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GERMINATION AND GROWTH PERFORMANCE OF COMMIPHORA WIGHTII AND ACACIA SENEGAL UNDER DIFFERENT SALINITY FROM ARID COAST OF KACHCHH, GUJARAT

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ABSTRACT

Germination ability and growth in terms of stem height increment was investigated for two halophytes, namely Commiphora wightii and Acacia senegal under different salinity regime ranging from 1 to 8% of NaCl by subjecting them to an exposure period of 10 weeks. Seeds of these two halophytes were subjected to salinity intervals of 0.5%. The aim of the study is to judge the ability of seeds to germinate at different salinity ranges and at which salinity the best germination and growth occur. For Commiphora wightii, inhibition of germination and stunting plant growth was recorded at 5% and above but for Acacia senegal stunting plant growth was recorded at 6.5% and above. Stem height increment among the two species was higher at 17 cm at 5% salinity regime than 15 cm at 1, 3 and 4% salinity regime in C. wightii and for A.senegal higher at 64.2 cm at 1.5% salinity regime than 54.6 cm at 2.5 and 6% salinity regime. Findings of the present result has significance in terms of understanding the distribution of these two halophytes and their tolerance to different soil salinity levels and cultivation in saline lands of Kachchh as a medicinal, economical utilization and fodder source.

Keywords: Arid, Halophytes, Kachchh, Salinity, Shoot Height

INTRODUCTION

The varied climatic conditions and long coastline have resulted in a rich diversity of halophytic flora in Kachchh. *Commiphora wightii* and *Acacia senegal* are dominant tree species in coastal tract of Kachchh district in the state of Gujarat, India. In coastal Kachchh these two species are predominantly found on sand dunes and near coastal regions.

As per Flowers *et al.* (1986) halophytes could be defined by their "ability to complete the life cycle in a salt concentration of at least 200 mM NaCl under conditions similar to those that might be encountered in the natural environment". The germination responses of seeds of glycophytes, non-halophytes and halophytes to salinity are highly variable and species specific (Ungar, 1978, 1982). In general, researchers have concluded that salinity is inhibitory to the germination of halophyte seeds in two ways: (1) causing a complete inhibition of the germination process at salinities beyond the tolerance limits of a species, and (2) delaying the germination of seeds at salinities that cause stress to seeds but do not prevent germination (Ungar, 1978, 1982).

The success of annual halophyte populations is greatly dependent on the germination responses of their seeds to salinity. Because the evaporative power of the air is greater during the summer months, surface salt marsh soils tend to have higher soil salinity and more negative water potential in summer than in the spring (Ungar, 1987). Seed germination, seedling emergence, and their survival are particularly sensitive to substrate salinity (Mariko *et al.*, 1992 and Baldwin *et al.*, 1996). However, most short-term studies indicate a noticeable delay in the rate of germination following exposure to salt stress (Bernstein and Hayward, 1958; Kaufmann, 1969; Ungar, 1991).

Several factors such as water, temperature, light and salinity interact in the soil interface, regulating seed germination. They may even co-act with the seasonal variation in temperature under saline conditions, producing differential effect on the germination of halophytes (Ungar, 1995; El- keblawy and Al-Rawai, 2005). This variation could be due to different ecological settings of the region where they belong. However, many halophytes have the potential to germinate at any time of the year under favorable temperature and edaphic conditions (Woodell, 1985; Ungar, 1991).

Many earlier investigations on quantification of salt tolerance of plant species are based on experiments in which NaCl was the predominant salt (Debez *et. al.*, 2004; Khan, *et. al.*, 2005; Koyro, 2006). Sodium chloride (NaCI) is required for normal growth (Ayala and O'Leary, 1995). The limit of salt tolerance varies among halophytes (Khan, 2002), and this variation could be due to a number of factors such as variation in morphology and distribution (Baskin and Baskin, 1998).

As salt concentration increases beyond a threshold level, both the growth rate and ultimate size of most plant species progressively decreases (Garg and Gupta, 1997).

In the light of these earlier finding, this study aims to investigate the germination response, survival and salt tolerance of two native species under different salinity regime in an uncultivated land of an arid zone. No detailed studies have been carried out to establish the salinity tolerance and germination response of tree species such as *Commiphora wightii* and *Acacia senegal.* Better knowledge about the range of salinity tolerance of these two plants can indicate which trees are native of India. In Gujarat, *C. wightii* is mainly found in Kachchh and some parts of Saurashtra region (Sabnis and Rao, 1983; Shah, 1978). The present investigation was carried out to understand the adaptive features of *C. wightii* and *A. senegal* in terms of their germination capacity and tolerance under different salinity regimes which allow them to grow and flourish in saline arid regions of Kachchh.

MATERIAL AND METHODS

Description of the tree species:

1. *Commiphora wightii* (Arn.) Bhandari (Burseraceae) is a perennial, slow growing, medium sized tree with crooked and spinescent branches attaining a height varying from 1.5 to 2.5 m. *It* is a threatened plant species of Indian arid region (GEC, 1996; WCMC, 1994) reported from the states of Gujarat and Rajasthan with restricted distribution (Dixit and Subba Rao, 2000). In Gujarat *C. wightii* is present along with *Euphorbia* and *Acacia* species (Thomas and Shrivastava, *2010*).
2. *Acacia Senegal* (L.) Willd. (Mimosaceae) is a small deciduous 3-6 meter height tree known by the common names Rfaudraksha, Gum Acacia, Gum Arabic tree, or Gum Senegal tree. It is native to semi-desert regions of Sub-Saharan Africa, as well as Oman, Pakistan, and northwestern India. The plant is common in coastal sand dunes and scrub forest in the coastal and near coastal regions of Gujarat (Banerjee *et al.*, 2002). Due to its tolerance to dry soils, *A. senegal* is the grows luxuriantly in drier parts of the coastal belt. Qadir *et al.* (1966) reported that this plant in high abundance on shallow soil of *Euphorbia Acacia-Grewia* community in the Karachi University Campus.

Seed Collection

Mature, uninfected seeds of well grown mother trees supplied by the forest department nursery were used for the present experiment. Similarly, pure raw salt collected from the salt works of Kachchh coast was used to prepare different soil salinity regime (Figure 1). Experimental pots were filled with soil collected from riverbed and the salinity, pH and conductivity of the soil was estimated prior to experiment by following Saxena (1990) for sand salinity. Conductivity and pH of the pot soil was analyzed using a pH-conductivity meter (Cyber Scan PC 300).

Figure 1. Seed of *Commiphora wightii*, *Acacia senegal* and Raw salt

Method for Salinity Creation

Ten kg of air dried river soil was ground and passed through the 2 mm sieve and the collected sand was mixed with 150 grams of wet cow dung. To this sand, natural salt was mixed at different ratios as indicted in table 1. This mixture was filled in 12 Kg polythene bags in two replicates (Figure 2). Ten seeds were sown in each bag and were arranged in open air where they are exposed to normal sunlight. For control, similar number of bags filled with untreated riverbed soil having 0.98 dS/m EC and 6.6 pH and sown with the same number of seeds was used. It was ensured that both control and experimental bags were subjected to same milieu like sunlight and water availability and other environmental conditions. The experiment was conducted in two different periods during November, 2011 and May 2012. On the basis of November 2011 experiment (0 to 5% NaCl solution), new salinity regimes of 0 to 8% were created and artificially salinized with raw NaCl except control bag (Table 1) in order to test the germination rates of seeds in two different seasons.

Figure 2. Seeds at the bag with created NaCl concentrations from Control and 170 to 1367mM

Table 1. Salinity levels created during the Experiment

S. No.	Treatments	Salinity
1	T0 Control	Not adding any Salinity
2	T1	100 gm NaCl (1% , 170mM)
3	T2	150 gm NaCl (1.5% , 256mM)
4	T3	200 gm NaCl (2%, 341mM)
5	T4	250 gm NaCl (2.5%, 427 mM)
6	T5	300 gm NaCl (3%, 512mM)
7	T6	350 gm NaCl (3.5%, 598mM)
8	T7	400 gm NaCl (4%, 683mM)
9	T8	450 gm NaCl (4.5%, 769mM)
10	T9	500 gm NaCl (5%, 854mM)
11	T10	550 gm NaCl (5.5%, 940mM)
12	T11	600 gm NaCl (6%, 1025mM)
13	T12	650 gm NaCl (6.5%, 1111mM)
14	T13	700 gm NaCl (7%, 1196mM)
15	T14	750 gm NaCl (7.5%,1282mM)
16	T15	800gm NaCl (8%,1367mM)

Germination Treatment

The experimental and control bags were arranged in randomized manner with an upper green house cover. Germination performance was treated and tested during normal day temperature of 30-35^{0}C. Night temperature during experimental days was below 30^0 C.

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In total, 15 different treatments and one control bags supplied with tap water (EC - 2.97 dS/m, pH 6.97) were studied for germination. During the experiment, equal amount of tap water was supplied to each bag for irrigation on a daily basis. The experiment was repeated in three times with two replicates during the study. Observation on seed germination was initiated after 8 days. After the eighth day, observation at regular intervals of 24 hours was carried out to check the germination process whereas increment in stem height was measured at the interval of 8 days. The experiment was terminated on 80th day after obtaining results for 10 regular observations.

RESULTS

Fifteen pots each for two tree species were studied for their germination behavior under different salinity regimes (Figure 3). The results obtained for germination percentage and seedling height increment under different salinity treatments are given below.

Figure 3: Seed germination at different salinity of *C. wightii* and *A. Senegal*

C. wightii Germination

In all the salinity regimes, seeds of *C. wightii* germinated after 5 days except at 5% salinity regime which registered germination on 12th day. Continued increment in stem height was observed in all the pots till the end of 16th day. In 1% to 2.5% pots, leaves turned yellow and leaf shrinkage was also observed after 16th day. In the treatment pots of 3.5% to 4.5%, growth as stem height increment reduced from 0.6 to 2 cm after 32nd day comparing control pots. The difference between control and treatment pots in these salinity regimes was up to 5 cm.

Comparing the control plant and different treatment regimes, growth in terms of height increment was highest at 3% and 5% pots though in 5% pot germination was delayed by 6 to 7 days. At 3% to 4% salinity regime, plant height increment was fairly high but at 5% salinity level, significant height increment up to 17 cm was observed in *C. wightii* seedlings up to 80th day. The percentage germination was reduced in all the pots of *C. wightii* above 5% salinity regime (Figure 4). Pots with 5.5% to 7.5% salinity regime recorded the lowest height increment of 0.1 to 10 cm compared to control plant. However, after 56 days at 5.5% to 8% regimes increase in salinity resulted in a progressive decrease in germination and the leaves undergo shrinkages and exhibit yellow colored.

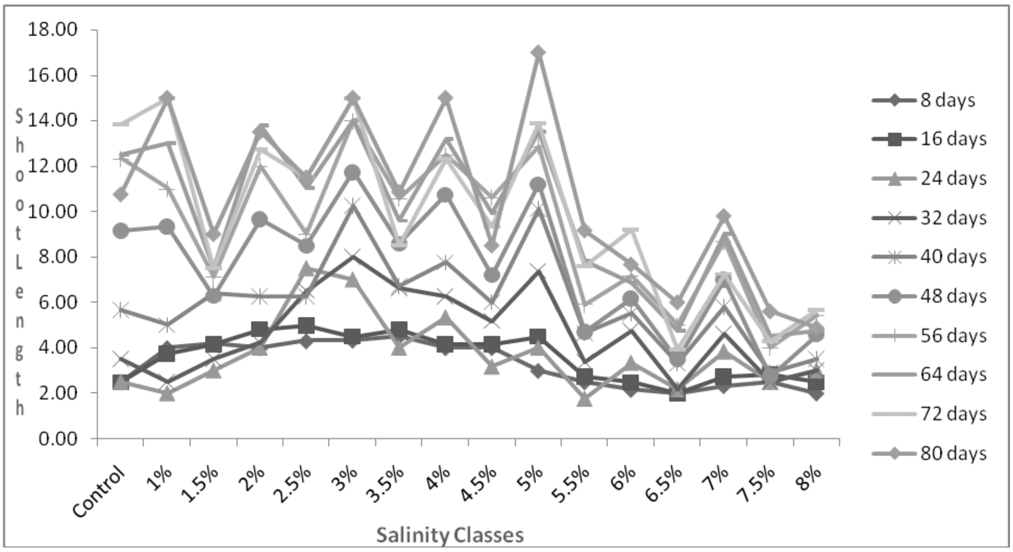

Figure 4. Shoot length (in cm.) trend under different salinity in *C. wightii*

In higher salinity of 8% and above, the plant leaves totally dried up after few days. In the present study reduction in plant height may due to the high salt or lower salt in media resulting yellow or shrinkage of leaf.

A. senegal Germination

In *A. senegal*, seed germination was relatively fast and uniform comparing *C. wightii*. Similarly, shoot height at control pots was perceptibly lower than those at 1% and 1.5% salinity regimes at 8th day of observation (Figure 5).

In 2% to 5.5% salinity regimes, uniform increment in height could not be registered. After 24 days at 3.5% and 6% salinity regime, though shoot growth increment was recorded, the leaves exhibited senescence with yellowish brown. Shoot height steadily decreased in *A. senegal* at salinity regimes of 6.5 and 7% NaCl solution. Comparing to the germination progress, in 8th day to 32nd days, steady increase in height was observed. From 40th days to 72nd day shoot height was not uniform and it varied with salinity (Fig. 5).

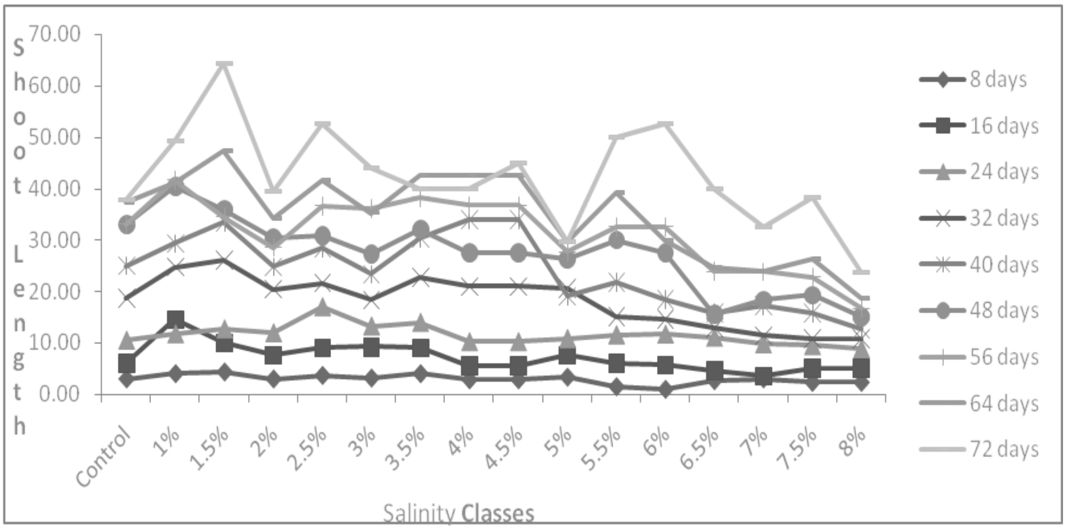

Figure 5. Graph showing the shoot length (in cm.) trend with different salinity in *A. senegal*

At 8% salinity, declined growth was observed but complete inhibition or drying leaves at specific salinity during the germination process was not recorded. At 1.5% salinity level, well established height more than 26 cm than the control growth was observed in *A. senegal* seedling on 72nd day of experiment.

DISCUSSION

The seedling growth test can reflect the performance of the genotype under varying saline conditions. In the present study best salinity tolerance level of plant with better performance growth with respect to plant species and salinity were studied. Control plants of *C. wightii* under 30 – 40 % treatment showed first germination whereas in *A. senegal* first germination occurred at 70% after 8 days of experiment.

Germination under saline condition and seedling growth are considered critical for glycophytes but not for halophytes (Garg and Gupta, 1998). From the results obtained in the present study, It is obvious that effect of soil salinity does not depend on genotype alone but plant type also influences this to a considerable extent. Germination depends upon the absorption of water by the germinating seed. It has been noted that in *C. wightii*, several factors are involved in seed quality such as seed maturity, period of collection (season), environmental conditions during development, harvest and storage condition.

Spatial variability (heterogeneity) in terms of micro topography and soil characteristics in terms of salinity are the major factors controlling the distribution and abundance of *C. wightii* in Kachchh Gujarat (Dixit and Subba Rao, 2000).

Khan and Asim (1998) and Wilson *et al.* (1999) suggested that seedling growth under external saline condition may provide the information regarding the exact performance of pots. Strogonov (1964) stated that property of salt tolerance changes with the development of plant and may also change with the type of salinity. In tune with this observation, in the present study different salinity regimes inhibited growth and germination in varying proportions. Both the trees selected for this study have different salt tolerance levels during their vegetative and reproductive stage with *A. senegal* displaying higher tolerance to increased salinity than *C. wightii*.

Van Hoorn (1991) found that increasing salt concentration delayed germination but after 10 days a high germination percentage was attained for salt tolerant crops like sorghum, sunflower and wheat implying that salt ions are imperative for the plant physiology. In the present study, results confirmed this observation in the case of *C. wightii* which showed higher germination percentage after 12 days of exposure to increased salinity. In natural conditions, stunted growth of halophytes under increased saline condition was earlier reported by Maliwal (1997) and Afria and Narnotia (1999) similar to present condition. At 5% salinity in *C. wightii* germination was fairly good and above that seedling growth in terms of shoot height declined as salt concentration increased. For *A. senegal*, 1.5% salinity regime height growth is best followed by 6% salinity also good up to 72 days.

Previous studies in *Atriplex amnicola* indicated increased growth after addition of NaCl to the growth medium up to 25-50 m*M* but after that growth declined with increasing salt concentration (Aslam *et al.*, 1986). At 5 dS/m EC in *Leucaena leucocephala* germination was 100 % (Yasin *et al.*, 1993). In *Prosopis juliflora* salinity levels of > 10 dS/m EC, seedling immergence was completely inhabited. In *Prosopis glandwose*, beyond 15 dS/m EC, plants could not survive (Ahmad *et al.*, 2000). The present study results indicated that at 7dS/m EC, germination was well established in *C. wightii* but above this level seedling emergence was inhabited.

From the present result it is clear that the peak of germination in *C. wightii* occurs at 5% salinity regime. Plants differ in their capacity to tolerate saline condition because salt influences seed germination and seedling growth through the osmotic retention of water in soils and specific effect on metabolite process (Akhtar *et al.*, 2003). When halophytic grass, *Aeluropus lagopoides* were grown under saline condition, germination, seedling growth and fresh weight registered a perceptible reduction (Gulzar and Khan, 2001). Halophytes have the capacity to overcome both ionic and osmotic effects at different salinity levels found throughout the world (Flowers *et al*., 1999).Growth is closely linked with this ability as the availability of nutrients, their uptake and distribution becomes highly complicated in the presence of NaCl salt (Khan and Gulzar, 2003). The present investigation needs to be extended further in order to determine the seedlings' reduced germination trend recorded for *A. senegal*.

In conclusion, results presented here showed that at higher salinity the leaves undergo shrinkage and exhibit yellow color and >5% salinity range leads stunted plant growth for *C. wightii*. The ideal growth and best performance was observed between 3 to 5% salinity levels in *C. wightii* whereas for *A. senegal* the salinity tolerance level is higher up to 6%. Increased research effort on the halophytic species which have an economic utilization and rehabilitation of salt affected lands is essential for better soil and irrigation management.

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