	M.s of sub-stomatal of CO ₂	M.s of transpiration rate(E)	M.s of stomatal conductance	M.s of photosynthetic rate (A)	M.s of chlorophyll a	M.s of chlorophyll b	M.s of carotenoid	M.s of Na+ content on dry root	M.s of Na+ content of dry shoot
NaCl	3	0.014ns	0.340*	0.688ns	42.557*	0.001**	0.027ns	5904.395ns	118.638*	0.133ns	16.523ns	7.166ns	1.956ns	2.416ns	2337.813ns	51.026ns
Error	12	0.004	0.094	0.964	7.401	1.270	0.011	5376.812	27.403	0.048	53.701	3.470	6.645	3.75	5070.899	11.373

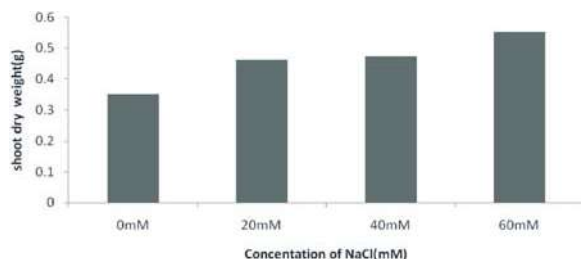


Fig. 6: Effect of NaCl on shoot dry weight (g)

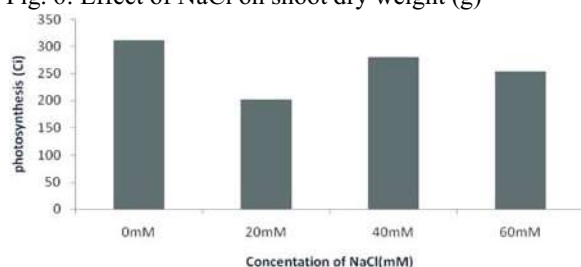
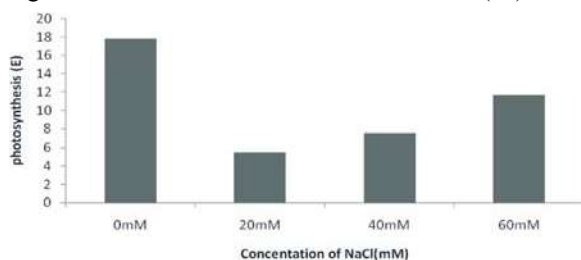
Fig. 7: Effect of NaCl on Sub-Stomatal CO₂ (Ci)

Fig. 8: Effect of NaCl on Transpiration rate (E)

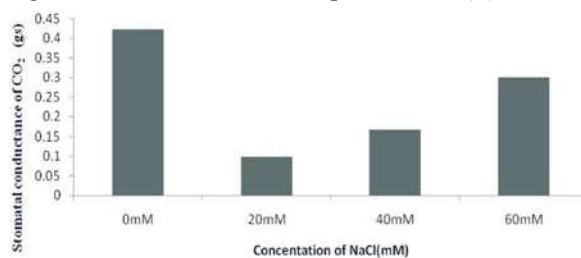
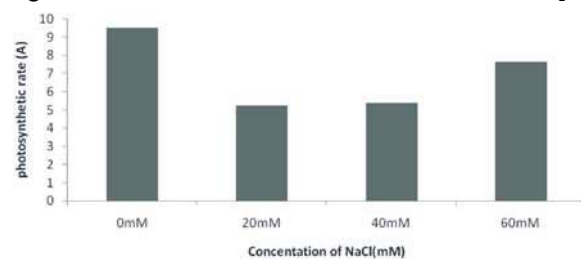
Fig. 9: Effect of NaCl on Stomatal conductance of CO₂

Fig. 10: Effect of NaCl on photosynthetic rate (A)

weight relatively with an increase in concentration of NaCl that was (20mM, 40mM, 60mM), respectively for T₁, T₂, T₃ plants.

Photosynthetic Analysis

Sub-Stomatal CO₂ of Sunflower (Ci): Sub-Stomatal conductance showed non-significant results and random effects in sunflower (variety 555.1). It was observed that control group (0mM) showed maximum sub-Stomatal CO₂ as compared to other groups. However, T₂ (40mM) and T₃ (60mM) plant groups showed increase sub-Stomatal CO₂ as compared to T₁ (0mM) plant group (Fig. 7).

Transpiration Rate (E): Effect of NaCl on transpiration rate of Sunflower (variety 555.1) was significant and by applying 20mM NaCl it showed decrease in transpiration rate (E) but with increasing concentration as 40mM and in 60mM transpiration rate is higher from T₁ (20mM) may. The control group (0mM) showed maximum transpiration rate (E). It might be due to anatomical adaptations in sunflower because of salinity stress.

Stomatal Conductance of CO₂ (gs): Stomatal conductances of CO₂ in Sunflower (variety 555.1) showed non-significant results. As it was observed that control group which was subjected to (0mM) of NaCl showed maximum stomatal conductance of CO₂ (gs) as compared to other plant groups i.e. T₁ (20mM), T₂ (40mM) and T₃ (60mM) of NaCl (Fig. 9).

Photosynthetic Rate (A): Effect of NaCl on sunflower variety 555.1 showed non-significant results. As control group which was subjected to (0mM) of NaCl showed maximum photosynthetic rate (A) as compared to other groups. However, in T₃ plants under (60mM) concentration of NaCl showed maximum photosynthetic rate (A) as compared to T₁ (20mM) and T₂ (40mM) plant groups.

Chlorophyll A: The chlorophyll a content affected non-significantly by salt stress. However it was observed that Chlorophyll a content was maximum in T₀ (control group) (0mM), T₁ (20mM) and T₂ (40mM) plant groups as compared to T₃ plant group (60mM) of NaCl (Fig. 11).

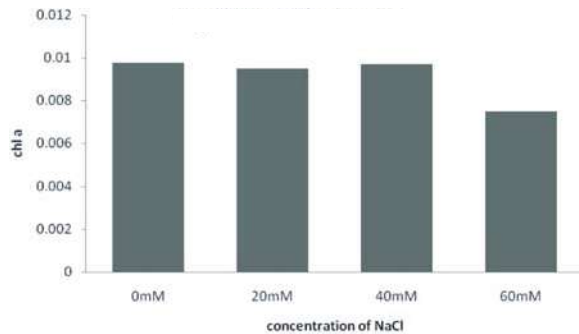


Fig. 11: Effect of NaCl on chl a

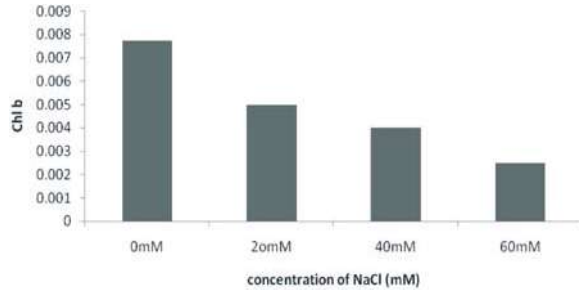


Fig. 12: Effect of NaCl on chl b content

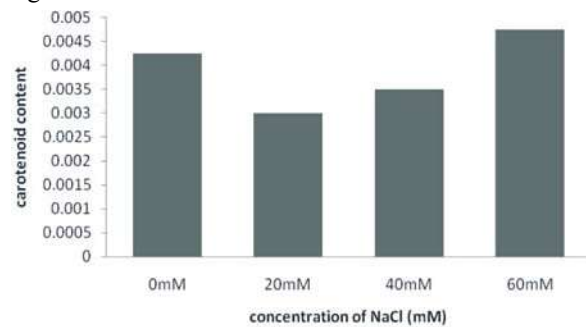


Fig. 13: Effect of NaCl on carotenoid content

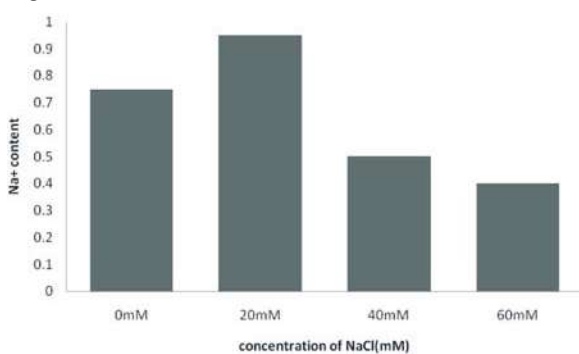


Fig. 14: Effect of NaCl on root Na+ content

Chlorophyll b: Chlorophyll b showed non- significant results and gradually decrease by increasing NaCl concentration in sunflower (variety 555.1). As T₀ group (0mM) have maximum chlorophyll b content but T₁ (20mM), T₂ (40mM) and T₃ (60mM) showed relative decrease in chlorophyll b content.

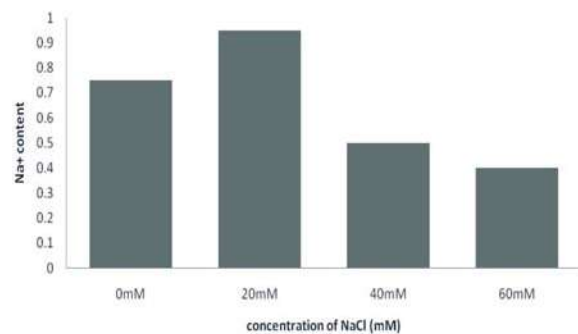


Fig. 15: Effect of NaCl on shoot sunflower Na+ content

Carotenoid: Carotenoid in sunflower (variety 555.1) showed non- significant results. By applying 20mM and 40mM of NaCl it decreased but by 60mM it increased as compared to control (0mM). In other words T₃ plant group (60mM) Carotenoid content was maximum as compared to T₀ (0mM), T₁ (20mM) and T₂ (40mM) plant groups.

Concentration of Na⁺: Sodium ion concentration of dry root and shoot of sunflower showed non-significant results. In root Concentration of Na⁺ increased T₁ (20mM) concentration of NaCl as compared to other plant groups i.e. T₀ (0mM), T₂ (40mM), T₃ (60mM). While the shoot also showed the same trend (Fig. 14, 15).

Results showed that morphological parameters (length of root, length of shoot and fresh weight of shoot of sunflower) were significantly affected and leads to reduction in sunflower plant growth as a result of salt stress, also been reported in other plant species [9-11]. Physiological parameters (Photosynthetic rate, transpiration rate, sub-stomatal CO₂ and stomatal conductance of CO₂) are significantly affected by application of NaCl [12-14]. The plants under salt stress could not activate the dehydration mechanism like making root membranes impermeable for toxic ions of Na⁺ and Cl⁻ so plants could not maintain stomatal conductance [15] thus reduction in growth occurs. The uptake of Na⁺ and K⁺ was considered an important physiological mechanism contributing to salt tolerance in many plant species [16]. plants showed reduction in chlorophyll content under salt stress due to increase activity of chlorophyll degrading enzyme chlorophyllase [17]. The end results was reduction of growth, plant pigments, ionic imbalance and physiological and morphological attributes of *Helianthus annuus* variety 555.1 when subjected to salt stress by applying NaCl in different concentrations.

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