GERMINATION AND SEEDLING GROWTH OF RICE (*Oryza sativa* L.) AT DIFFERENT NaCl CONCENTRATIONS

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ABSTRACT. A research study was carried out with the aim of analyzing germination and seedling growth of rice (*Oryza sativa* L.) at different salt concentrations in the medium, using Pokkali and Amistad'82 cultivars, with different tolerance degrees to this stress condition. Seeds germinated in NaCl solutions of 0, 100, 150 and 200 mM, evaluating germination percentage periodically and finally determining seedling fresh and dry weights. Likewise, imbibition dynamics was appraised. Germination process was restrained by salt concentration increments in the medium, a fact which was not related to seed water absorption. Seedling fresh and dry weights were also affected by saline stress; however, reductions with respect to the check were higher in the former compared to the latter. Results suggest that early germination stages are affected by ion toxicity whereas the further seedling development is inhibited by water stress. A differentiated cultivar performance was observed.

RESUMEN. Se condujo un experimento con el fin de analizar la germinación y el crecimiento de plántulas de arroz (Oryza sativa L.) en diferentes concentraciones de sal en el medio. Se emplearon los cultivares Pokkali y Amistad'82, con diferentes grados de tolerancia a esta condición de estrés. Las semillas germinaron en soluciones de NaCl de 0, 100, 150 y 200 mM y periódicamente se evaluó el porcentaje de germinación, y al finalizar ésta se determinaron las masas fresca y seca de las plántulas. Paralelamente se evaluó la dinámica de imbibición. El proceso de germinación resultó inhibido por el aumento de la concentración de sal en el medio, efecto que no estuvo relacionado con la toma de agua por las semillas. Las masas fresca y seca de las plántulas también resultaron afectadas por el estrés salino; sin embargo, las reducciones con relación al control fueron superiores en la primera en comparación con la segunda. Los resultados sugieren que los estadios iniciales de la germinación se ven afectados por la toxicidad de iones, mientras que el desarrollo posterior de la plántula además resulta inhibido por la deficiencia hídrica. Se destacó el comportamiento diferencial de los cultivares.

Key words: *Oryza sativa*, rice, saline stress, germination, seedling growth

Palabras clave: *Oryza sativa*, arroz, estrés salino, germinación, crecimiento plántulas

INTRODUCTION

Soil salinity is one of the main problems affecting plant development, so that it restricts crop plantation areas; nevertheless, attaining newly bred tolerant cultivars to this stress condition could extend the use of these soils.

Yeo and Flowers (1984) pointed out that it is advisable to include physiological criteria to breeding programs, since it makes massive screening methods easier, they being faster and much more objective; also, they supply more information about the system and permit to combine several characteristics, which separately do not increase plant survival under saline conditions, to obtain a resistant cultivar.

During plant development, seeds are sometimes the first to face abiotic stress conditions; particularly salinity affects both embryo active growth reassumption and seedling growth through its influence on different physiological and biochemical processes of this early growth stage (Levitt, 1980), mainly upon water relations as well as ion toxicity (Rana Munns and Annie Termaat, 1986).

On the other hand, saline conditions also disturb root metabolism, thereby reducing hormone synthesis and/or translocation, needed for leaf metabolism, causing leaf growth reduction and senescence enhancement (Prisco, 1980).

Rice is a salt sensitive species, absorbing large sodium and chloride quantities from an external medium of relatively moderate concentrations (Flowers and Yeo, 1981), and its sensitivity varies during growth (Flowers and Yeo, 1981; Ponnamperuma, 1984).

In Cuba, salinity affects almost 60 % paddy lands at different rates (Castillo, 1987), it limiting its extension and productivity.

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Therefore, the present study was conducted in order to analyze rice germination and seedling growth at different sodium chloride concentrations.

MATERIALS AND METHODS

Rice seeds (*Oryza sativa* L.) from cultivars Pokkali (tolerant) and Amistad'82 (susceptible) were placed in petri dishes (20 seeds per plate), adding 5 mL NaCl solution (100, 150 and 200 mM) to them; the seeds receiving only distilled water were chosen as control. Each treatment consisted of five observations.

Germination was evaluated 24, 48, 72 and 96 hours after supplying the solution, considering radicle emergence as germination criterion. 96 hours later, seedlings were removed from the endosperm, determining its fresh and dry weights (after oven drying at 80°C until constant weight).

Seed imbibition dynamics was recorded in five 20-seed groups per treatment, by adding 10 mL distilled water or saline solution from the above mentioned concentrations, then water uptake was periodically determined up to 11 hours after laying treatments.

Data corresponding to germination percentages, and seedling fresh and dry weights of each cultivar were separately submitted to analysis of variances according to a one-way classification model.

RESULTS AND DISCUSSION

Both germination rate and its final percentage were inhibited by NaCl concentration increment in the medium (Figure 1). Accordingly, differences between cultivars became evident.

Pokkali attained high germination percentages 48 hours after treatment establishment (Figure 1A), with higher amounts than 85 % even at 150 mM; nevertheless, 200 mM significantly restrained final germination to 30 %.

On the other hand, treatment differences were evident within 48 hours in Amistad'82 (Figure 1B), with a lower germination rate, and germination was significantly inhibited at 100 mM NaCl concentration. Differences remained until 96 hours. 200 mM concentration restrained embryo growth reassumption almost completely.

Seed water imbibition was not substantially modified by salt treatments (Figure 2), which suggests germination inhibition was not due to an osmotic effect. Bal and Chattopadhyay (1985) reported similar results; however, Prakash and Prathapasenan (1988) found in rice seeds (cultivar GR-3) that water absorption significantly decreased at saline concentrations of 150 mM.

In both cultivars, concentrations from 100 mM NaCl onwards reduced seedling fresh weight (Table I). Pokkali showed reductions of 67.5, 89.5 and 98.8 % at concentrations of 100, 150, and 200 mM, respectively. Regarding seed germination, Amistad'82 was much more reduced in relation to Pokkali, 79.9 and 96.5 % at 100 and 150 mM respectively.

Salt concentration affected seedling dry weight (Table II); however, its reductions were lower than in fresh weight, they being of 32.9 and 64.6 % for Pokkali, and between 20.8 and 49 % for Amistad'82.

Muhammed, Akkar and Neue (1987) found a decrement in rice plant fresh and dry weights at 50 and 100 mM saline concentrations.

The highest fresh weight reductions compared to dry weight suggest that osmotic stress conditions decreased seedling water absorption, independently of NaCl ion toxic effect.

Different events could be distinguished at germination process: seed water imbibition, activation and/or synthesis of enzymes related to reserve mobilization, substance translocation towards the embryonal axis and its active growth reassumption through the synthesis of new products.

Results suggest a differential effect of NaCl at germination and seedling establishment. Consequently, initial events were not modified by osmotic potential variation, as water imbibition was not substantially affected, but it seems that germination was inhibited through ion toxic effect.

Accordingly, Gill and Singh (1985) reported carbohydrate metabolism disturbances of rice seeds under saline conditions, and they also established that stress

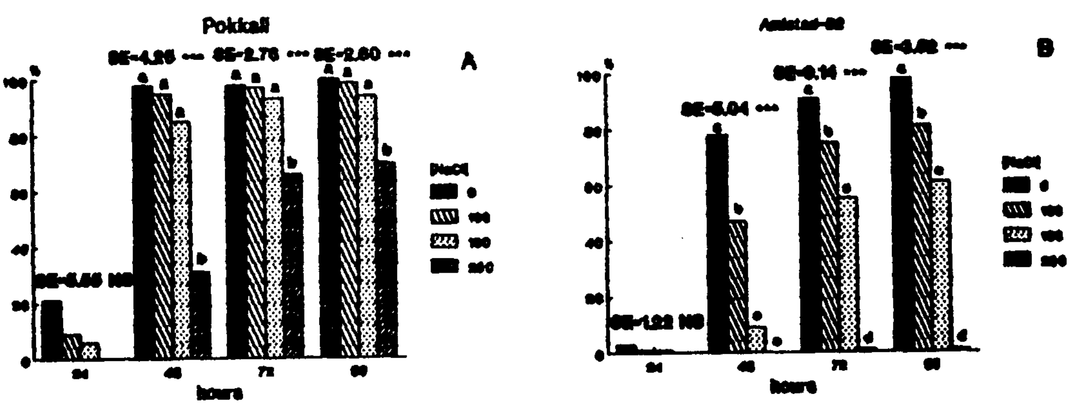

Figure 1. Rice Seed Germination Percentages Under Different Saline Concentrations

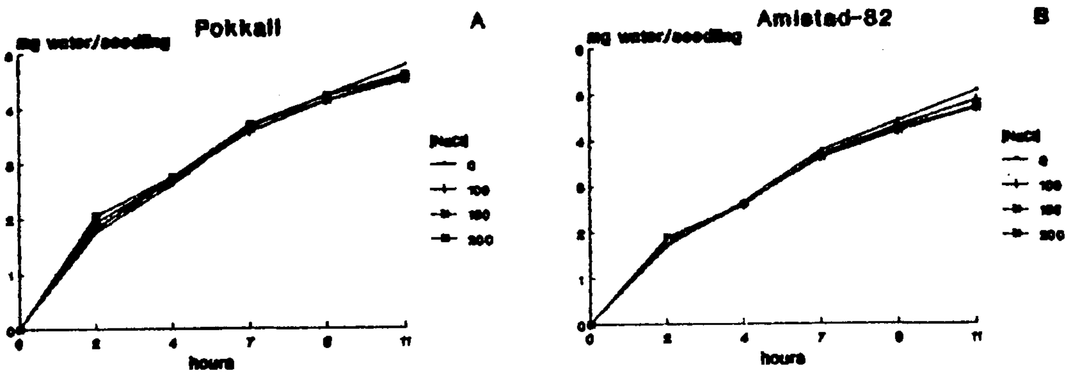

Figure 2. Rice Seed Imbibition Dynamics Under Different Saline Concentrations

Table I. Rice Seedling Fresh Weight (mg/seedling) Under Different NaCl Concentrations During Germination and Early Growth

	NaCl (mM)				
Cultivar	0	100	150	200	SE $\bar{x}$
Pokkali	21.88 a	7.10 b	2.30 c	0.26 d	0.26***
Amistad'82	12.16 a	2.44 b	0.42 b	0.00 b	0.86***

Means with common letters do not differ at $p<0.05$, according to Duncan's Multiple Range Test

Table II. Rice Seedling Dry Weight (mg/seedling) Under Different NaCl Concentrations During Germination and Early Growth

	NaCl (mM)				
Cultivar	0	100	150	200	SE $\bar{x}$
Pokkali	3.16 a	2.12 b	1.38 bc	1.12 c	0.28***
Amistad'82	1.92 a	1.52 b	0.98 b	0.00 b	0.26***

affected α-amylase activity and decreased starch at germination, the latter being lesser at higher salinity levels. Krishnamurty, Anbazhagan and Bhagwat (1986) also found a carbohydrate metabolic disorder of rice plant leaves under saline conditions.

Moreover, salinity delays RNAse activation and/or *de novo* synthesis in *Vigna unguiculata* cotyledons, it inhibiting RNA degradation while delaying mobilization of hydrolysis products towards embryonal axis (Gomes-Filho *et al.*, 1983).

Other metabolic seed disorders occur due to saline stress, particularly the ones related to phosphorolytic enzymes (alkaline and acid phosphatase, pirophosphatase and phytase), diminishing phosphate and energy availability (Dubey and Sharma, 1990).

These statements suggest that in this study, salinity affected seed germination through the complex metabolic relations characterizing this process which involves transcription, reserve mobilization, phosphorilated compound availability and translocation, among others.

The greatest effect found in fresh weight compared to seedling dry weight suggests that saline stress injury is due to osmotic factors as well as to ion toxicity at this developmental stage.

A differential behaviour of cultivars demonstrates the genetic potential existing for salinity tolerance (Flowers and Yeo, 1981); Yeo and Flowers (1986) established that traditional non-dwarf cultivars, such as Pokkali and Nona Bokra, overcome salinity effects because their vigor enables them to tolerate growth reduction, a trait that by itself could predominate more than any other physiological adaptation. A greater growth rate have a dilution effect, since Pokkali presents the same net sodium uptake in its roots as other susceptible semi-dwarf varieties, but a lesser ion concentration in its stem (Yeo and Flowers, 1984).

One possible salinity tolerance mechanism is polyamine content increase (spermidine and spermine) in contrast with low diamine levels; on the contrary, salt susceptibility should be related to a higher diamine increment and the incapability to keep high polyamine levels (Krishnamurthy and Bhagwat, 1989). Basu and Gosh (1991) also related rice salt tolerance (at least at seedling stage) to increased polyamine synthesis induced by stress.

Nevertheless, Prakash and Prathapasenan (1988 a and b) succeeded in overcoming inhibitory NaCl effects during germination and plant growth trough exogenous putrescine applications.

Present results pointed out that a 100 mM NaCl concentration is enough to distinguish between susceptible and tolerant cultivars during germination; nevertheless, 150 mM is needed to establish differences at seedling stage.

Besides, it seems that early germination events are only affected by ion toxicity, while seedling development is in addition inhibited by water stress. These aspects should be proved by the use of NaCl and non-toxic solutions of a similar osmotic potential.

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