



Original Research Article

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Depression of Growth and Pigment Content of *Sorghum vulgare* L. (White Sorghum) by Salt Stress

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ABSTRACT

Soil salinity is one of the major environmental problem affecting agricultural production in arid and semi-arid regions of the world. A pot culture experiment was conducted to estimate the effect of NaCl stressed *Sorghum vulgare* L. variety of MFSH-4 (White Sorghum) the plant belongs to family Poaceae, is a sub tropical crop, grown worldwide, particularly in South Asia for edible and fodder purposes, while little is known about its salinity tolerance. The seed were sown in plastic pots from 30 days after sowing (DAS). The plants were treated with 25mM, 50mM, 75mM and 100mM sodium chloride on 30th, 40th and 50th DAS. The plants samples were collected from 40th, 50th and 60th DAS. The plants were collected for estimating the growth parameters and pigment content of the plants. The sodium chloride treatment decreased the root length, stem length, total leaf area, fresh weight, dry weight, chlorophyll and carotenoid content with increasing concentration of NaCl to a larger extent when compared to control in all the treatment day.

Introduction

Soil salinity is an increasing problem in the world and main obstacle to agricultural productivity especially in areas where irrigation is necessary because water contains large amount about 30g sodium chloride per liter, of salt (Flower, 2004). According to the United Nations reports, 20% of agricultural land and 50% of world crop land are salt affected. Soil salinity is one of the most serious

problems in Pakistan (Almodares et al., 2014). Soil salinity is one of the main problem for plant growth in agriculture, especially in countries where crops should be irrigated. Soil salinity has been considered a limiting factor to crop production in arid and semi arid regions of the world. Saline soils are estimated about 5-10 of the world's arable land and the area affected by salinity is increasing steadily. Salt affected soils are distributed throughout the world and no continent is free from

the problem. Globally, a total land area of 831 million hectares is salt affected. However, soil salt accumulation can change with time and place, as a function of soil management, water quality. Irrigation method, and the weather conditions salt accumulation is mainly related to a dry climate, salt-rich parent materials of soil formation, insufficient drainage and saline ground water or irrigation water (Amelework, et al., 2012).

The soil salinity may be due to poor water management, high evapo-transpiration rate submerged irrigation and also due to pre-exposure of lands to sea water. The extent of soil salinity and sodicity problems variation from 5% to 10% of the world cultivated lands. Among these sodium chloride adverse by effects the plant growth and development. Soil salinity is a global problem that affects approximately 20% of irrigated land and reduces crop yields significantly (Qadir et al., 2014).

Salinity is one of the major abiotic stress factors that affect plant growth and productivity, especially in arid and semi arid regions, e.g. Iran, due to intensity of evaporation and insufficient amount of rainfall for substantial leaching, saline soils are abundant. Many species of higher plants, including most crops are subjected to growth inhibition under high NaCl concentration. The salt-induced inhibition of plant growth so called salt stress, is caused not only by osmotic effects on water uptake but also by variable effects on plants cell metabolism under salt stress while the first component can bring about water deficit the excess of an specific ion can cause toxicity and or induce nutritional disorders (Dai et al., 2011).

Salinity of water and soil is a important environment factor restricting the growth and production of plants in arid and semiarid areas. By the next 25 years 30% and by the mid 21st century, 50% of agricultural lands will be destroyed by salinity which will have a negative impact on agricultural production (This et al., 2010). Lack of plants germination in saline soils is often due to high concentration of salt in seed planting area

resulting from the upward movement of the soil solution, and consequently the salt accumulation in soil surface (Song et al., 2008). Salts affect the germination process by restricting the amount of available water, osmotic effect or due to the damage caused by the entrance of ions into germination metabolic process. Salinity stress is one of the factors preventing germination and establishment of seedling (Almansour et al., 2001).

Sorghum is a crop belonging to the millet family (Poaceae) which is suitable for producing grain and forage in the summers in arid and semiarid areas and it can be used for reclamation of saline soil in irrigated agriculture (Evans, 2006). Sorghum is considering one of the most important crops for production cereal grains and fodder for humans and animals and is the most famous Egyptian summer crop after rice and maize, vegetative leaves used as feed for animals and birds in the summer season and contribute to solving the problem of fodder in summer. Also grain yield used to bridge the deficit in wheat flour to produce bread municipal. A biotic stress such as water stress and salinity was the incumbent in the first resistor work to improve the resistance for environmental stresses, especially the problem of water shortage. Sorghum is predictable to play an increasingly significantly function in cultivation and gathering world food desire in the continece of climate modification, ground degradation and mounting water reduction (Amelework et al., 2015).

Materials and methods

Seeds of *Sorghum vulgare* L. variety of MFSH-4 (White Sorghum) were obtained from Bavani Agro, Kaveripattinam. The experiments were conducted at the Botanical Garden and Plant Physiology Laboratory, Post Graduate and Research Department of Botany, Government Arts College for Men, Krishnagiri.

The Sorghum seeds were surface sterilized with 0.2 percent HgCl₂ solution, for 5 minutes with frequent shaking and thoroughly washed with tap water and seeds were sown in polythene bags (300 mm

diameter) filled with 3kg of soil mixture containing red soil, sand and farm yard manure (FYM) at 1:1:1 ratio ten seeds were sown per pot the seedlings thinned to five per pot on the 10 day after sowing and all the pot were watered to the field capacity with tap water up to 29 days after sowing (DAS). On 30th DAS the polythene bags were arranged in five row, first one row is control (irrigation of tap water) and remaining rows were given 25mM, 50mM, 75mM and 100mM NaCl on 30, 40 and 50 DAS. Pot culture experiment carried out in a completely randomized design (CRD) with three replicates for each treatment. Plants were uprooted randomly 40th, 50th and 60th DAS, washed carefully and separated into root, stem and leaves for estimating growth parameters and pigment contents were analyzed.

Growth parameter

Root length

Root Length was taken from the point of root-stem transition region to the tip of the tap root and the length of lateral roots were also taken from calculating the total root length and expressed in centimeters per plant.

Stem length

The length from shoot tip up to the plant point of root-stem transition region was taken as stem length and the length of the branches were also taken as total stem length and expressed in Centimeter per plant.

Total leaf area

The total leaf area of the plant was measured using LICOR photoelectric area meter (Model L1-3100, Lincoln, USA) and expressed in cm² per plant.

Fresh and dry weight

Plants were harvested randomly on 40, 50 and 60 DAS and separated into root, stem and leaves. Then the plant materials was immediately weighed to

determine the fresh weight and dried in an oven at 100°C till a constant dry weight was obtained the dry weight was expressed in gram per plant.

Determination of pigments

Chlorophyll and carotenoid were extracted from the 3rd leaf and estimated following the method of Arnon (1949).

Extraction

Five hundred milligram fresh third leaf material was ground with 10ml of 80 percent acetone and centrifuged at 3500 rpm for 10 minutes at 4°C. This procedure was repeated until the residue became colorless. The extract was transferred to a graduated tube and made up to 20ml with (80%) acetone and assayed immediately.

Estimation

Three milliliters aliquots of the extract was transferred to a cuvette and the absorbance was read at 645,663 and 480 nm with a spectrophotometer (Milton and Roy, Spectronic 21) against 80 percentage acetone as blank. Chlorophyll content was calculated using the formula of Arnon (1949).

Total chlorophyll

$$\text{Total Chlorophyll (mg/g FW)} = \text{Chlorophyll 'a'} + \text{Chlorophyll 'b'}$$

Chlorophyll 'a'

$$\text{Chlorophyll 'a' (mg/g FW)} = (12.7) \times (\text{OD}663) - (2.69) \times (\text{OD} 645)$$

Chlorophyll 'b'

$$\text{Chlorophyll 'b' (mg/g FW)} = (22.9) \times (\text{OD} 645) - (4.68) \times (\text{OD} 663)$$

Carotenoids

Extraction

Five hundred milligram fresh third leaf material was ground with 10ml of 80% acetone and centrifuged at 2500 rpm for 10minutes at 4°C. This

Procedure was repeated until the residue became colorless the extract was transferred to a graduated tube and made up to 20ml with 80% acetone and assayed immediately.

Estimation

Three milliliters aliquots of the extract were transferred to a cuvette and the absorbance was read at 480nm with a spectrophotometer, against 80% acetone as blank. Carotenoids content was calculated using the formula:

$$=A_{480} + (0.114 \times A_{663}) - (0.638 \times A_{645}).$$

Results and discussion

Root growth

In *Sorghum vulgare*, the root length was decreased by the 25mM, 50mM, 75mM and 100mM sodium chloride treatment to larger extent when compared to control and it was 50.1, 46.5, 38.2, 35.1 and 31.4 cm per plant respectively on 40 DAS, 59.2, 54.4, 42.2, 38.2 and 33.2 cm per plant respectively on 50 DAS and 68.4, 60.5, 50.0, 48.5 and 36.8 cm per plant respectively on 60 DAS (Fig. 1).

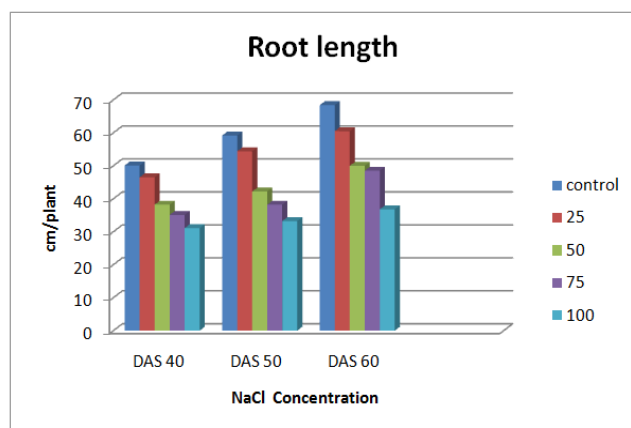


Fig.1: Effect of NaCl stress on root length of Sorghum (values are expressed in cm/plant).

Reduced root growth under NaCl salinity was observed in a number of plants like *Phalaris minor* (Prakash and Singh, 1984). Maize and Wheat (Lewis et al., 1989; Azaizah and Steudle, 1991). It

has been stated that depending on increasing salinity levels, decrease in vegetative growth have been observed in plants (Pessarakli and Hayat, 2006). According to Shannon et al. (1994), however, under field conditions, the decrease in the shoot and roots ratio under saline conditions, on the opposite, allows a better use of the soil moisture and of nutrients, which may have a beneficial effect on plant growth (Galli et al., 2016) reported that spraying the shoots of soybean plants with salicylic acid significantly increased the growth of shoots and roots measured after seven days of treatment. The salinity tolerance of many species because salinity causes the decrease of germination rate and percentage and also the reduction of rootlet growth similar results were reported by the increasing salt stress effect on root length (Ashraf et al., 2002).

Stem growth

Sodium chloride stress decreases the stem length to a larger extent when compared to control in sorghum plant (Fig. 2).

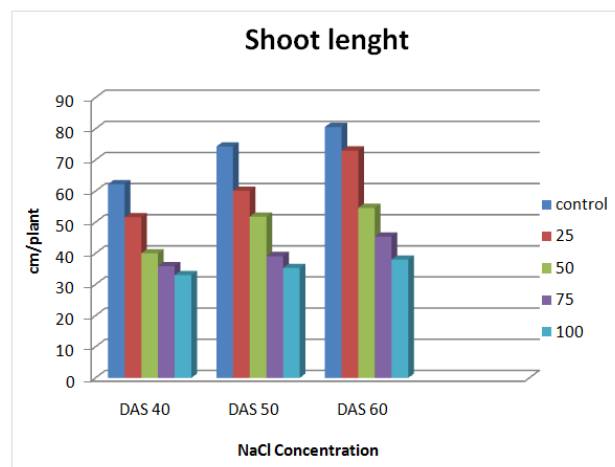


Fig. 2: Effect of NaCl stress on shoot length of Sorghum (values are expressed in cm/plant).

The NaCl treatment also marginally reduced the growth of the stem when compared to control. The shoot growth was shown to decrease by increasing salinity in *Cuminum cyminum* (Garge et al., 2002). The length of the stem and of the first internode on the other hand, also turned out to be much more sensitive to the salt stress than the length

of shoots, and a higher salt retention in the stem (Jini and Joseph, 2017). Reducing in shoot growth due to salinity is commonly expressed by a reduced leaf area and stunted shoots (Lauchli and Epstein, 1990). High salinity levels caused a decrease in shoot length (Pessarakli and Kopec, 2009).

Fresh and dry weight

The fresh weight and dry weight of the NaCl stressed plants decreased when compared with control (Figs. 3 and 4). Decrease in root and shoot development (Shannon and Grieve, 1999; Chookhampaeng, 2011). According to the finding for our study significant decreases have been observed in the fresh and dry total Plant weights depending on the increasing irrigation water salinity (Mehdi et al., 2010).

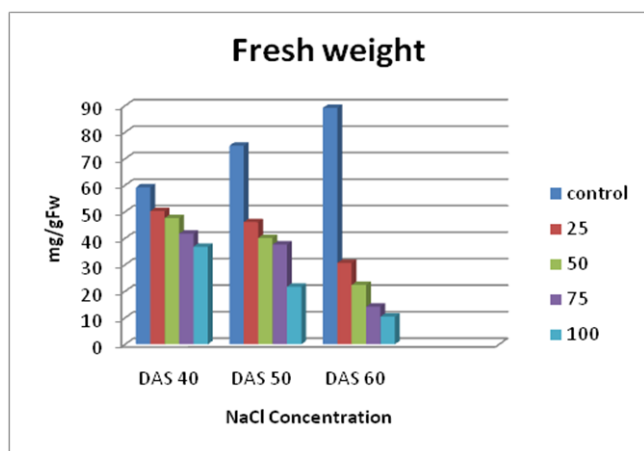


Fig. 3: Effect of NaCl stress on fresh weight of Sorghum (values are expressed in gram/plant).

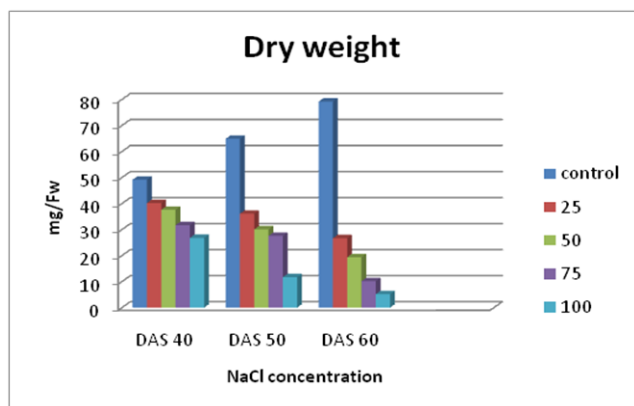


Fig. 4: Effect of NaCl stress on dry weight of Sorghum (values are expressed in gram/plant).

Sodium chloride stimulated the growth parameters the higher salinities the growth and pigments were decreased gradually. The reduction in uptake of water may be the reason for the decreased fresh and dry weight in the NaCl stressed Sorghum plants. Sodium chloride treatments significantly reduced fresh and dry weight as well as relative growth rate of shoot and root in Barley (Hurkuman and Tanaka, 1987). The obtained results indicated that the increased concentration of NaCl negatively affected the shoot fresh weight is decreased by the higher concentration of the salt (Khatoon et al., 2010).

Total leaf area

Sodium chloride stress decreased the total leaf area when compared to control in Sorghum plant (Fig. 5). Reduction in leaf growth under salinity was reported in many plants like red gram (Joshi and Nimbalkar, 1983). Wheat and Maize (Lewis et al., 1989). *Apium graveolens* (Pardossi et al., 1998) and Sorghum (Lu and Zhang, 1998). Increasing levels of salinity caused reduction in leaf area and number of leaves in mung bean (Chakrabarti and Mukherji, 2002) and dry mass, water content, leaf area and photosynthetic pigment in maize and broad bean plant. The reduction in root and shoot growth observed in the experiments may be due to the injury caused by NaCl treatment.

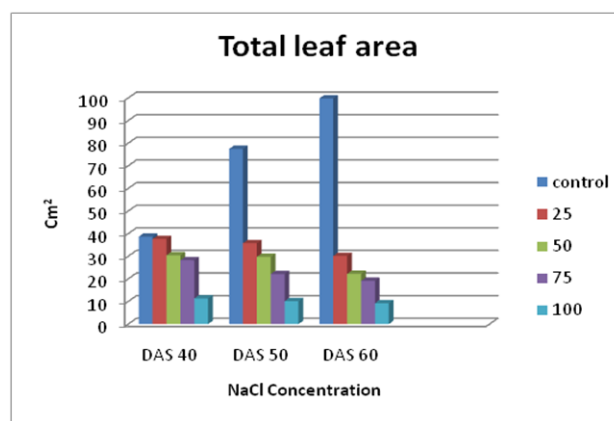


Fig. 5: Effect of NaCl stress on total leaf area of Sorghum (values are expressed in cm² fresh weight).

Photosynthetic pigment analysis

The amount of chlorophyll a, b, total chlorophyll

and carotenoid contents were to decreased gradually to increasing salt concentration to a larger extent when compared to control in all the treatment day (Figs. 6 to 9). Chlorophyll amount and yield have been observed in plants subject to salinity stress. It is stated that when a plant is subject to salinity stress for a long period, ion toxicity and water deficiency in mature leaves and carbohydrate deficiency and related signs and observed in young leaves (Shannon and Grieve 1999, Chookhampaeng, 2011).

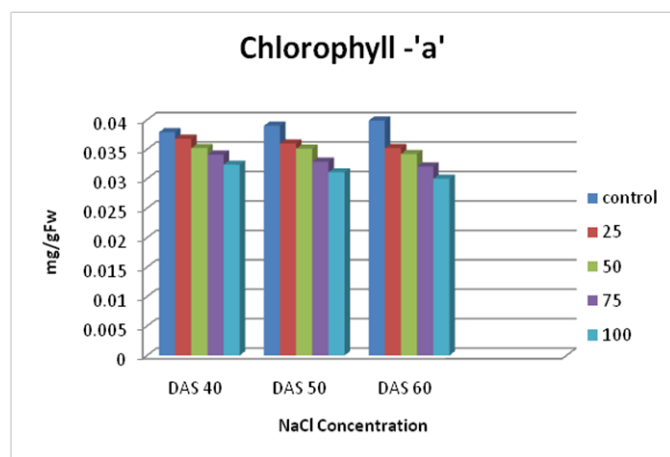


Fig. 6: Effect of NaCl stress on chlorophyll 'a' content of Sorghum (values are expressed in mg/g fresh weight).

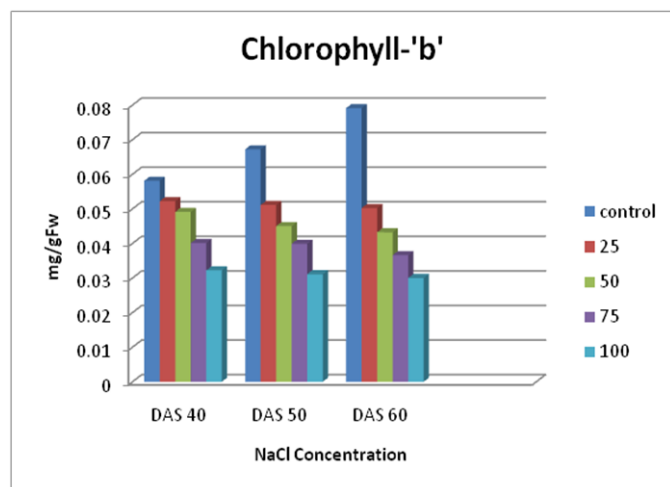


Fig. 7: Effect of NaCl stress on chlorophyll 'b' content of Sorghum (values are expressed in mg/g fresh weight).

The results on the effect of different concentration of sodium chloride on the growth morphology of *Cajanus cajan* are given in NaCl stimulated the

photosynthetic pigments chlorophyll a, b and carotenoids commonly in 5mμ, in the higher salinities the growth and pigments were decreased gradually in rice (Sahu et al., 2001) Soybean (Liu and Vanstaden, 2000). NaCl has been shown to bring about a reduction in the overall growth and productivity of plants by perturbing the functioning of vital components of photosynthesis like PSI, PSII and Rubisco (Chen and Murata, 2002). Decrease in total chlorophyll content may be observed due to ion accumulation and functional disorders observed during stoma opening and closing under salinity stress, (Molazem et al., 2010; Nawaz et al., 2010).

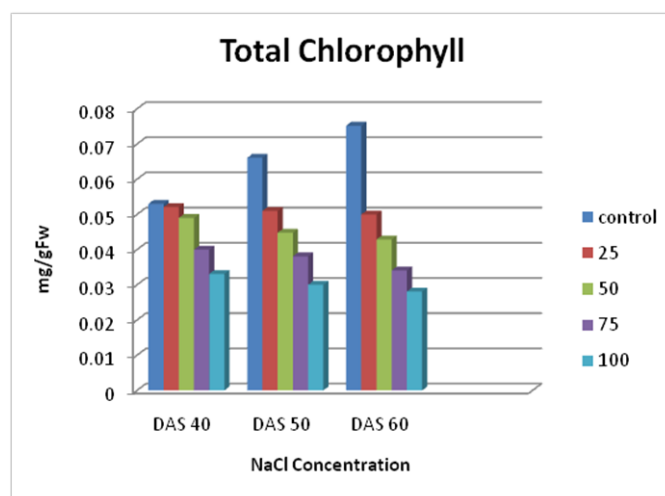


Fig. 8: Effect of NaCl stress on total chlorophyll content of Sorghum (values are expressed in mg/g fresh weight).

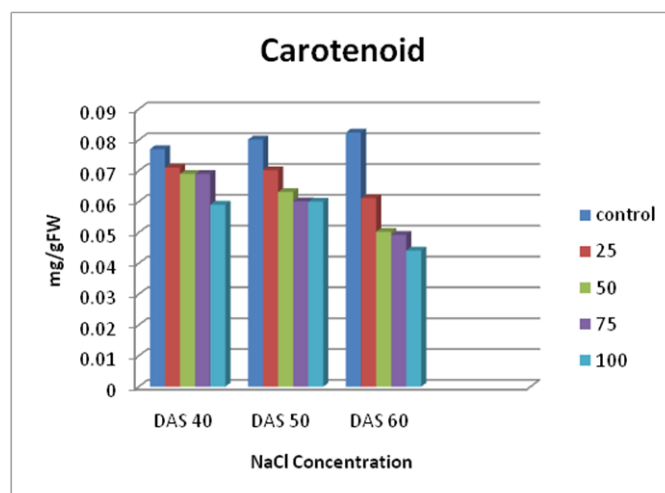


Fig. 9: Effect of NaCl stress on carotenoid content of Sorghum (values are expressed in mg/g fresh weight).

Chlorophyll is one of the most important pigment components providing photosynthetic ability of a plant. Chlorophyll content varies due to salinity levels, eventually affecting plant growth and development. Chlorophyll a-b and total chlorophyll contents decreased in both rice cultivars due to salt stress. The decreased chlorophyll content under saline condition could be due to impaired biosynthesis or increased pigment degradation (Fang et al., 1998; Edelman, 2008).

The decreased content of both chlorophyll and carotenoids could probably be a result from the mineral deficiency. Total chlorophyll content in both salt stressed plants declined with the salinity increase. It was established that carotenoids decreased to a lesser extent than chlorophyll. Ion accumulation in leaves adversely affected chlorophyll content (Meloni et al., 2003).

Conflict of interest statement

Authors declare that they have no conflict of interest.

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