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Comparative studies on the NaCl tolerance potential of three rice varieties

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Nowadays soil salinity is a major threat to agriculture. It significantly reduces the yield of many crops including rice. Since rice is the staple food of Asia, its reduction in the yield directly reflects in the human society. The present study was a comparison of NaCl stress tolerance potential of three rice varieties. Among the three rice varieties, one was a traditional variety (Chitteni) and other two were hybrid varieties (Aathira and Jyothi). The seeds of all the three varieties were allowed to germinate in various concentrations of NaCl and the growth attributes of the seedlings (germination percentage, shoot length, fresh and dry weight, dry weight percentage and moisture content percentage) were measured. At higher concentration of NaCl, the seedlings showed reduction in shoot length, fresh weight, dry weight etc. The NaCl concentration at which the seedlings showed 50% growth retardation was taken as the maximum NaCl stress tolerance potential of the variety. It was observed that the traditional rice variety Chitteni showed more NaCl stress tolerance potential as compared to the hybrid varieties. Thus from the results of the study it can be inferred that the traditional rice variety Chitteni can be used for salinity stress tolerance breeding purposes due to its higher NaCl stress tolerance potential.

Key words: Salt tolerance, stress, germination, seedling

Introduction

Plants are exposed to various environmental conditions throughout their life period. Some of these environmental conditions become adverse to the growth and development of plants. These environmental factors include biotic and abiotic factors which interfere with the growth and development of plants. Abiotic stress cause changes in soil-plant-atmosphere continuum and is responsible for reduced yield in several major crops. Therefore, the subject of abiotic stress response in plants is gaining considerable significance in the contemporary world.

The major abiotic stresses for which plants are exposed include extreme temperature, drought or high salinity. These stresses are the most significant factors which cause substantial and unpredictable loss in the crop production (Jakab et al., 2005). Increased food demand all over the world demands the increased crop production, which is threatened by rapidly depleting good quality irrigation water resources and changing environmental conditions. Soil salinity is a major limitation to agricultural productivity in many parts of the world, especially in arid and semi-arid areas (Dubey, 1997).

Rice (Oryza sativa L.) is one of the most important cereal crops in the world and salinity significantly affects the growth and reproduction of this important crop. Different varieties of rice show different salinity tolerance potentials. In the present study we selected three rice varieties-one traditional cultivar (Chitteni) and two hybrid varieties (Aathira and Jyothi) and made comparative studies on the NaCl tolerance potential of these varieties.

Materials and Methods

Plant material

Rice is an important cereal crop which is rich in carbohydrate and belongs to the family Poaceae and is the staple food of Asia. The rice cultivar Chitteni is a traditional variety well known for its massive cultivation over the districts of Palakkad and Thrissur. The seeds of Chitteni were collected from Kerala Agricultural University, Mannuthi, Thrissur, Kerala. Seeds of hybrid rice varieties Aathira (Ptb 51) and Jyothi (Ptb 39) were collected from Regional Agricultural Research Station (RARS) Pattambi, Kerala.

Methods

Rice seeds were washed with 0.1% mercuric chloride, detergent solution and distilled water to remove any dirt present on the seed surface. The washed seeds were surface dried by using filter paper. The seeds were allowed to germinate in Petri dishes containing absorbent cotton soaked with distilled water (control), different concentrations of NaCl (25, 50, 75, 100 and 125mM) solution. The Petri dishes were kept under a continuous light (120 mol m-2 s-1) at 25+2oC. The growth of treated as well as control seedlings were recorded on 10 d after germination.

Growth parameters such as germination percentage, shoot length, fresh weight, dry weight, moisture content and dry weight percentage were studied.Percentage of germination was calculated by using the formula,

$$\text{Germination percentage} = \frac{\text{No. of seeds germinate X 100}}{\text{Total No. of seeds}}$$

Samples (seedlings) were weighed using electronic balance. For fresh weight and dry weight measurements the seedlings were blotted and wrapped separately in pre-weighed labeled aluminum foils. Fresh weight of the samples was determined by weighing them immediately after wrapping. For dry weight measurements the samples were kept in an hot air oven at 1000 C for one hour followed by at 600C for overnight. After 48 h the samples were transferred to a desiccator, allowed to cool and then weighed. The samples were reweighed as described above at regular intervals (24h), until the weights became constant. The dry weight percentage was calculated by using the following formula:

$$\text{Dry weight percentage} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

Moisture content percentage was calculated by using the following formula

$$\text{Moisture content percentage} = \frac{\text{Fresh weight - Dry weight}}{\text{Fresh weight}} \times 100$$

Results and Discussion

It was observed that, seeds of the three rice varieties were not germinated simultaneously. In all the three varieties, germination percentage was maximum in control and decreased gradually as the concentration of NaCl increased (Fig. 1). Same trend was observed in shoot length (Fig. 2), fresh weight (Fig. 3) and dry weight of the seedlings (Fig. 4). As far as the dry weight percentage and moisture percentage is concerned, it was varied in control and treatments (Figs. 5, 6).

The three rice varieties showed decrease in seedling growth as the concentration of NaCl increased. The seedling growth decrease was about 50% at 50 mM NaCl in the case of hybrid varieties (Aathira and Jyothi) and above this concentration, the shoot length, fresh weight and dry weight of the seedlings were very less. But the traditional rice variety Chitteni showed more tolerance towards NaCl and it could tolerate up to 75 mM NaCl. At 125mM NaCl, even some of the seeds failed to germinate irrespective of the varieties. Thus from the study it was clear that the seeds of Aathira and Jyothi can tolerate a concentration of NaCl upto 50 mM and above this concentration, the growth of the seedlings was less. Whereas, the traditional rice variety Chitteni can tolerate up to 75 mM NaCl.

As different rice varieties are known to exhibit different levels of NaCl stress tolerance potential it is necessary to check the NaCl tolerance potential of these varieties for future stress breeding programmes. Usually plants exposed to stressed conditions make changes in some of their physiological and biochemical features which make them to cope up with the stressed situations. Thus the reduction in the growth attributes of rice seedlings under NaCl conditions may be an adaptive mechanism of the seedlings to cope up with the stresses. The reduction in plant growth in a stressful environment is also ascribed to the altered level of plant hormones (Roy et al., 1995; Bita and Gerats, 2013; Hasanuzzaman et al., 2013).Out of the three varieties studied, the traditional variety Chitteni showed more NaCl tolerance potential and it was evident from the results.The high stress tolerance potential of traditional variety may be due to its genetic makeup and this ability can be utilized for further breeding purposes.

Conclusions

The studywas conducted to compare the NaCl stress tolerance potential of three rice varieties. As the concentration of NaCl increased, the seedlings showed reduction in shoot length, fresh weight, dry weight etc. From the results of this study it was concluded that the traditional rice variety Chitteni showed more NaCl stress tolerance potential when compared to the two hybrid varieties Aathira and Jyothi.

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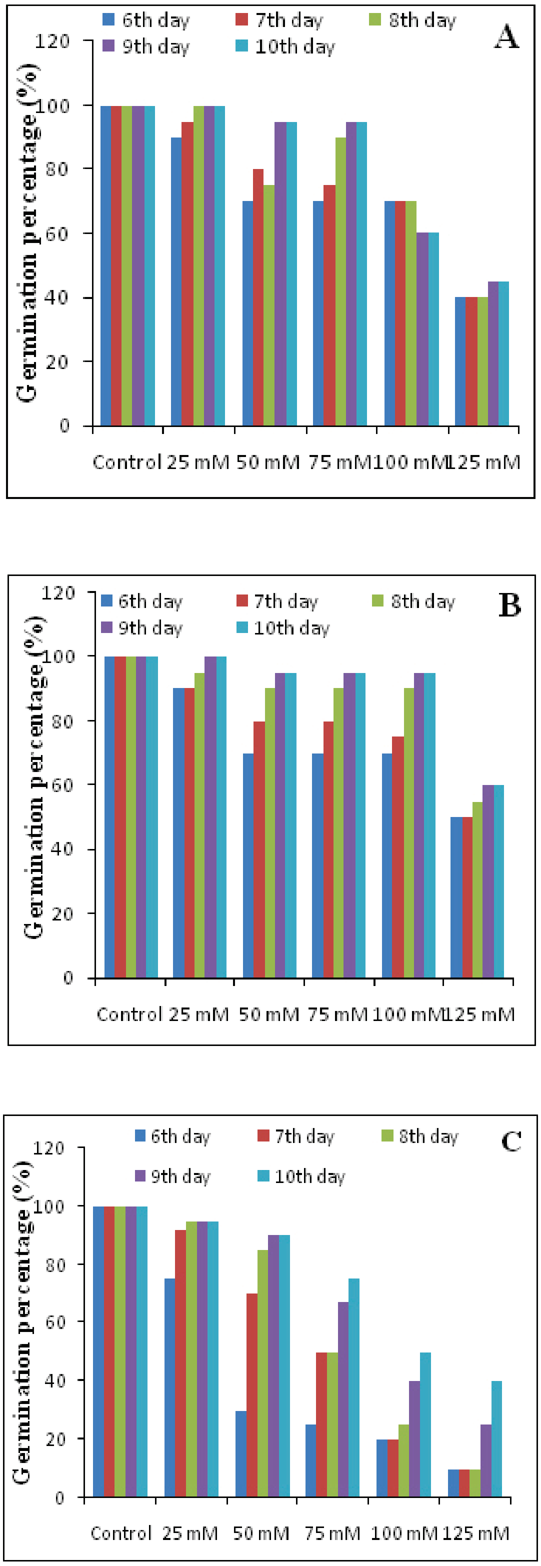

Figure 1: Germination percentage of Chitteni (A) Aathira (B) and Jyothi (C) seedlings grown in unstressed (control) and various concentrations of NaCl solutions.

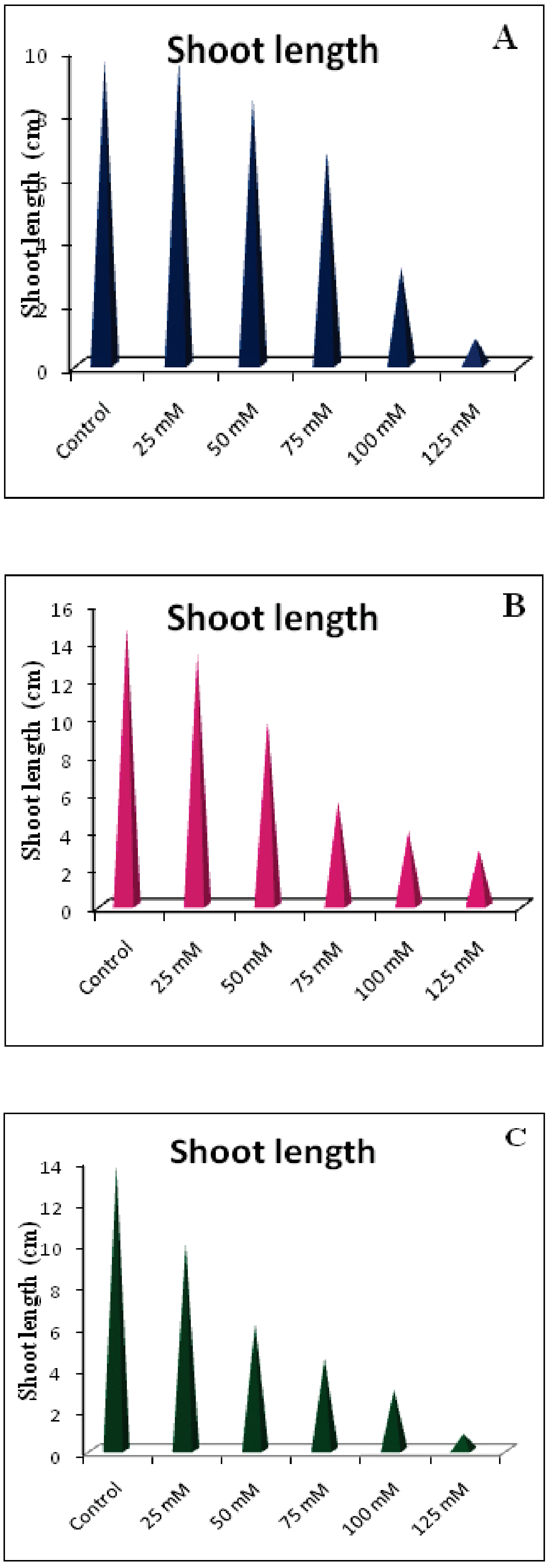

Figure 2: Shoot length of Chitteni (A) Aathira (B) and Jyothi (C) seedlings grown in unstressed (control) and various concentrations of NaCl solutions.

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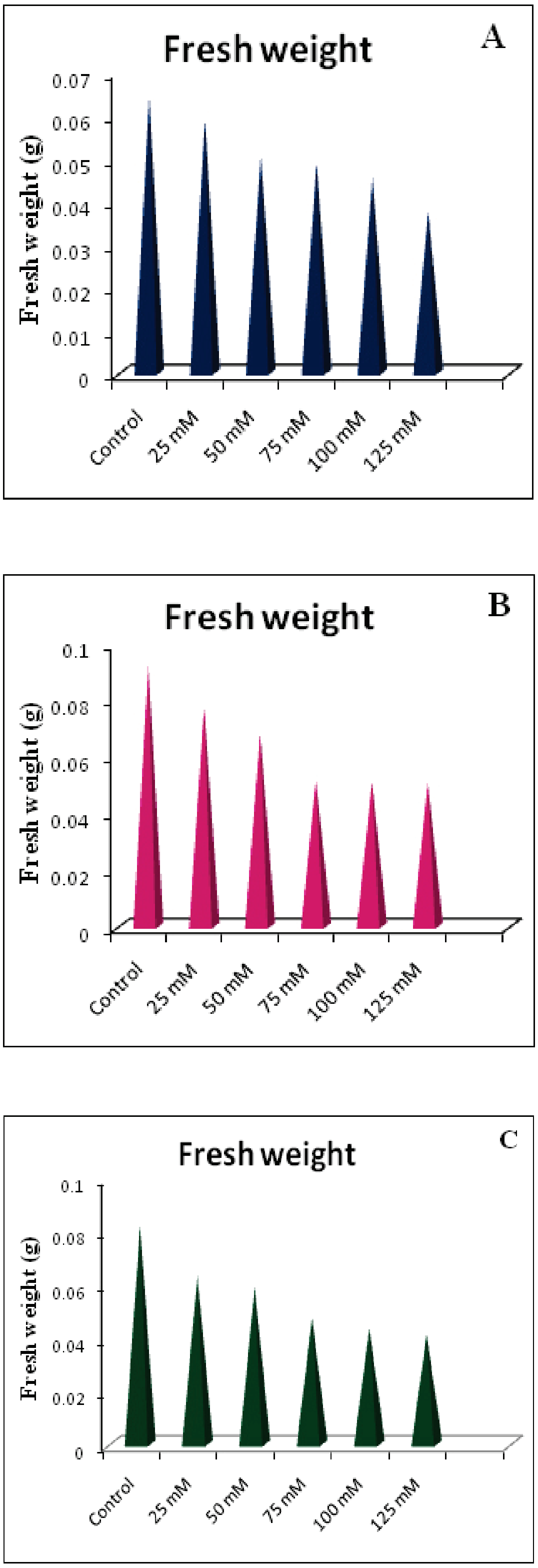


Figure 3: Fresh weight of Chitteni (A) Aathira (B) and Jyothi (C) seedlings grown in unstressed (control) and various concentrations of NaCl solutions.

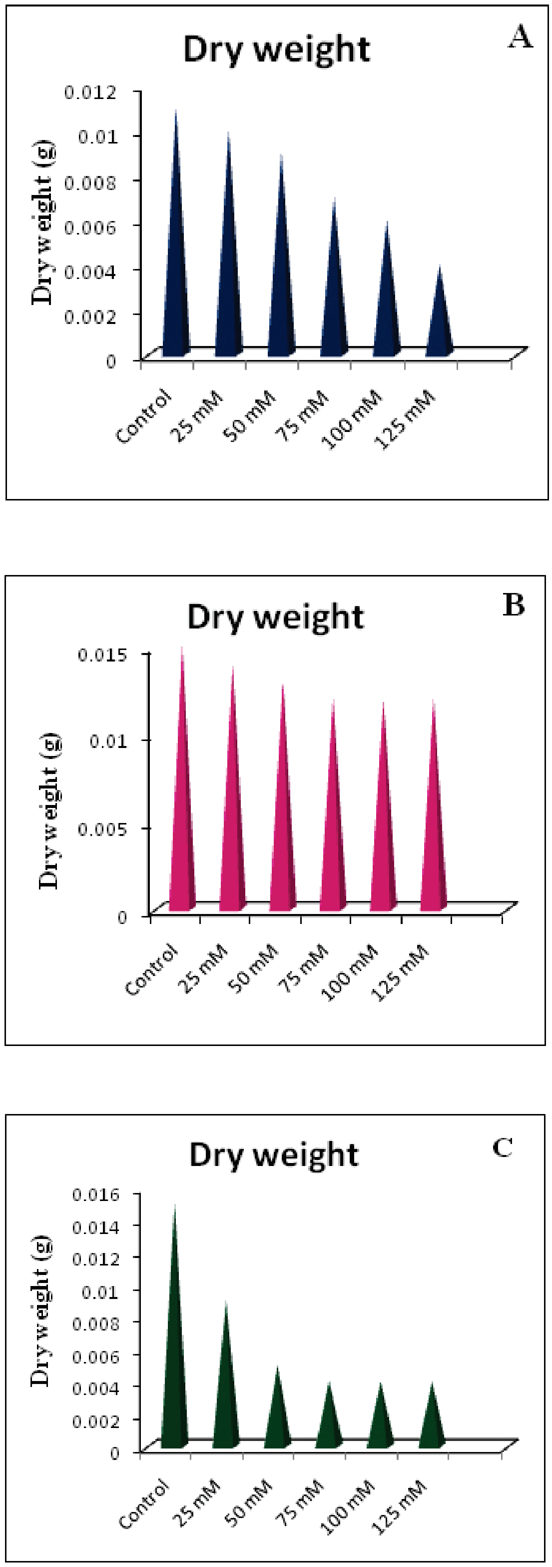
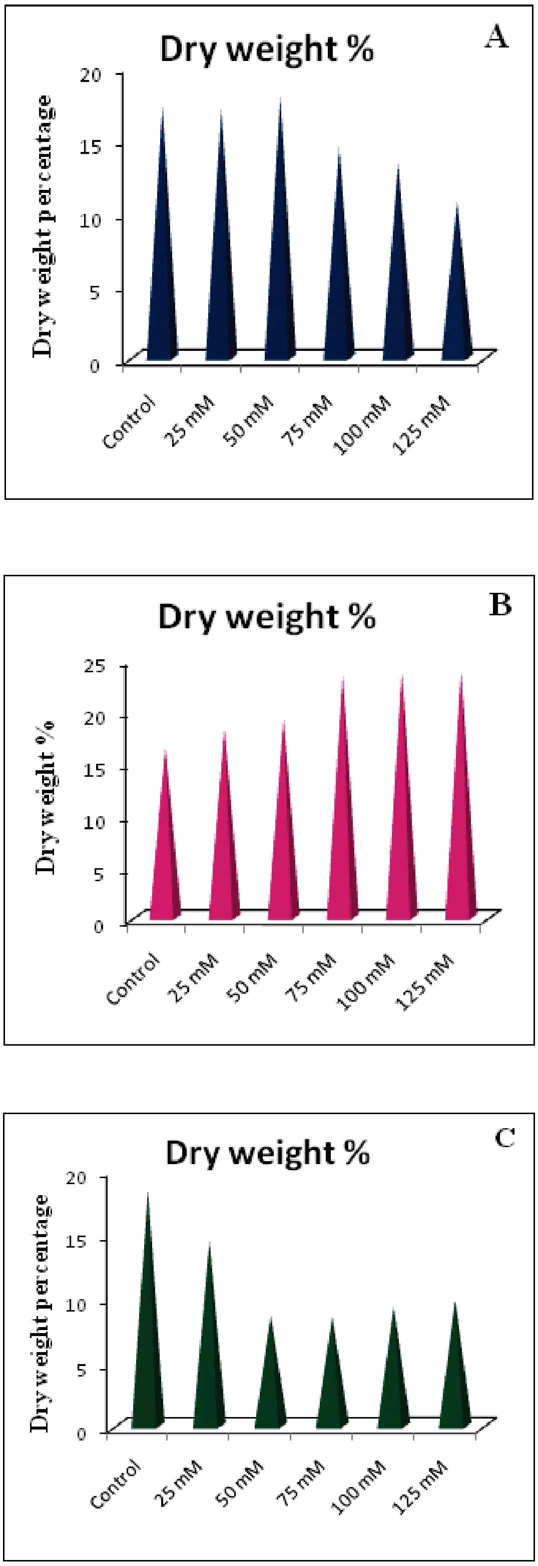


Figure 4: Dry weight of Chitteni (A) Aathira (B) and Jyothi (C) seedlings grown in unstressed (control) and various concentrations of NaCl solutions.



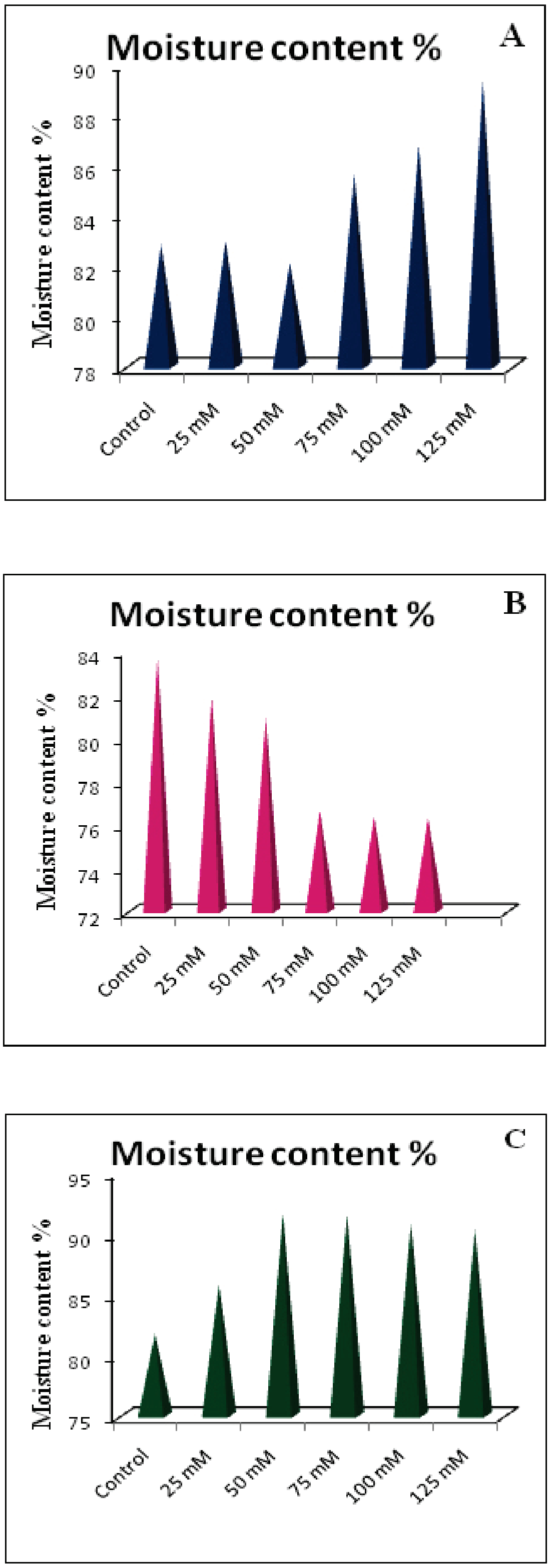


Figure 5: Dry weight percentage of Chitteni (A) Aathira (B) and Jyothi (C) seedlings grown in unstressed (control) and various concentrations of NaCl solutions.

Figure 6: Moisture content percentage of Chitteni (A) Aathira (B) and Jyothi (C) seedlings grown in unstressed (control) and various concentrations of NaCl solutions.