Growth of three cultivars of Jew’s mellow (*Corchorus olitorious*) under different dilutions of Red Sea water

By:
Mohammed Mukhtar Mohammed Abdallah
B.Sc. (Agricultural Extension)
Faculty of Agricultural Sciences
University of Gezira, 1998

Supervisor:
Dr. El Tayeb El Hag Ali Ahmed

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Desertification and Desert Cultivation Studies Institute
University of Khartoum
2011
DEDICATION

THIS WORK IS DEDICATED WITH LOVE TO

MY FATHER

MY MOTHER

AND TO ALL THE MEMBERS OF

MY FAMILY
Acknowledgement

The one who does not thank people, does not thank God.

My gratitude to my Supervisor Dr. El Tayeb El Hag Ali Ahmed for his patience and help, and to Dr. Abd Alwahab Hassan (University of Kartoum) and Dr. Izzeldinn Mohamed Kheir university of Al Zaeem El azhari and Dr Mubarak Abd Rahman (DADCSI, University of Kartoum) and my cousin Osama El Amin for their help and my gratitude also to the technician of laboratory and Electronic Library DADCSI University of Khartoum) for their help and to all my colleagues, and my friends.
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Abstract

Growth of three cultivars of Jew’s mallow (Corchorus olitorious) under different dilutions of Red Sea water mixed with fresh water

Mohammed Mukhtar Mohammed Abd Allah

An experiment was conducted at the Faculty of Agriculture University of Al Zaeem Al Azhri, to evaluate growth of three cultivars of Jew’s mallow (Corchorus olitorious) irrigated with mixtures of Red Sea water and fresh water. The cultivars were Janubeea, Egyptian Baladi and Saaeedi, grown in loamy sand culture in plastic pots. The plants were irrigated with mixture of water of EC 3.4, 4.6 and 5.5 ds/m and fresh water. Data were collected on plant height, number of branches per plant, number of leaves per plant, number of fruits per plant and fresh and dry weight of shoots and roots. Generally, increasing the level of salinity of irrigation water significantly decreased the rate of growth. Saline water with EC 4.6 dS/m and 5.5 dS/m resulted in the death of plants. In the remaining treatments, plant height ranged between 13.36 cm and 2.94 cm, number of branches per plant ranged between 4.06 and 0.00, number of leaves per plant ranged between 7.49 and 2.37, number of fruits per plant ranged between 2.67 and 0.00, shoot fresh weight ranged between 4.05 g and 0.42g, shoot dry weight ranged between 0.83 g and 0.04 g, roots fresh weight ranged between 1.63 g and 0.08 g and roots dry weight ranged between 0.24 g and 0.01g for fresh water 0.4 dS/m and 3.45 dS/m treatments respectively. No significant genotypic differences in all characteristics of growth were found among the cultivars under
different saline water treatments. However, cultivar Janobeea appeared to be more salt tolerant than other cultivars. It was generally observed that Baladi cultivar was slow grower even under fresh water. The death of plant under the 4.6 dS/m treatment may indicate that Corchorus has low tolerance to salinity. Corchorus can only tolerate mixed water with no more than 5% Sea water which may not be very encouraging for growing it under conditions where Sea water is to be used for vegetable production. 

Nitrogen application led to significant improvement in plant tolerance to salinity.
ثلاثة سلاطنتى
بالميه الآلمراء
البحر مياه مخففة تحت الملوخية
العذبة عبد الله محمد مختار محمد
تخصيص: إلى الثلاثة
للتقييم الأزهري الزعيم جامعة الزراعة بقبولية
الأجريق الودية البحري مياه ممزج
العذبة والميه الآلمراء
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الشريعة الكارية للفصل 1: كأثر لانكس، 1973، تعتبر الكرج نباتاً محتفلاً في النمو لزمناً.

النباتات الموت تحت تأثير الملحية، حيث أن النيكل 4.6% يشير إلى الأسماك أكثر، وليس للملحية، ضعيف 5% من المياة، مما يجعل من زراعة البحر، على شجاعة البحرية.

النتروجيني للحمية، تستخدم الملحية للفاكهة والثمار، يتم استخدام الملحية في تحسينات الأسماك. كما أن النيكل 4.6% يعد مثيراً للخطر.
Chapter One

Introduction

Soil salinity stress is one of the most serious limiting factors for crop growth and production in the arid regions. About 23% of the world’s cultivated lands are saline and 37% are sodic (Khan and Duke, 2001).

Soil salinity in agricultural soils refers to the presence of high concentration of soluble salts in the soils solution of the root zone. These concentrations of soluble salts through their high osmotic pressures affect plant growth by restricting the uptake of water by the roots. Salinity can also affect plant growth because the high concentration of salts in the soil solution interferes with balanced absorption of essential nutritional ions by plants (Tester and Devenport, 2003).

The Red sea is one of the areas most severely affected areas by drought and desertification in Sudan. The population there is chronically poverty-stricken, disease-ridden with hunger and malnutrition devastating the whole area.

Any attempt to improve plant growth through increased water supply can be useful in combating desertification and in the reduction of poverty.
The total area of the Red Sea state is 212,410 kilometers square, approximately 55% of this area is rangeland, 42% is salt affected and decertified land, and 3% is agricultural land. Only 30% of the agricultural land is utilized. Most of the water of the seasonal streams is lost through drainage into the Red Sea or into the sand dunes (Ministry of Agriculture & Animal Resources and Irrigation, 2000).

In many developing countries there are extensive costal lands where sea water and harvested water can be utilized for crop production. These water resources are usually neglected, and can be used for growing halophytes (Daoud et al., 2004).

The Red Sea coastal fringe is dissected by seasonal steams (Khors) that drain into the Red Sea after heavy rains. The beds and banks of these khors provide opportunities for the high soil salinities of the salt marshes to be reduced by fresh water thus encouraging special vegetation types (Ali and Mohammed, 1991). Farming activities include cultivation of a limited number of horticultural crops such as tomatoes (Lycopersicon esculentum), okra (Hibiscus esculentus), watermelon (Citrulus lanatus) and sweet beans (Dolicos lablab). The seeds of these crops are sown in the moist subsoil after the removal of dry surface soil layer (Ali and Mohammed, 1991).
When saline water is available, cultivation of salt-tolerant plants can improve food and/or fodder supplies, increase employment, combat desertification and contribute to soil reclamation. Furthermore, thousands of kilometers of coastal land may be turned into agricultural lands with use of sea water for irrigating salt-tolerant crops (National Research Council, 1990).

The greatest advantage of seawater agriculture is that it is opens up coastal lands, which were previously unusable for agricultural production due to the fresh water shortage (Magbol et al., 1996).

Excessive salinity has been considered the most important edaphic factor limiting the distribution of plants in certain natural habitats, and constituting an increasingly severe agricultural problem in wide areas of the world. The selection of salt tolerant lines, therefore, continues to challenge plant scientists. Screening for potentially useful germplasm, however, represents only the initial step of the breeding process (Serrano and Gaxiola, 1994).

*Corchorus olitorius* (Mulukhiya, Mallow leaves) is an important vegetable crop in Sudan. It is widely grown in northern and central Sudan both under irrigation and rain-fed conditions. In the Red Sea state, it is grown, along with other vegetables, under irrigation using Khor water in Arbaat and
elsewhere. Domestic water use in that state also largely depends on the same sources of water and, therefore competes with vegetable production. One way to ease that competition is to look for the possible use of sea water mixed with fresh water for vegetable production so that more fresh water is spared for domestic use. To achieve that end, vegetable crop cultivars which can grow successfully under a blend of sea and fresh water must be screened.

Therefore, the objective of this study is to screen some cultivars of mulukhiya for growth and production using different dilutions of Red Sea water mixed with fresh water.
Chapter Two

Literature Review

2-1 Salinity

Soil salinity in agricultural soils refers to the presence of high concentrations of soluble salts in the soil solution of the root zone. These concentrations of soluble salts through their high osmotic potentials affect plant growth by restricting the uptake of water by the roots. Salinity can also affect plant growth because the high concentration of salts in the soil solution interferes with balanced absorption of essential nutritional ions by plants (Tester and Devenport, 2003).

Large parts of the world are covered by dry arid and semi-arid regions. The main characteristic of these regions is that they have low erratic rainfall in which during the greater part of the year, precipitation is less than potential evapotranspiration (Salih, 1996). This is the major factor of salinity in arid regions.

Salinity, on the other hand, is regarded as the one of the main factors that contributes to desertification process (FAO and UNEP, 1984).

Many factors interact with salinity and complicate studies of the effect of salinity. For example humidity, temperature, light, irrigation and soil fertility, all alter the effect of salinity when present (Allen et al., 1994).

Irrigation water contains some of the minerals including calcium, magnesium, sodium, as the water evaporates and transpires it leaves sodium in the soil (Serrano et al., 1999).
2-2 Saline Agriculture

Irrigation plays a crucial role in agricultural productivity, and the need for more water is becoming inevitable in arid and semi-arid areas of the world. As the world population increases the demand for fresh water increases to support agriculture to meet the growing demand for food and feed. According to the estimates of FAO 50% of irrigation schemes are salt-affected and about 10 million ha of irrigated land of the world are thought to have gone out of cultivation each year due to secondary salinization (Szaboles, 1987).

The principal criteria to determine irrigation water quality are salinity, sodicity, and specific ion concentrations. However, the effects on crops of a given water are not determined solely by its solute composition. These water quality factors should be considered in relation to the specific conditions under which the water is to be used, that is, soil properties, irrigation methods, cultural practices, climatic conditions, and the crop to be grown (Bernstein, 1967; Rhoades 1972).

As competition for fresh water increases, water of better quality is used primarily for domestic purposes, whereas water of lower quality e.g. saline or polluted water often is used for irrigation (Khroda, 1996). One challenge for the future will be to maintain or even increase crop production with less water that may often be of poor quality. Irrigation with saline water is successfully practiced today in many countries such as Israel, Italy and the US (Rhoades et al., 1992). There seems to be a general lack of information on the prevalence and composition of saline aquifers in sub-Saharan Africa (Karlberg and Penning de Vries, 2003). Nevertheless, some countries, such as South Africa, Botswana and Zimbabwe, have documented the presence of
saline aquifers. Information on to what extent saline water is being used for irrigation in sub-Saharan Africa is virtually lacking (Karlberg and Penning de Vries, 2003).

The basic principle behind a sustainable agricultural system based on irrigation with saline waters, is that the salt concentration in the soil has to be kept at relatively constant levels, below a threshold value specific for each crop species (Maas and Hoffman, 1977). To some extent this is a self-regulatory process by the plant (Shani and Dudley, 2001). When soil salinity increases, the plant responds by decreasing water uptake. Thus more water is available for leaching of salts from the soil. That technique has been successfully used in combination with, removing more salt from the root zone. These feedback interactions by the plant and the soil salinity are further complicated by the processes of soil evaporation and drainage. Nevertheless, previous studies have shown that long-term sustainable agricultural system based on saline water irrigation can be established, provided appropriate management techniques are applied (Rhoades et al., 1992).

Drip irrigation is one such irrigation technique suitable for use with saline water (Shalhevet, 1994). The major benefit of drip irrigation is its high water application efficiency, which can reach values of 90%, although 80% are practicable (FAO, 1997). This can be compared with surface irrigation schemes, which normally have an efficiency of around 50%. Several characteristics make drip irrigation suitable for irrigation with low-quality water. Since soil evaporation is generally low, less salt is accumulated in the root zone as a result of evaporation compared to less water efficient irrigation methods. Secondly, the salt tends to accumulate away from the active root zone at the wetting front close to the soil surface (Shalhevet,
Finally, foliar absorption of salts and leaf burn are avoided as the irrigation water is applied below the canopy, as opposed to sprinkler irrigation. Simplified drip irrigation systems that depend less on spare parts and involve lower initial costs have been developed for small-scale farmers (FAO, 1997), and are being used by farmers in for example Kenya, Zimbabwe and South Africa.

Karlberg and Penning de Vries (2003) concluded that in areas where water causes limitations for irrigation, drip irrigation with saline water is a promising option provided the implementation is combined with appropriate management and training of the farmers. However, there is a need for further research to establish which management techniques are suitable under what environmental conditions when saline water is combined with low-cost drip irrigation in sub-Saharan Africa.

There has been an interest in the use of sea water, or very saline ground water for irrigation either diluted to stretch the use of the scarce fresh water supplies of the saline irrigation water or even using sea water have been encouraged (ICBA, 2004).

### 2-3 Taxonomy of Corchorus

*Corchorus* belong to family Tiliaceae. It is a genus of about 40 - 100 species of flowering plants, native to tropical and subtropical regions throughout the world (Nath, 1976). The cultivated species *Corchorus olitorius* has diverse common names, and is used in different contexts, with jute applying to fibre produced from the plant and mulukhiya (alternatively spelled molokhiya) applied to the leaves used as vegetables. Mulukhiya is a popular as a vegetable in many parts of the near and far east and Africa. Other common
names include nalta jute, jute mallow and Jew’s mallow and mallow leaves (Schery, 1951).

2-4 Plant Description and Genotypes

Corchorus is herbaceous annual, glabrous except on petioles; strong taproot; stems 30 to 100 cm and much-branched when growing as a weed or vegetable culture, when grown for fiber stems straight, slender up to 4 m, there are many types; leaves alternate, light green; stipules 2, linear, up to 1 cm long, deciduous, petiole to 2 cm long; lamina lanceolate 5 to 12 by 2 to 5 cm, serrate, 2 lower teeth prolonged into fine, pointed auricles, tips acuminate; flowers solitary or in few flowered cymes, opposite the leaves, sepals usually 5, free, narrow, as long or shorter than petals; petals usually 5, yellow, 4 to 5 mm long, short corona separates petals from insertion of stamens; stamens 10 to many, free, filaments short, anthers small, bilobed, style short, stigma flat, ovary superior, 5-locular with numerous ovules; fruit a long, cylindrical, 10-riged, beaked capsule, glabrous, 5 to 10 cm long, 0.5 to 0.8 cm in diameter, 5 to 6 chambers formed by transverse septa, 25 to 40 seeds per chamber with 140 to 200 in each fruit; seed pyramidal, 1 to 2 mm long, color varying with variety from grayish-blue or green to brownish-black. Wild types have black seeds" (Holm et al., 1997).

2-5 Agronomic and climatic requirements of Corchorus

The native range is Asia and Africa, now pantropical in cultivation and as a weed (Smith, 1981).
The plant prefers light (sandy), medium (loamy), and heavy (clay soils) (Epenhuijsen, 1974). It thrives well in acid, neutral and basic (alkaline) soils. It cannot tolerate shady environments and requires moist soil. High (Dense) plant population is known to affect behavior of individual plants in terms of vegetative growth and reproductive development (Enyi, 1977; Yayock, 1980. Corchorus is propagated by seeds. Compost or farm yard manure, phosphorus, potash, and nitrogen fertilizers are used as a fertilizer.

2-6 Importance, composition, nutritional value and uses of Molokhia (Corchorus olitorius)

Corchorus olitorius L., is widely consumed as a vegetable among rural communities in most parts of Africa (Velempini et al., 2003). The plant is also eaten in some parts of Asia (Furumuto et al., 2002). According to Zakaria et al. (2006), mulukhiya is used in folklore medicine in the treatment of gonorrhea, chronic cystitis, pain, fever and tumors. Corchorus olitorius is known to contain high levels of iron and folate which are useful for the prevention of anemia (Oyedele et al., 2006).

Leaves are used cooked in soups and several other national dishes. The leaves are used fresh or dried, and they can be stored after drying and used later on during periods of scarcity. The leaves become mucilagious when cooked, a property highly appreciated.

The composition of Corchorus olitorius leaves per 100 g fresh edible portion is: water 80.4 g (74.2–91.1), energy 243 kJ (58 kcal), protein 4.5 g, fat 0.3 g, carbohydrate 12.4 g, fibre 2.0 g, Ca 360 mg, P 122 mg, Fe 7.2 mg, β-
carotene 6410 µg, thiamin 0.15 mg, riboflavin 0.53 mg, niacin 1.2 mg, ascorbic acid 80 mg (Leung, W.-T.W., Busson, F. & Jardin, C., 1968).

Nitrogen fertilizer greatly improves the micronutrient content, e.g. Fe, P, Ca, carotene and vitamin C.

2-7 Effects of salinity on plants and soil:

Salinity is a presence of excessive levels of soluble salts either in irrigation water or soil (Mustafa, 2007). Salinity is expressed as electrical conductivity (EC) and is reported in units of dSm\(^{-1}\). Soil with an EC >4.0 dSm\(^{-1}\) are considered saline (Mustafa, 2007). Irrigation water with an EC >7.0 dSm\(^{-1}\) may restrict growth of several crops (Ayers and Westcot, 1985). The effects of salts on plants and soils are well documented.

Salinity induces poor stand development due to inhibition of germination, reduced growth rates, and reduced yield and total crop failure (Warrance et al., 2002). Salts in the soil solution increase osmotic potential. Plants must expend more energy to produce solutions to lower osmotic potential (Maas, 1994).

Chaudhuri and Chaudhuri (1997) in their experiment on the effect of short term NaCl stress on water relations and gas exchange of two jute species, C. capsularis and C. olitorius found that the net photosynthetic rate (Pn) and transpiration rate (E) and water use efficiency (WUE) greatly declined. Also they found that, the relative water content, leaf water potential, water uptake, transpiration rate, water retention, stomatal conductance, net photosynthetic rate and water use efficiency of two jute species decreased due to salinity stress, and there was an adverse effect and decline in stomatal aperture,
guard cell K+ and stomatal conductance (gs) of the two jute species under salinity stress.

Salinity normally decreases plant photosynthetic rates. Exceptions are the halophytes, in which photosynthetic rates do not always decrease and may even be increased with increasing conductivity of the soil solution (Gale, 1975). Photosynthetic activity can be interfered with in two ways: by modifying either stomatal conductance or the mesophyll capacity to CO2 assimilation (Farquhar and Sharkey, 1982).

Plant growth can be inhibited by high salt concentrations through osmotic stress, nutritional imbalance, and specific ion toxicity (Alam 1994; Jacoby 1994; Munns and Tester 2008). Salinity- induced cellular disturbances may be caused by osmotic and ionic effects (Greenway and Munnas, 1980 Prat and Fathi Ettai, 1990, Alarcon et al., 1993) although it is not always possible to demarcate which of the two is more damaging.

Exposure to salt may affect plant metabolism by an osmotic effect, causing a water deficit, or by a specific ion effect (depends on the types of salt and species), causing excessive ion accumulation. Also the duration, during which plant, are exposed to stress, affects the type of damage (osmotic effect or ion accumulation). For instance, Rana and Annie (1986) found that short-term effect of NaCl on leaf elongation in wheat arise from osmotic effects. Levitt (1980) has mentioned that salt stress, exposes plant to physiological drought stress (osmotic dehydration) which is, analogous to freeze and evaporative dehydrations. Fernandez-Ballester et al. (1998) working on sour orange (Citrus aurantium L.) mentioned that osmotic potential of leaves decreased with increasing salt concentration in nutrient solution.

Several studies showed external signs of salt toxicity in tomatoes due to irrigation with saline water such as sclerosis, leaf burning and poor
vegetative growth (Gornat et al., 1973; Flowers et al., 1977; Adler and Wilcor, 1987).

The accumulation of Na+ in leaves increases with increase in NaCl concentrations and the increased uptake may be due to increased diffusion through damaged membranes and restricted outward active exclusion of Na+ (Nawaz et al., 1998). This shows partial exclusion mechanism for tolerating the toxic ions present in the growth medium (Maas and Nieman, 1978; Greenway and Munns, 1980; Ashraf et al., 1994; Ahmadi et al., 2009).

Adverse changes in morphological structures associated with physiological modifications due to salinity may be the main elicitors of growth decline under salt stress. Salt accumulation in the expanding leaves has been correlated with photosynthetic decline and with ultra-structural and metabolic damages and sequential death of leaves (Yeo and Flowers 1986), and growth vigor may be related to the survival efficiency of different varieties (Yeo et al. 1990).

The concentrated salt surrounds the root membrane, and it is thought that the morphology of the roots affects the amount of salt taken into the plant (Maggio et al., 2001).

Plant responses to salinity change with plant age, plant development, and growth stages (Maas 1993).

Crop species growing on salt affected soils are subjected to toxic effects of sodium and chloride ions (Flowers, 1985) and cause dehydration, (Steponkus, 1980), the combined effects of these two, adversely affect the physiological activities of the plant to such an extent that plant growth becomes severely restricted, or impossible. The result is a considerable loss and some time a total loss of yield. The work of Epstein in the 1960s and 1970s showed that resistance to sea water salinity can be found within barley
and wheat, and similarly at least a substantial degree of salinity tolerance has been found in some crop varieties. In salt-affected soils the presence of soluble salts adversely affects the growth of most crops. James et al. (1982) defined a saline soil, which contains a sufficient quantity of soluble salts to interfere with the growth of most crops. Crops and different cultivars of the same crop vary considerably in their tolerance to salinity (Mass, 1986). Salt accumulation in root zone causes the development of an osmotic stress (osmotic effect) and disrupts cell ion homeostasis by inducing inhibition in the uptake of essential nutrients like K+, Ca2+ and NO3− (possibly leading to nutrient deficiency) and accumulation of Na+ and Cl− to potentially toxic levels within cells (specific ion effect) (Marschner, 1995; Zhu, 2001). These primary stresses induce the generation of reactive oxygen species (ROS) (Melloni et al., 2003), cause hormonal changes (Munns, 2002), alter carbohydrates metabolism (Gao et al., 1998), reduce the activity of certain enzymes (Munns, 1993) and impair photosynthesis (Loreto et al., 2003). As a consequence of these metabolic modifications, cell division and elongation declines or it may be completely inhibited and cell death is accelerated (Hasegawa et al., 2000). It has been reported that two major physiological traits enable the plant to tolerate salinity: (a) compensatory growth following adjustment to salinity and (b) ability to increase both leaf area ratio (LAR) and net assimilation rate (NAR) to achieve this increased growth (Wiynarah 1990). Structural components of plants including leaf structure that undergo changes due to salinity are intimately linked to physiological and biochemical activities of the plant (Cushman and Bohnert 1995, Bohnert and Jensen 1996).
The seedling growth parameters, length, fresh and dry weights of seedlings decline with increasing the external osmotic potential. The leave emergence was observed on 5th day in the case of control seedling and it was delaying by about a two day in the seedling in salt solutions. (Abass et al., 2005).

The decreases of seedling lengths in response to the increase in the concentration of NaCl was reported by Parashar and Verma, (1988) who observed an adverse effect on plumule and radicle growth in wheat during the early stages of seedling growth under saline conditions.

The germination percentage was recorded and three week old seedlings were examined for root length, shoot length, Na+, K+ accumulation and K+/Na+ ratio. The controlled growth room conditions have been used for screening in different crops like lentil (Ashraf and Waheed, 1990) and maize (Khan et al., 2003) at the seedling stage. It has been reported that sensitive cultivars accumulate ions more quickly than tolerant cultivars and this ion accumulation leads to leaf death and, progressively, death of the plant (Munns, 2002). Azhar et al., (2007) used three week old seedlings for the assessment of salt tolerance in cotton, which is member of Malvaceae family.

There was a reduction in plant height of the okra genotypes with increased NaCl concentration in growth medium but the reduction level was low in the tolerant and more in the two sensitive genotypes in both summer and spring plantings. A reduction in the plant height was reported in okra (Abid et al., 2002) and in canola (Qasim et al., 2004) with increased salinity in growth medium.

Under saline conditions, the number of branches per plant was also decreased but more in salt sensitive genotypes and less in salt tolerant genotypes. The number of branches plays an important role in yield increase
by bearing more number of pods and the similar reduction in number of
tillers in wheat was reported by Bhatti et al., (2004).
The okra genotypes had late flower in the saline environment than the control. However, the tolerant genotypes started flowering earlier than sensitive genotypes under salinity. Similarly, the onset of flowering was depressed in canola with increased salt concentration in growth medium (Qasim et al., 2004).
The number of pods per plant, pod weight, pod length and pod girth were severely affected by salinity but there was consistency in the tolerance level of the selected genotypes. These results are in line with the findings of Ashraf and Ahmad, (2000), who reported reduction in plant height, monopodia per plant, bolls per plant and mean boll weight in six lines of cotton with increased salt concentration in growth media.
The reduction in fresh pod yield of okra under salt stress has been reported in earlier studies by Minhas and Gupta, (1993) and Abid et al., (2002). Similarly a significant reduction in garlic yield under salt stress was reported by Mangal et al., (1990).

2-8 Classification of Plants According to Their Response to Salinity

There is a range of plant species having tolerance to saline conditions from glycophytes that are sensitive to salt, to halophytes which survive in very high concentrations of salt (Volkmar et al., 1998). Even within glycophytes, there is a wide range of salinity tolerance among higher plants (Robinson et al., 1997), and variability in salt tolerance has been found occurring in plants
within a particular crop species suggesting a potential for genetic improvement of crop plants for salinity tolerance (Allen et al., 1994). Some physiological characteristics have been determined in halophytes to differentiate between halophytes and non-halophytes in their response to salinity (Läuchli, 1984).

2-9 Effect of Saline Water on Soil Properties

High amount of sodium (Na+) relative to amount of calcium (Ca+2) and magnesium (Mg+2), i.e., sodicity, can cause deterioration of soil physical properties. Water infiltration rate and hydraulic conductivities are low in sodium-affected soils (Rhoades and Loveday, 1990) due to the dispersion and swelling of clay (Shainberg, 1990). Water movement into and through soils increases with increasing salinity and decreases with increasing sodicity. Flocculation occurs as the soluble salt concentration increases (Karen and Shainberg, 1984) and infiltration rate increases. Therefore, both the relative amount of sodium and the total amount of soluble salts in a water source influence infiltration rate (Ayeres and Westcot, 1985). Accumulation of salts can affect the physico-chemical properties of the soil, and thus the suitability of the soil as a medium for plant growth (Bresler et al., 1982; Rhoades et al., 1992; Szabolcs, 1994).

Soils with a high clay fraction are more readily affected. The clay fraction has the greatest specific surface area and is, therefore, most active in the physico-chemical processes such as swelling and dispersion (Shainberg and Levy, 1992). The difference between swelling and dispersion processes are important. Swelling of reference clays in soil is not greatly affected by low exchangeable sodium percentage (ESP) values but increases markedly as the
ESP increases above 15. Instead, the dispersion of clay is very sensitive to low levels of sodicity and increases markedly at the low ESP range (Emerson and Bakker, 1973; Shainberg and Levy, 1992). Shainberg et al. (1981) concluded that when high-quality water is used, an ESP of five can be detrimental to the physical properties of the soil. However, when water of higher salinity is used, an ESP of 15 is required for damage to the physical properties of soils.

2-10 Effect of fertilizer on salinity

Growth inhibition and the adverse effects induced by salinity can be alleviated by proper use of fertilizer and water management, depending on plant species, salinity level, and environmental conditions (Shen et al. 1994; Soliman et al. 1994; Albassam 2001; Flores et al. 2001; Tuna et al. 2007). Fertilization with N may, however, contribute to soil salinization and increase the negative effects of soil salinity on plant performance (Villa-Castorena et al. 2003).

In addition, the potential for NO3 leaching may increase where moderate to high amounts of salts are present in the soils because plants under salt stress can not absorb and or utilize the applied N as efficiently as the plants not subjected to salt stress (Ward et al. 1986; Pessarakli and Tucker 1988; Bowman et al. 2006).

It is important to study plant growth response to N and soil salinity during the whole plant life cycle to reveal whether the amount of N applied alleviates or aggravates the detrimental effects of salinity during specific growth stages (Villa-Castorena et al. 2003).
2-11 The Effects of Salinity on Corchorus

In an experiment by Abass et al, (2005), who studied the effect of salinity stress on germination and subsequent seedling growth of different genotypes of jute, using different concentrations, of NaCl (1000, 3000 and 5000 ppm). He reported that the different varieties of jute showed higher growth at 1000 ppm NaCl as compared with control; however there was gradual decreases in the growth with the highest concentration of NaCl in all jute varieties.
Chapter Three

Material and Methods

3-1 Experimental Description

3-1-1 General
The experiment was carried from 1st of October 2009 to the 30 of October 2009 to investigate the effects of irrigation with different dilutions of Sea water with fresh water on the growth and productivity of three cultivars of Corchorus. Irrigation water was brought from the Red Sea, The experiment was carried out at Khartoum North, in the horticulture nursery in Faculty of Agriculture, University of Al Zaeem Al Azhari, latitude 15° 38’ N, longitudes 32° 31’ E.

3-1-2 Plant Material

Three varieties of Corchorus were selected for this study. Two of them were Egyptian varieties: Baladi and Saeedi cultivars purchased from Cairo market and the third was a Sudanese landrace known as Janoobia purchased from Madani market in central Sudan.

3-1-3 Soil Material

A sandy soil was brought from west Omdurman. It was found by earlier studies to be close in its characteristics to the soil found in Red Sea state where a research project for utilizing Red Sea water mixed with fresh water
was established (Ahmed, 2009). The present study was part of that research project which aims at selecting crops and pasture varieties suitable for growth in Red Sea state soil using mixed sea and fresh water.

The soil was analyzed before irrigation for pH and EC as shown below:

\[ pH = 7.75, \text{SAR} = 6 \text{ and } EC = 2.4 \text{ dSm}^{-1} \]

### 3-1-4 Irrigation Water

Red sea water was mixed with fresh water (EC = 0.4 dSm\(^{-1}\)) to attain different levels of salinity for irrigation of Corchorus varieties.

The Red Sea water was analyzed for the main cations, anions, EC, pH and SAR, which are presented in table 3-1

#### Table (3-1) Main chemical properties of the Red Sea water

<table>
<thead>
<tr>
<th>Cations (me/L)</th>
<th>Anions (me/L)</th>
<th>EC</th>
<th>pH</th>
<th>SAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na</td>
<td>Ca</td>
<td>Mg</td>
<td>K</td>
<td>T.D.S</td>
</tr>
<tr>
<td>653</td>
<td>28</td>
<td>121</td>
<td>138.1</td>
<td>922.1</td>
</tr>
</tbody>
</table>

| | | | 57 | 7 | 59.9 |
3-2 Methods and Layout of the Experiment

3-2-1 Pot Experiment

A split-split plot design with three replicates was used for the experiment. Cultivars were allotted to the main plots, salinity treatments to the sub-plots and nitrogen fertilization to the sub-sub plots. Eight kg of the soil were placed in plastic pots 20 cm in height and 25 cm in internal diameter. Twenty four such pots were prepared for each of the 3 varieties of Corchorus. Salinity treatments were four salinity levels as follows: fresh water (Control) of EC =0.4 dSm\(^{-1}\) and saline water composed of sea and fresh water in the following proportions and EC:

- 1:10 (Seawater: Fresh water), EC = 5.55 dSm\(^{-1}\)
- 1:15 (Seawater: Fresh water), EC = 4.6 dSm\(^{-1}\)
- 1:20 (Seawater: Fresh water), EC = 3.45 dSm\(^{-1}\)

Two levels of nitrogen fertilizer (In the form of urea) one at the rate of 200 Kg/ha (N1) and the other at zero Kg/ha (N0) were used for each salinity level. Fertilizer was applied before sowing. Thus, 8 pots were allotted for each cultivar giving 24 pots in each block. Thus a total of 24 X 3 pots were used in the experiment.

About fifteen seeds were sown in each pot and each was irrigated with fresh water for 7 days for establishment before application of mixed water treatments.

Plants of each variety were thinned to five plants in each pot about two weeks after germination. The pots were irrigated daily to ensure that the soil was kept moist (near field capacity) by applying one liter of water (Ahmed, 2009).
3-3 **Data Collection and Assessment Methods**

The following measurements were taken

3-3-1 **Plants height (cm)**

The height of each plant was measured from the soil level to the tip of the plant using a ruler and the average of the five plants was taken.

3-3-2 **Number of leaves per plant**

The average number of leaves of plants in each pot after 30 days was calculated.

3-3-3 **Number of branches per plant**

The average number of branches per plant in each pot after 30 days was calculated.

3-3-4 **Number of fruits plant**

The average number of fruits per plant in each pot was calculated.

3-3-5 **Shoot and roots fresh and dry weights**

At the end of the experimental period, plants from each pot were taken out and each plant was separated into shoots and roots. The fresh weights of shoots and roots were obtained using a sensitive balance. Then the average weight of the three plants for shoot and root was taken.
Shoots and roots were then dried in an Oven at 65 °C for 48 hours and the average dry weights for each pot was obtained using a sensitive balance.

3-4 Statistical Analysis

SAS statistical analysis system was used for analyzing the data.
Chapter Four
Results

4-1 The effects of saline water on plant height (cm)

Figs. (1-1) and (1-2) show the effect of water salinity on plant height in the three *Corchorus* cultivars. Plant height significantly decreased with increasing the level of water salinity. Nitrogen application significantly increased plant height compared to non fertilized treatment. The results showed that there were no significant differences between cultivars in plant height under the different salinity treatments no fertilizer was applied, but it was observed that V1 had the lowest plant height when compared to V3. On the other hand significant differences were observed when nitrogen fertilizer was applied, where V1 had the lowest plant height compared to the other two cultivars under the fresh water treatment. It was, however, only significantly lower than V2 under W2 treatment.
Figs. 1-1 Effect of *irrigation water of different* levels of salinity on plant height (cm) of three cultivar of corchorus with out nitrogen application (N0).

LSD = 4.54

W1 = Fresh water  
W2 = 1:20 (Seawater: Fresh water), EC =3.45 dSm\(^{-1}\)  
W3 = 1:15 (Seawater: Fresh water), EC = 4.6 dSm\(^{-1}\)  
W4 = 1:10 (Seawater: Fresh water), EC = 5.55 dSm\(^{-1}\)
Figs. 1-2 The effect of saline water on plant height (cm) of nitrogen applied treatments (N1).

LSD = 4.54

W1 = Fresh water
W2 = 1:20 (Seawater: Fresh water), EC = 3.45 dSm\(^{-1}\)
W3 = 1:15 (Seawater: Fresh water), EC = 4.6 dSm\(^{-1}\)
W4 = 1:10 (Seawater: Fresh water), EC = 5.55 dSm\(^{-1}\)
4-2 The effects of saline water on numbers of branches per plants

Table (1) shows the effect of water salinity on number of branches per plants in the three Corchorus cultivars. Number of branches per plants significantly decreased with increasing the level of water salinity. There was a significant effect of nitrogen fertilizer on number of branches per plants which increased when fertilizer was used compared to the treatment when no fertilizer was applied.

The results showed that there were no significant difference between the cultivars V1 and V2 in number of branches per plants under the under water salinity levels W1 (EC =0.4 dS/m) and W2 (EC =3.34 dS/m) but those cultivars had significantly more branches than V3 when the fertilizer was applied.
### Table (1) Effect of different levels of saline water and nitrogen on number of branches per plant on three cultivars of corchorus

<table>
<thead>
<tr>
<th>Variety</th>
<th>Irrigation water salinity levels</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W₁</td>
<td>W₂</td>
</tr>
<tr>
<td></td>
<td>N₀</td>
<td>N₁</td>
</tr>
<tr>
<td>V₁</td>
<td>1.10</td>
<td>3.49</td>
</tr>
<tr>
<td>V₂</td>
<td>0.00</td>
<td>4.06</td>
</tr>
<tr>
<td>V₃</td>
<td>0.33</td>
<td>1.33</td>
</tr>
<tr>
<td>Average</td>
<td>0.48</td>
<td>2.96</td>
</tr>
<tr>
<td>Lsd₀.₀₅</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

W₁ = Fresh water  
W₂ = 1:20 (Seawater: Fresh water), EC = 3.45 dSm⁻¹  
W₃ = 1:15 (Seawater: Fresh water), EC = 4.6 dSm⁻¹  
W₄ = 1:10 (Seawater: Fresh water), EC = 5.55 dSm⁻¹
4-3 The effects of saline water on numbers of leaves per plants

Figs. (2-1) and (2-2) show the effect of water salinity on number of leaves per plant in the three *Corchorus* cultivars. There was a significant decrease in the number of leaves per plant with increasing the level of water salinity. There was a significant effect of nitrogen on the number of leaves per plant which increased when nitrogen was applied compared to the treatment when no fertilizer was applied.

The results showed that there were no significant differences between cultivars in number of leaves per plant under the different salinity treatments, but it was observed that V2 had the highest number of leaves per plant when no fertilizer was applied.
Figs. 2-1 Effect of irrigation water of different levels of salinity on numbers of leaves per plants on three cultivar of corchorus with out nitrogen application (N0).

LSD = 2.53

W1 = Fresh water
W2 = 1:20 (Seawater: Fresh water), EC = 3.45 dSm\(^{-1}\)
W3 = 1:15 (Seawater: Fresh water), EC = 4.6 dSm\(^{-1}\)
W4 = 1:10 (Seawater: Fresh water), EC = 5.55 dSm\(^{-1}\)
Figs. 2-2 The effect of saline water on numbers of leaves per plant of nitrogen applied treatments (N1).

LSD = 2.53

W1 = Fresh water
W2 = 1:20 (Seawater: Fresh water), EC = 3.45 dSm\(^{-1}\)
W3 = 1:15 (Seawater: Fresh water), EC = 4.6 dSm\(^{-1}\)
W4 = 1:10 (Seawater: Fresh water), EC = 5.55 dSm\(^{-1}\)
4-4 The effects of saline water on numbers of fruits per plants

Table (2) shows the effect of water salinity on number of fruits per plant in the three Corchorus cultivars. The number of fruits per plant generally significantly decreased with increasing the levels of water salinity. On the other hand, application of nitrogen fertilizer led to a significant increase in the number of fruits per plant compared to the treatments when no fertilizer was applied.

Under the fresh water treatment W1 (EC= 0.4 dS/m) V3 gave the highest number of fruits when no fertilizer was applied. When fertilizer was applied, the highest number was given by V2. Fruit production continued only in V1 under W2 and W3 when nitrogen was applied and only under W3 in V3.
Table (2) Effect of different levels of saline water and nitrogen on number of fruits on three cultivars of corchorus

<table>
<thead>
<tr>
<th>Variety</th>
<th>Irrigation water salinity levels</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W₁</td>
<td>W₂</td>
</tr>
<tr>
<td></td>
<td>N₀</td>
<td>N₁</td>
</tr>
<tr>
<td>V₁</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>V₂</td>
<td>0.00</td>
<td>2.67</td>
</tr>
<tr>
<td>V₃</td>
<td>0.67</td>
<td>1.00</td>
</tr>
<tr>
<td>Average</td>
<td>0.22</td>
<td>1.56</td>
</tr>
<tr>
<td>Lsd₀.₀₅</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

W₁ = Fresh water  
W₂ = 1:20 (Seawater: Fresh water), EC = 3.45 dSm⁻¹  
W₃ = 1:15 (Seawater: Fresh water), EC = 4.6 dSm⁻¹  
W₄ = 1:10 (Seawater: Fresh water), EC = 5.55 dSm⁻¹
4-5 The effect of saline water on shoot fresh weight

Figs. (3-1) and (3-2) show the effect of saline water on shoot fresh weight in the three *Corchorus* cultivars. Shoot fresh weight significantly decreased with increasing the level of water salinity. It was observed that under the salinity level W3 (EC = 4.6 dS/m) all plants died except those of V2 when no fertilizer was applied, but when nitrogen was applied under that level of salinity all plants survived. Under the salinity level W4 (EC = 5.55 dS/m) all plants died at the two levels of nitrogen application N1 and N0. On the other hand there was a significant effect of nitrogen fertilizer on shoot fresh weight which increased when fertilizer was used compared to the treatment when no fertilizer was applied.

The results showed that there were no significant differences between cultivars in shoot fresh weight under the different salinity treatments, but it was observed that V2 had the lowest shoot fresh weight when no fertilizer was applied, whereas it gave the highest weight when nitrogen fertilizer was applied, compared with V3.
Figs. 3-1 Effect of irrigation water of different levels of salinity on shoot fresh weight (g) of three cultivars of Corchorus without nitrogen application (N0).

LSD = 1.30

W1 = Fresh water
W2 = 1:20 (Seawater: Fresh water), EC = 3.45 dSm\(^{-1}\)
W3 = 1:15 (Seawater: Fresh water), EC = 4.6 dSm\(^{-1}\)
W4 = 1:10 (Seawater: Fresh water), EC = 5.55 dSm\(^{-1}\)
Figs. 3-2 The effect of saline water on shoot fresh weight (g) of nitrogen applied treatments (N1).

LSD = 1.30

W1 = Fresh water
W2 = 1:20 (Seawater: Fresh water), EC =3.45 dSm⁻¹
W3 = 1:15 (Seawater: Fresh water), EC = 4.6 dSm⁻¹
W4 = 1:10 (Seawater: Fresh water), EC = 5.55 dSm⁻¹
4-6 The effect of water salinity on shoot dry weight

Table (3) shows the effect of saline water on shoot dry weight in the three *Corchorus* cultivars. There was a significant decrease in shoot dry weight with increasing levels of water salinity. Again it was observed that under the salinity level W3 (EC = 4.6 dS/m) all plants died except those of V2 when no fertilizer was applied. When nitrogen was applied under that level of salinity all plants survived. Under the salinity level W4 (EC=5.55 dS/m) all plants died at the two levels of nitrogen application N0 and N1. On the other hand there was a significant effect of urea fertilizer on shoot dry weight which increased when fertilizer was used compared to the treatment when no fertilizer was applied.

There were no significant differences between cultivars in shoot dry weight under the different salinity treatment, but it was observed that V2 had, again, the highest shoot dry weight when fertilizer was applied.
Table (3) Effect of different levels of saline water and nitrogen on shoot dry weight on three cultivars of corchorus (g)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Irrigation water salinity levels</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W1</td>
<td>W2</td>
</tr>
<tr>
<td></td>
<td>N0</td>
<td>N1</td>
</tr>
<tr>
<td>V1</td>
<td>0.17</td>
<td>0.41</td>
</tr>
<tr>
<td>V2</td>
<td>0.15</td>
<td>0.83</td>
</tr>
<tr>
<td>V3</td>
<td>0.18</td>
<td>0.59</td>
</tr>
<tr>
<td>Average</td>
<td>0.17</td>
<td>0.61</td>
</tr>
<tr>
<td>LSD0.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

W1 = Fresh water
W2 = 1:20 (Seawater: Fresh water), EC = 3.45 dSm⁻¹
W3 = 1:15 (Seawater: Fresh water), EC = 4.6 dSm⁻¹
W4 = 1:10 (Seawater: Fresh water), EC = 5.55 dSm⁻¹
4-7 The effects of saline water on root fresh weight (g)

Figs. (4-1) and (4-2) show the effect of water salinity on roots fresh weight in the three *Corchorus* cultivars. Roots fresh weight significantly decreased with increasing the level of water salinity. There was a significant effect of urea fertilizer on roots fresh weight which increased when fertilizer was used compared to the treatments when no fertilizer was applied. The results showed that there were no significant differences between cultivars in roots fresh weight under the different salinity treatment, but it was observed that V2 had the highest root fresh weight with or without fertilizer application.
Figs. 4-1 Effect of irrigation water of different levels of salinity on roots fresh weight (g) on three cultivar of corchorus with out nitrogen application (N0).

LSD = 1.30

W1 = Fresh water
W2 = 1:20 (Seawater: Fresh water), EC = 3.45 dSm⁻¹
W3 = 1:15 (Seawater: Fresh water), EC = 4.6 dSm⁻¹
W4 = 1:10 (Seawater: Fresh water), EC = 5.55 dSm⁻¹
Figs. 4-2 The effect of saline water on roots fresh weight (g) of nitrogen applied treatments (N1).

<table>
<thead>
<tr>
<th>Water regime</th>
<th>Roots fresh weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>1.0</td>
</tr>
<tr>
<td>W2</td>
<td>0.8</td>
</tr>
<tr>
<td>W3</td>
<td>0.6</td>
</tr>
<tr>
<td>W4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

LSD = 1.30

W1 = Fresh water
W2 = 1:20 (Seawater: Fresh water), EC = 3.45 dSm\(^{-1}\)
W3 = 1:15 (Seawater: Fresh water), EC = 4.6 dSm\(^{-1}\)
W4 = 1:10 (Seawater: Fresh water), EC = 5.55 dSm\(^{-1}\)
4-8 The effects of saline water on roots dry weight (g)

Table (4) shows the effect of irrigation water salinity on root dry weight in the three Corchorus cultivars. Roots dry weight significantly decreased with increasing the levels of water salinity. There was a significant effect of urea fertilizer on roots dry weight which increased when fertilizer was used compared to the treatment when no fertilizer was applied.

The results indicated that there were no significant differences between cultivars in roots dry weight under the different salinity treatment and different nitrogen application, but it was observed that V2 had the highest root dry weight when no fertilizer was applied.
Table (4) Effect of different levels of saline water and nitrogen on roots dry weight on three cultivars of corchorus (g)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Irrigation water salinity levels</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W1</td>
<td>W2</td>
</tr>
<tr>
<td>Fertilization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N0</td>
<td>N1</td>
<td>N0</td>
</tr>
<tr>
<td>V1</td>
<td>0.04</td>
<td>0.12</td>
</tr>
<tr>
<td>V2</td>
<td>0.06</td>
<td>0.23</td>
</tr>
<tr>
<td>V3</td>
<td>0.05</td>
<td>0.24</td>
</tr>
<tr>
<td>Average</td>
<td>0.05</td>
<td>0.19</td>
</tr>
<tr>
<td>Lsd&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

W1 = Fresh water
W2 = 1:20 (Seawater: Fresh water), EC =3.45 dSm<sup>-1</sup>
W3 = 1:15 (Seawater: Fresh water), EC = 4.6 dSm<sup>-1</sup>
W4 = 1:10 (Seawater: Fresh water), EC = 5.55 dSm<sup>-1</sup>
Although *Corchorus* is an important vegetable crop in the tropic and subtropics, there is generally a lack of literature on the effect of salinity on that crop. From the results of the experiment for characteristics of growth, it would appear that a mixture of sea water and tap water with an EC of 3.4dS/m would result in acceptable growth of all cultivars tested. A mixture of EC above that either resulted in slower growth or led to stunted growth and plants mortality.

This is in conformity with the results reported by Gouia *et al.* (1994) who found that high salt stress results in slower growth and even death of seedlings of cotton. Seedlings had lower dry matter accumulation, less roots, softer and darker leaves. The results of the experiment also revealed the effect of salinity on plant growth becomes more deleterious with increasing the level of salinity. It has also been reported by Hussain *et al.* (2009), who studied the effect of different salts levels of salinity on growth and ion contents of black seeds (*Nigella sativa* L.) that, all growth attributes such as fresh and dry shoot weights and shoot length decreased with increase in salinity levels.

It was observed that nitrogen fertilizer had a positive effect on all growth parameters. Many studies have been conducted to evaluate N and other nutrients uptake by plants under saline conditions (Papadopulos and Rendig 1983; Feigin 1985; Villa-Castorena *et al.*, 2003; Kutuk *et al.*, 2004). The results revealed the positive effect of nitrogen at low and moderate levels of salinity on plant on growth. Chen (2008) studied the effects of salinity and
nitrogen on cotton growth in arid environment, using different levels of salinity ranging between 2.4 dS/m to 17.1 dS/m. He found that N uptake increased with N fertilization at adequate rates at both low and medium soil salinities but was not influenced by over N fertilization. At higher salinities, N uptake was independent of N rates and was mainly influenced by soil salinity.

**5-1 Effect of Salinity on Plant Height**

The result of the experiment showed an adverse effect of saline water on the three *Corchorus* cultivars plant height when nitrogen was not applied. Salinity of more than 3.4dS/m-1 was found to be detrimental to plants of all cultivars. After three weeks of growth, plant height in plants irrigated with saline water was reduced progressively with increase of salinity. The results are in conformity with those of Abid *et al.* (2002) who studied the response of okra (*Abelmoschus esculentus* L.) to EC and SAR of irrigation water using different levels of ECiw (2, 4 and 6 dS/m) and SARiw [10, 15 and 20 (mmol L-1)1/2] respectively. They found that increasing of ECiw and SARiw had significant adverse effect on plant height. Also, the results agreed with Qasim *et al.* (2004) who found that a reduction in plant height was reported in okra with increased salinity in growth medium. Also, Haq (2009) assessed genetic variability for salinity tolerance in okra at the seedling stage. He found that shoot length of 39 okra genotypes decreased significantly with increasing NaCl concentrations.

On the other hand the experiment revealed that N led to increase in plant height gradually from high to low rate of increase depending on the levels of salinity. This is probably due do the effect of nitrogen uptake on growth.
This agrees with the report of Maas and Grattan (1999) who mentioned that plant response to fertilizers depends on severity of salt stress in the root zone. Under low salinity stress, nutrient deficiency limits plant growth more than salinity and a positive interaction or an increased salt tolerance response occurs. While under moderate and high salinities, the limiting effect of salinity also affects plant growth (Hu et al. 1997, Grattan and Grieve 1999).

5-2 Effect of Salinity on number of Branches per Plant

The results of this study showed that the numbers of branches per plant of Corchorus was adversely affected by salinity. This is in agreement with the report by Haq (2009) who found that under saline conditions, the number of branches per plant was decreased but more in salt sensitive genotypes and less in salt tolerant genotypes. The number of branches plays an important role in yield increase by bearing leaves and fruits. A similar reduction in number of tillers in wheat was reported by Bhatti, et al. (2004). Ashraf (2002) showed that under high salt stress, the growth rate of cotton was significantly reduced with less fruiting branches.

5-3 Effect of Salinity on number of Leaves per Plant

Saline water or soil is usually associated with reduced biomass production (Rogers et al., 1997; Noaman and El-Haddad, 2000). The response of number of leaves to increasing salinity was generally similar to that of plant height. Number of leaves is largely determined in the primordial stage by genetic factors. However, the rate of leaf appearance and leaf expansion are
determined by environmental factors (Milthorpe, 1956). Hence salt stress affects number of leaves by apparently slowing down the rate of leaf appearance and expansion resulting in fewer leaves under salinity treatments.

### 5-4 Effect of salinity on number of fruits per plants

It was observed that number of fruits was significantly reduced by salinity and particularly high salinity levels. Adverse effects of salinity on the number of fruits and generally on the reproductive growth may be attributed to several factors. The most important fact being that less water and mineral elements are available for reproductive growth due to the lowering of soil water potential that results in physiological drought (Maas, 1990 and Wilkinson, 1994). Another factor is the reduction in photosynthesis necessary for reproductive growth (Abid et al, 2000). Hormonal imbalance resulting from high salinity (Maas, 1990) may also be involved. The results of this study agree with those of Abid et al. (2002) who found that the fresh pod yield of okra was affected significantly with high salinity treatments over the control with normal salinity. In that study the highest fresh pod yield of okra was noted in the control, whereas the lowest was found in the salinity treatment of ECiw 6.0 dS m-1 and SARiw 20 mmol L-1. Also, Ashraf and Ahmad (2000) reported reduction in plant height, monopodia per plant, bolls per plant and mean boll weight in six lines of cotton with increased salt concentration in growth media. Also, Minhas and Gupta (1993) reported a reduction in fresh pod yield of okra under salt stress. Similarly a significant reduction in garlic yield under salt stress was reported by Mangal et al. (1990). Also, Ashraf (2002) showed
that under high salt stress, the growth rate of cotton was significantly reduced with less fruiting branches.

5-5 Effect of Salinity on Shoot Fresh Weight

The results of the experiment showed that the lowest salt concentration gave the best fresh weight. Plant growth was severely retarded by high levels of salinity of irrigation water leading to the decrease of fresh weight. The decrease of growth by high salt concentration may result from several negative effects. The most important of which is the restriction of water and nutrient uptake by plants due to the reduction of water potential of the medium. Salinity may also cause ionic imbalance and toxicity. It also reduces photosynthetic capacity of plants (Houle et al., 2001; Abid et al., 2002 and Jamic et al., 2006). The result supports the finding of Abass et al. (2005) who studied the effect of salinity stress on germination and subsequent seedling growth of different genotypes of jute, using different concentrations of NaCl (1000, 3000 and 5000 ppm). They reported that the different varieties of jute showed higher growth at 1000 ppm NaCl as compared to the control; however, there was gradual decrease in the growth in all jute varieties with the increase in concentration of NaCl. Also, Minhas and Gupta (1993) reported 50, 75 and 90% reduction in fresh yield of okra, respectively at ECiw 2.1, 3.9 and 6.7 dS/m. High salt concentration has multiple adverse effects on plant morphology, physiology, metabolism, enzyme activity and crop yield. The application of N seemed to have counteracted the adverse effect of increasing salt concentration. Chen et al. (2008) found that adverse effects of soil salinity on cotton growth could be alleviated by fertilizer application, but over fertilization with N might
contributes to soil salinization and increases the negative effects of soil salinity on plant performance.

5-6 The Effect of Saline Water on Shoot Dry Weight

It was observed that shoot dry weight was adversely affected by salinity and particularly at high salinity levels. This is possibly due to the adverse effect of salinity on production of photosynthesates and hence accumulation of dry matter. That result agreed with that of Abid et al. (2002) who reported that in okra plant height, fresh and dry weights, fresh pod yield, photosynthesis, transpiration rate and turgor potential were depressed with increasing levels of ECiw and SARiw. Chen (2008) mentioned that the dry mass of different cotton plant parts was significantly affected by the soil salinity levels, and decreased with increasing levels of soil salinity.

5-7 The Effect of Saline Water on Roots Fresh Weight

It was observed that root fresh weight was adversely affected by salinity particularly at high salinity levels. High salinity has been reported to cause anatomical modifications in roots which include early vacuolation of the apical meristem. Also, translocation of organic matter from leaves may have been hampered by the lack of water in roots such as roots hydraulic resistance that suppresses or reduces root growth (Willkins, 1994; Navarro et al., 2007; Zain Alabdeen and Ahmed, 2009). Other modifications are the suberization of hypodermis and endodermis and the formation of complete casparian strip close to the apex. The latter reduces the free passage of ions from the apoplast to the root xylem which ultimately results in the reduction
of root growth (Maas, 1990; Shannon et al., 1994). The modifications were reported to have adaptive advantages for prolonged survival in saline environments (Neumann, 1995). The finding of this study supported the report of Abid et al. (2002) who found a significant effect on fresh and dry weight of okra plant by high salinity over the control. In that experiment with normal salinity levels he mentioned that it is evident that at similar ECiw and SARiw reduction in dry weight was found to be more than that of fresh weight.

5-8 The Effect of Saline Water on Roots Dry Weight

The results showed that root dry weight was affected by salinity and particularly affected by high salinity levels. This Finding agrees with Chen et al. (2008) who reported that root dry mass decreased linearly with soil salinity. Also the reduction in dry matter production with increasing salinity level was noticed by a number of researchers (Abd-Ella and Shalaby, 1993; Leidi and Saiz, 1997; Qadir and Shams, 1997; Ashraf and Ahmad, 1999; Basal et al., 2006).
Summary and Recommendation

The Study has shown that Corchorus growth was significantly reduced by increasing the levels of salinity of the water. There was no genotypic variation in salt tolerance between the cultivars. Nitrogen application led to significant improvement in plant tolerance to salinity.

The death of plant under the 4.6 dS/m treatment may indicate that Corchorus has low tolerance to salinity. Corchorus can only tolerate mixed water with no more than 5% Sea water which may not be very encouraging for growing it under conditions where Sea water is to be used for vegetable production. Screening more cultivars may reveal existing genotypic variations in salt tolerance.
Reference:


Food and Agriculture Organizaton of the United Nations (FAO) and united Nations Environment Program (UNEP), (1984). Provisional Methoology for Assessment and Mappingof Desertification.


SAS, (1997) (Statistical Analysis System), was used for statistical analysis of data.


