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Influence of Salinity on Emergence and Early Seedling Growth of *Tamarindus indica* L.

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Summary

The influence of 0, 30, 60 and 120 mM NaCl on seedling emergence and early growth of *Tamarindus indica* L. was investigated under greenhouse conditions. The first seeds in the non-saline treatment emerged (E_{1st}) 7.5 days after sowing (DAS), 50 % of seeds had emerged (E_{50}) 8.4 DAS, and a maximum of 88.1 % of seeds had emerged 11.8 DAS. Addition of 30, 60 or 120 mM NaCl delayed E_{1st} by 1.5, 4.2 and 7.2 days, respectively, compared to the control. E_{50} at 30 and 60 mM NaCl was achieved 10.7 and 15.7 DAS, respectively, whereas seeds at 120 mM failed to reach E_{50}. Seedling growth was not markedly affected by 30 mM, but progressively stronger inhibitory effects were observed within the 60 and 120 mM treatments.

Zusammenfassung

Einfluss von Salinität auf Keimung und Sämlingswachstum bei *Tamarindus indica* L..

Der Einfluss von 0, 30, 60 und 120 mM NaCl auf Keimung und Sämlingswachstum bei *Tamarindus indica* L. wurde unter Gewächshausbedingungen untersucht. Die ersten Samen der Kontrolle keimten 7,5 Tage nach der Aussaat. 50 % der Samen waren nach 8,4 Tagen gekeimt und bis zum 11,8 Tag wurde die maximale Keimrate von 88,1 % erreicht. Die Applikationen von 30, 60 bzw. 120 mM NaCl verursachten eine Verzögerung des Keimbeginns um 1,5 (30 mM), 4,2 (60 mM) bzw. 7,2 (120 mM) Tage im Vergleich zur Kontrolle. Eine Keimrate von 50 % wurde nur in den Behandlungen 30 und 60 mM NaCl nach 10,7 bzw. 15,7 Tagen erreicht. In der Behandlungsvariante 120 mM lag die Keimrate unter 50 %. Das Sämlingswachstum wurde in der Behandlungsvariante 30 mM NaCl nur geringfügig beeinflusst, bei 60 und 120 mM verringerte sich das Sämlingswachstum jedoch deutlich.

Key words. Tamarind – *Tamarindus indica* – salinity – seed emergence – early seedling growth

Introduction

Tamarindus indica L. has recently attracted considerable interest from research and development agencies as a multipurpose tree. Tamarind fruit has many uses ranging from food and beverages to medicinal and industrial uses (GEBAUER and EBERT 2003). The tree is also grown throughout the tropics and subtropics for its beauty as a landscape specimen and its tolerance to harsh environmental conditions (GUNASENA and HUGHES 2000).

Soil salinity is one of the major problems affecting crop productivity in the world (EPSTEIN et al. 1980; GHASSEMI et al. 1995; LAMBERTS and TURNER 2000). In Northern Sudan, there are more than 340.000 ha of land affected by soil salinity. The Electrical Conductivity (EC) of the soils can be as high as 49.5 mS cm^{-1} (GEBAUER et al. 2004).

Tamarind is known to be a rather salt-tolerant tree species compared to other fruit trees (DWIVEDI et al. 1996; GEBAUER et al. 2001). In general, seed germination and early seedling growth are considered the most critical phase for establishment of plant species, and thus it is often emphasised that the tolerance of seeds to salt stress during germination should be determined (UNIYAL and NAUTIYAL 1998). However, effects of salinity on seedling emergence and early seedling growth of *T. indica* have not been investigated. Therefore, a study was initiated to evaluate the effect of sodium chloride (NaCl) salinity on seedling emergence and early stages of seedling development in *T. indica*. NaCl was chosen for the treatments, because in many saline soils it is the predominant soluble salt (FAO 1988; ZECH 2002).

Materials and Methods

Seeds of *T. indica* were collected from a wild stand in Western Sudan. Seeds were immediately extracted from the pulp, kept in paper bags and stored at room temperature until the set-up of the experiment.

To facilitate germination, seeds were scarified with H_2SO_4 (97 %) for 45 minutes at 25 °C (EL-SIDDIG et al. 2001). The pre-treated seeds were sown separately in a quartz sand-based medium (0.6–1.2 mm) contained within inverted pyramid cells (2 x 2 x 4 cm) of 40-cell plastic trays. Each cell has a small opening at the bottom of the tray to allow water to move up into the

quartz sand. The trays were placed in plastic pans (20 x 30 x 5 cm), to which the salt solutions were added. The experiment consisted of four treatments each replicated three times, with 40 seeds. Treatments were prepared by adding 0, 30, 60 and 120 mM NaCl to a standard nutrient solution.

Germination was scored daily for a period of 30 days. A seed was considered to be germinated when the hypocotyl hook was evident above the soil surface. Number of days to first emergence (E_{1st}), number of days to 50 % emergence (E_{50}), number of days between the emergence of the first and last seedling, i.e. emergence spread (E_s), and final emergence percentage (E_f) were determined. When the first opposite pair of leaves were fully expanded, seedlings were harvested and cleaned free of sand. Cotyledons were removed since they may have reflected imbibed moisture and not new growth. Plants were separated into shoots and roots for fresh weight (FW) determination. Dry weight (DW) was determined after oven drying the samples at 70 °C for 48 hrs (DW). Tissue water content, as % water related to fresh weight was calculated from the formula $[(FW–DW) \cdot 100)] \cdot FW^{-1}$.

Emergence and growth data were analysed statistically using analysis of variance (ANOVA). Differences among treatment means were determined by LSD at $\alpha<0.05$.

Results

As shown in table 1, seeds in the non-saline treatment emerged first 7.5 days after sowing (DAS), reached E_{50} 8.4 DAS and achieved a peak with 88.1 % in 11.8 DAS. Addition of 30, 60 or 120 mM NaCl slowed E_{1st} by 1.5, 4.2 and 7.2 days, respectively, relative to the control. At 30 and 60 mM treatments, E_{50} was achieved 10.7 and 15.7 DAS, respectively, whereas seeds at 120 mM failed to reach E_{50}. E_s also varied with increasing salt concentration, being shortest at the control and longest at the highest NaCl level. At 30, 60 and 120 mM, E_f were 80.0 %, 53.3 % and 13.2 %, respectively. Thus, the lower emergence percentages at higher salinity were associated with a slower and less synchronous emergence.

Salt treatment significantly affected shoot fresh weight (FW) and dry weight (DW), root FW and shoot/root ratios (table 2). The 30 mM treatment was not effective in reducing these parameters, but the addition of 60 and 120 mM NaCl decreased shoot FW by 35 % and 40 %, and shoot DW by 32 % and 38 %, respectively, relative to the control. The corresponding reduction percentages for root FW were 14 % and 22 %, for shoot/root FW ratio were 26 % and 23 % and for the shoot/root DW ratio were 28 % and 24 %, respectively. The water content related to fresh weight $[(FW–DW) \cdot 100)] \cdot FW^{-1}$ was slightly reduced in the shoots and roots of seedlings treated with 60 and 120 mM NaCl.

Discussion

The analysis of seedling growth in relation to increasing salinity presented a picture comparable to that of seedling emergence. Both were reduced only slightly by the lowest salt concentration (30 mM). Progressively stronger inhibitory effects were observed at higher salinity levels (60 and 120 mM). As salt concentration increases, the ability of the seeds to absorb the moisture necessary for germination may decrease due to reduction in water potential. NaCl salinity may also affect germination by facilitating the intake of toxic ions,

Table 1. Emergence of first seedling (E_{1st}), time to 50 % emergence (E_{50}), emergence spread (E_s) and final emergence (E_f) of *T. indica* seeds subjected to three salt treatments. Data are means of three replications ± SE. Means within a column followed by different letters are significantly different ($p<0.05$).

Treatment NaCl (mM)	E_{1st} (days)	E_{50} (days)	E_s (days)	E_f (%)
0	7.5±0.9a	8.4±0.9a	4.3±0.9a	88.1±4.4a
30	9.0±1.2ab	10.7±1.5ab	7.3±0.8b	80.0±5.8a
60	11.7±1.1bc	15.7±2.1b	9.7±1.0bc	53.3±2.9b
120	14.7±1.4c	—	9.9±1.2bc	13.2±1.7c

Table 2. Shoot and root fresh weight (FW) and dry weight (DW), water content and shoot/root ratio of *T. indica* seedlings emerged under three different salt treatments. Data are means of three replications ± SE. Means within a column followed by different letters are significantly different ($p<0.05$).

Treatment NaCl (mM)	Shoot			Root			Shoot/root ratio	
	FW (mg)	DW (mg)	Water content*	FW (mg)	DW (mg)	Water content*	FW	DW
0	345±14.8a	56±3.5a	84 %	112±6.9a	22.4±1.1a	80 %	3.1±0.27a	2.5±0.15a
30	309±8.4a	48±4.6ab	84 %	117±9.8a	24.4±2.3a	79 %	2.6±0.17ab	2.0±0.12ab
60	225±9.2b	38±3.4bc	83 %	96±5.8ab	21.2±1.7a	78 %	2.3±0.12b	1.8±0.23b
120	207±7.5b	35±2.9c	83 %	87±4.0b	19.1±1.7a	78 %	2.4±0.14bc	1.8±0.13b

*water content related to fresh weight $[(FW–DW) \cdot 100)] \cdot FW^{-1}$.

which may cause change of certain enzymatic or hormonal activities of the seed (SMITH and COMB 1991). These physicochemical effects upon the seed seem to result in a slower and/or lower rate of germination. Many reports (e.g. UNGER 1998; ALMANSOURI et al. 2001) suggest that the osmotic effect predominated in the reduction of germination and radical growth. Others (e.g. EVERITT 1984; GHOULAM and FARES 2001) suggest that the toxic effect of ions is the main cause for suppressed germination and seedling vigour. According to ZEKRI (1993) addition of Ca^{2+} increased seedling emergence of some citrus rootstocks under saline conditions. It is thought that insufficient Ca^{2+} aggravates salt effects through membrane disruption leading to a faster accumulation of harmful salts and/or leakage of respiratory substrates (MARCAR 1986). Some authors have observed that elevated Ca^{2+} concentration in the nutrient solution inhibited Na^+ and Cl^- uptake (BAÑULS et al. 1991; GRATTAN and GRIEVE 1999; Ebert et al. 2002).

All in all, the results of the present study indicate that a germination of more than 50 % can be achieved at a salinity level of up to 60 mM (NaCl) which is equal to an EC of 6 to 8 mS cm^{-1}. However, in the experiment NaCl was used as the sole salinising agent. Natural soil solutions always contain a mixture of salts rather than a single salt (GRATTAN and GRIEVE 1999).

In the present study, however, no attempt was made to determine which effect, osmotic potential or toxicity of salt ions, was predominant. In future research, this point can be clarified by germinating seeds in iso-osmotic solutions of NaCl and polyethylene glycol (PEG). Furthermore, the data gained in this study refer to the end point of the germination process, i.e. hypocotyl emergence from an individual seed. Further investigations are also needed to enhance our understanding of metabolic changes associated with the stressed seed during germination and emergence.

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