EFFECT OF SALINITY ON GROWTH AND GERMINATION OF FIVE RICE VARIETIES CULTIVATED IN AMPARA DISTRICT

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ABSTRACT: *Five new improved rice varieties released by Rice Research and Development Institute, Bathalagoda were screened against salt tolerance for seed germination and early seedling growth using five different salinity levels (0, 4, 8, 12, and 16 dS/m). Measurements were taken for root length, shoot length, fresh weight of seedlings, dry weight of seedlings, germination energy, speed of germination and final germination percentage. All the tested variables, except dry weight of seedlings, decreased with increasing salinity and had a significant difference (p<0.05) between salinity levels. Osmotic stress due to increasing salinity and toxic effect due to high sodium ion concentration interfere water absorption by plants and affect physiological activities in seeds and seed germination. Among the rice varieties used, Bg 357 rice variety had a higher root length, shoot length, fresh weight of seedlings, germination energy, speed of germination and final germination percentage and was considered as tolerant to salt. All the other rice varieties had different degrees of sensitivity to salinity.*

Keywords: Salt tolerance, germination, seedling growth, osmotic stress

1. INTRODUCTION

Rice is the staple food and the single most important crop occupying 34% (about 0.77 million ha) of the total cultivated area in Sri Lanka. About 1.8 million farm families are engaged in paddy cultivation and the country currently produces 2.7 million tons of rough rice annually satisfying 95% of the domestic rice requirement. It is projected that the demand for rice will increase at 1.1% per year and in order to meet this demand rice production should grow at the rate of 2.9% per year (Rice Research and Development Institute, Bathalagoda). Increasing the cropping intensity and national average yield are the options available to achieve this increasing demand.

Abiotic stresses, such as drought, heat, cold, nutrient deficiency and excess of salt or toxic metals like aluminum, arsenic and cadmium (Zhu, 2016), affect crop production worldwide reducing the average yields of major crops by more than 50% (Boyer, 1982). Salinity as an abiotic stress widely limit the crop production severely (Shannon, 1998). Soil salinity, defined as the presence of excess amounts of salts in soil solution in agricultural lands (Pradheeban et al., 2014), present electric conductivities sufficient to cause yield reduction in many crops (Ghosh et al., 2016). It is estimated that, about 49 million ha of land suitable for rice production remain uncultivated due to salinity in Asia (Ponnamperuma et al., 1980). Therefore, there is an urgent need to develop salt tolerant rice varieties due to the increasing threats of salinization of arable lands worldwide (Li and Xu, 2007).

Soil salinity increase due to increase in temperature that result in higher amounts of precipitation and lack of rain that result in lesser water retention in the soil and also due to human activities. Sirisena and Herath (2009) stated that soil salinity is gradually spreading in paddy fields of Sri Lanka both in coastal and inland areas.

Salinity affects plants by causing osmotic stress and ionic stress. Osmotic stress is caused by increased osmotic potential of rhizosphere due to high salt concentration and ionic stress is by high ion concentration (Zeng et al., 2003).

Rice is susceptible to salinity, especially, at early vegetative and later reproductive stages (Mass et al., 1977). Salinity induce both biochemical and physiological changes causing growth inhibition and yield loss (Rao et al., 2008). The effects of salinity on rice include inhibition of germination, difficulties in crop area establishment, leaf area development, decrease in dry matter production, delay in seed set and sterility (Khatun and Flowers, 1995). Previous research findings have well documented the effects of salinity on seedling growth, seedling establishment and grain yield components such as spikelet number and tiller number ultimately leading to reduction in grain yields (Zeng et al., 2003).

Various screening methods have developed to investigate salinity tolerance in rice at different growth stages under field and greenhouse conditions (IRRI, 1989; Chowdhury and Bowling, 1995). Screening under field conditions is difficult due to significant variations in environmental factors such as temperature, relative humidity, solar radiation and the presence of other soil related stresses during the growth period (Pradheeban et al., 2014). These methods become laborious, time consuming and cumbersome when working with large number of varieties. Therefore, screening of varieties at early growth stages under laboratory conditions using effective salinity indices like root length, shoot length, plant biomass, shoot Na^+/ K^+ ratio is an efficient method to differentiate a large number of varieties according to salinity tolerance (Pradheeban et al., 2014; Ghosh et al., 2016).

The information related to the salinity tolerance of new improved rice varieties released by Rice Research and Development Institutes of Sri Lanka is not well documented. In addition, seed characteristics such as speed of germination and germination energy and seedling characteristics such as shoot length and root length under salinity stress were not well studied in previous research works. Therefore, the present study was formulated to screen the effects of salinity on five widely cultivated new improved rice varieties in Ampara district, released by Rice Research and Development Institute, Bathalagoda as these were not screened against salinity previously.

2. METHODOLOGY

The experiment was carried out in the laboratory of Department of Biological Sciences, Faculty of Applied Sciences, South Eastern University of Sri Lanka in August 2018. Seeds of five new improved rice varieties (Bg 94/1, Bg 250, Bg 252, Bg 300, Bg 357) released by Rice Research and Development Institute, Bathalagoda were obtained from Rice Research Station, Sammanthurai.

Before the experiment, a randomly selected sample (greater than 100 seeds) of each rice variety was soaked in 5% sodium hypochlorite solution for five minutes (to surface sterilize), rinsed thoroughly with distilled water, removed all the floating seeds, selected 100 seeds randomly and placed in petri dishes separately lined with two tissue papers to test the germination percentage. Seeds were considered as germinated when shoot length exceeded more than 2 mm. Number of germinated seeds were counted after two days. Germination percentage of all the tested varieties was greater than 70% (Table 1).

Table 1. Germination percentages of tested rice varieties

Variety	Germination Percentage (%)
Bg 94/1	74
Bg 250	78
Bg 252	97
Bg 300	88
Bg 357	96

Ten, healthy, vigorous, uniform size and surface sterilized, seeds were selected and were placed in petri dishes lined with two tissue papers. Four salt solutions having concentrations 4, 8, 12 and 16 dS/m were prepared using sodium chloride. Distilled water was used as the control (0 dS/m). Each petri dish was moistened with 10 ml of respective salt solutions.

Treatments were arranged in a Completely Randomized Design (CRD) with three replicates. During the study period, the average room temperature was 29 ^{0}C with 12 hours photoperiod. The number of germinated seeds in each petri dish were counted daily for seven days.

Measurements

Measurements of Shoot Length (SL), Root Length (RL) and Fresh Weight of Seedlings (FWS) were taken separately for each 30 samples at the seventh day. Dry Weight of Seedlings (DWS) were measured after oven drying at 70 ^{0}C for three days.

Calculations

The following formulas were used to calculate Germination Energy (GE), Speed of Germination (SG) and Final Germination Percentage (FGP) (Ruan et al., 2002).

$$GE\ (\%) = \frac{Number\ of\ germinated\ seeds\ at\ 4\ DAS}{Total\ number\ of\ tested\ seeds} * 100$$

DAS = Days After Sowing

$$SG = \frac{Number\ of\ germinated\ seeds}{Days\ of\ first\ count} + \ldots\ldots\ldots + \frac{Number\ of\ germinated\ seeds}{Days\ of\ final\ count\ (7\ days)}$$

$$FGP = \frac{Number\ of\ total\ germinated\ seeds}{totlal\ number\ of\ tested\ seeds} * 100$$

3. DISCUSSION AND RESULTS

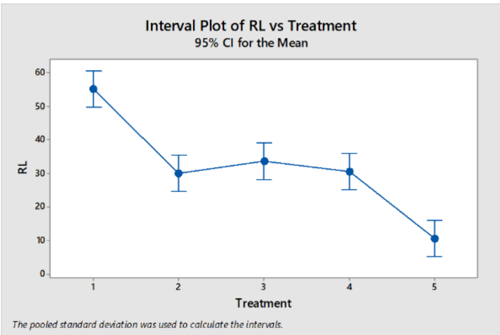
Effect of salinity on root length, shoot length, fresh weight and dry weight of tested rice varieties

It was found that there were significant ($p>0.05$) differences between treatments on root length (Figure 2), shoot length (Figure 3), fresh weight (Figure 4) and dry weight (Figure 5) of all the five rice varieties.

The root length of all the rice varieties except Bg 357 decreased with increasing salinity compared to control. Bg 357 rice variety showed a significant decrease in root length only after 12 dS/m (Treatment 4), indicating its salinity tolerance, compared to control (Treatment 1).

Bg 252 rice variety showed a reduction in root length up to zero continuously with increasing salinity. This might be due to inhibitory effect of sodium chloride to root elongation by restricting cell division and expansion of root (Pradheeban et al., 2014). Similar results were obtained by Rahman et al., (2001). In Bg 94/1, Bg 250 and Bg 300 there was a significant reduction in root length initially up to 4 or 8 dS/m could be due to osmotic effect which is tolerated up to 12 dS/m. The shoot length and fresh weight of all varieties too show more or less a similar trend. The second reduction in root length after 12 dS/m could be due to toxic effect of sodium and/or chloride ions. Thus all varieties except Bg 252 apparently tolerate up to 12 dS/m level of salinity. The dry weight of the seedlings increased significantly with increasing salinity. Dry matter accumulation was highest at 12 dS/m in Bg 250 and Bg 357 and in Bg 94/1 and Bg 300, it was highest at 8 dS/m. This might be due to the fact that salt tolerant species show lower osmotic potentials allowing them to absorb more water from the environment thereby maintaining metabolic activities. Further studies should be carried out test the effect of these salinity levels on the growth and reproduction of these varieties continuously.

Reduction in root and shoot length with increasing salinity have been observed in many crop plants like wheat, barley, pea and cabbage (Mer et al., 2000).



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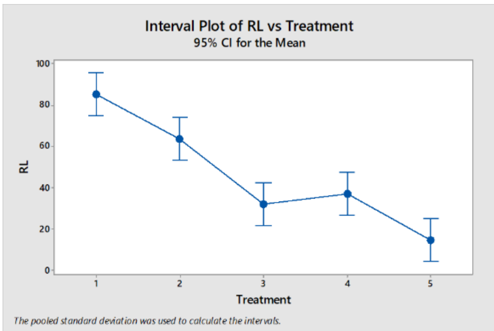

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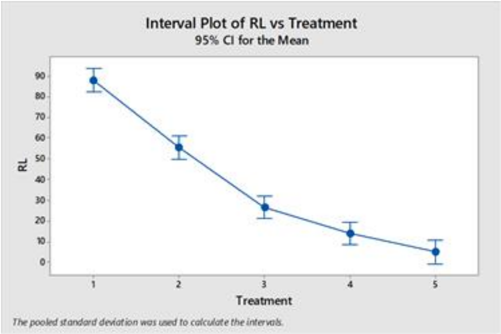

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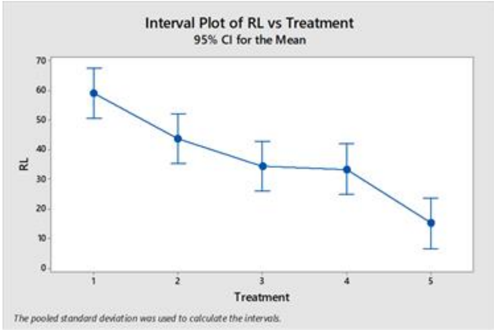

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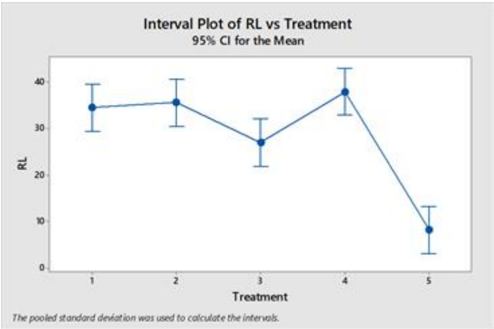

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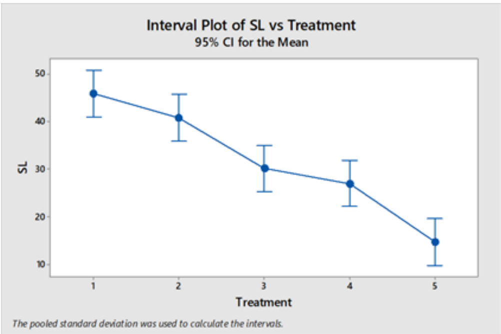
Figure 2. Effect of salinity on root length of tested rice varieties.
(a, b, c, d and e represent the effect of salinity on root length of Bg 94/1, Bg 250, Bg 252, Bg 300 and Bg 357 respectively).



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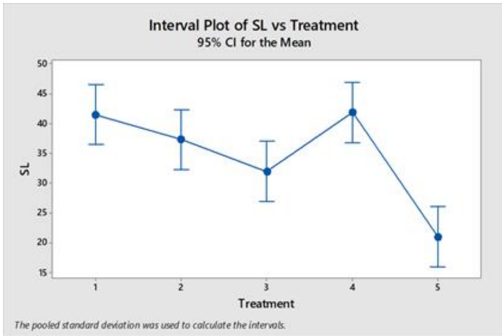

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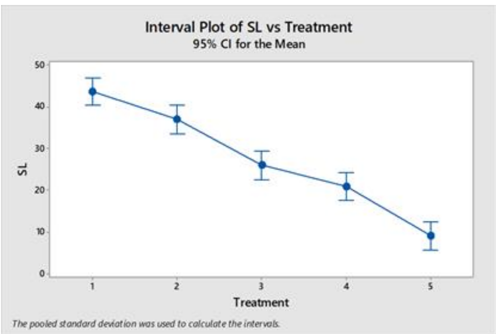

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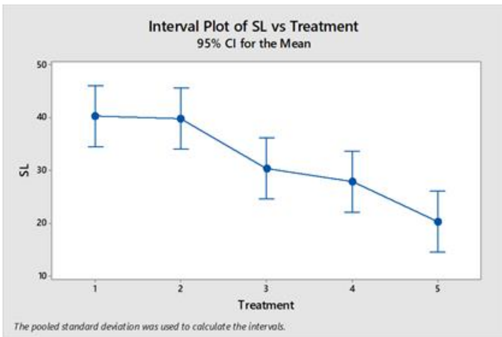

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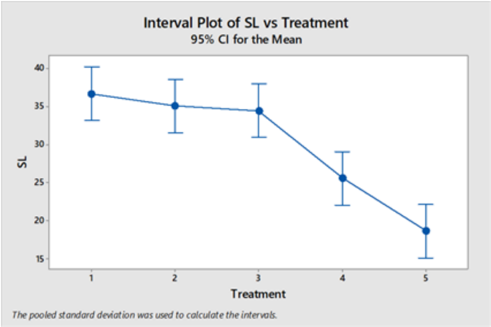

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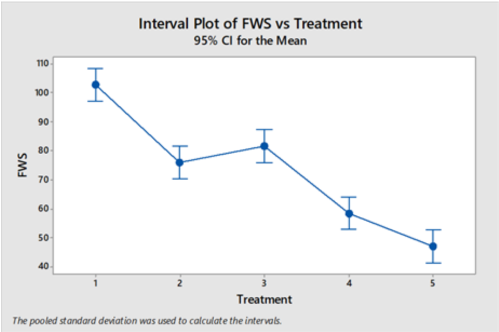
Figure 3. Effect of salinity on shoot length of tested rice varieties.
(a, b, c, d and e represent the effect of salinity on shoot length of Bg 94/1, Bg 250, Bg 252, Bg 300 and Bg 357 respectively).



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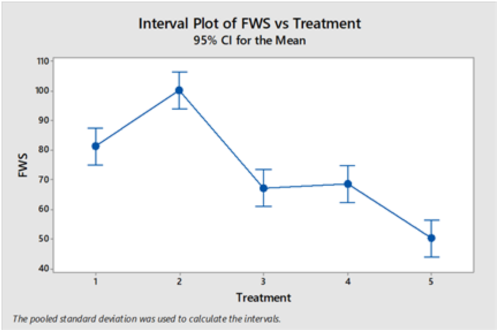

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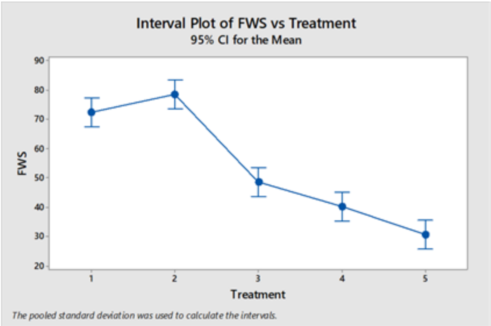

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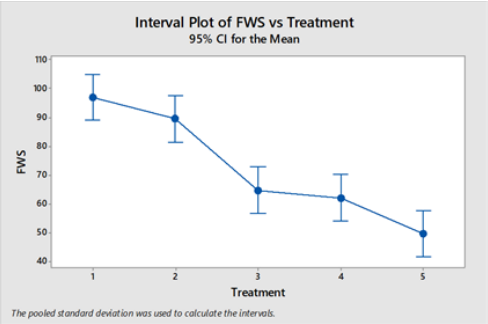

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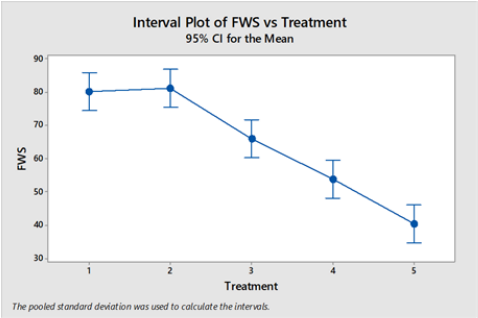

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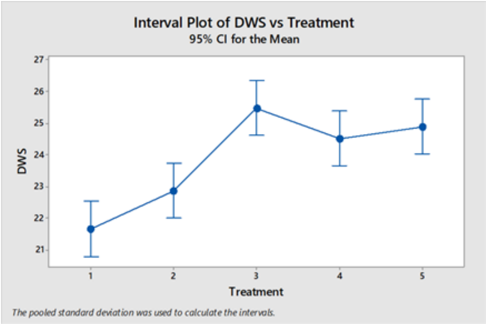
Figure 4. Effect of salinity on fresh weight of seedling of tested rice varieties.
(a, b, c, d and e represent the effect of salinity on fresh weight of seedlings of Bg 94/1, Bg 250, Bg 252, Bg 300 and Bg 357 respectively).



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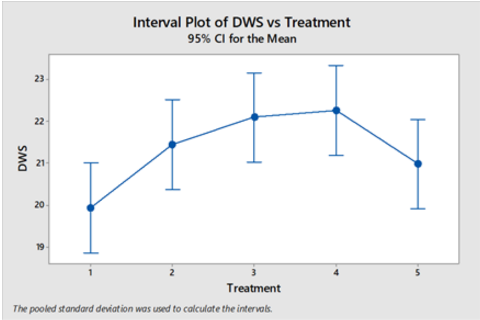

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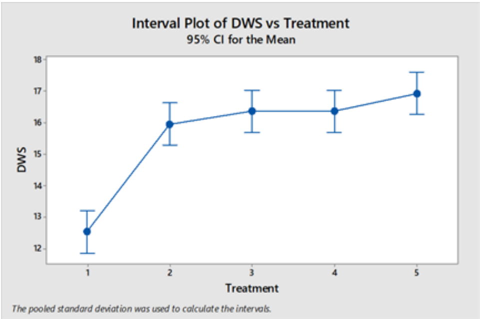

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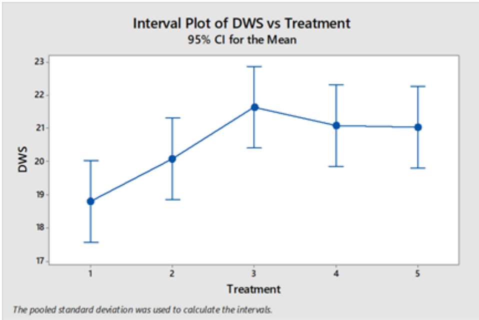

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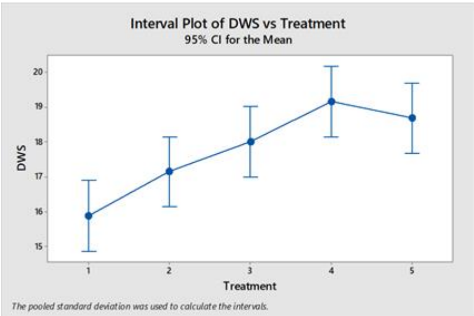

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Figure 5. Effect of salinity on dry weight of seedling of tested rice varieties.
(a, b, c, d and e represent the effect of salinity on fresh weight of seedlings of Bg 94/1, Bg 250, Bg 252, Bg 300 and Bg 357 respectively).

Effect of salinity on germination energy, speed of germination and final germination percentage of tested rice varieties.

It was found that there were significant (p>0.05) differences between treatments on germination energy (Figure 7), speed of germination (Figure 8) and final germination percentage (Figure 9) of Bg 300 and Bg 357 rice varieties.

Bg 300 rice variety showed a significant decrease in speed of germination with increasing salinity compared to control. The trends of decreasing germination energy, speed of germination and final germination percentage of Bg 357 rice variety were similar. In Bg 357 significant decrease in germination energy, speed of germination and final germination percentage was observed at 12 dS/m (Treatment 4), compared to control but a significant increase in these parameters was observed at 16 dS/m (Treatment 5) indicating its salt tolerance.

The developing osmotic stress with increasing salinity can interfere cell-water relationships. The osmotic effect reduces the water absorption by plant thereby affecting physiological activities in seeds and delay the germination processes

(Pradheeban et al., 2014). But the seeds of salt tolerant species have lower osmotic potential allowing them to absorb water from the environment.

In addition to osmotic effect, toxic effects due to high sodium ion concentration change the enzymatic activity and hormonal balance of seeds ultimately reducing the seed germination (Aliakbar and Kobra, 2008). Reduction in germination energy, speed of germination and final germination percentage with increasing salinity was also reported by Heenan et al., (1988) and Abeysiriwardena, (2004).

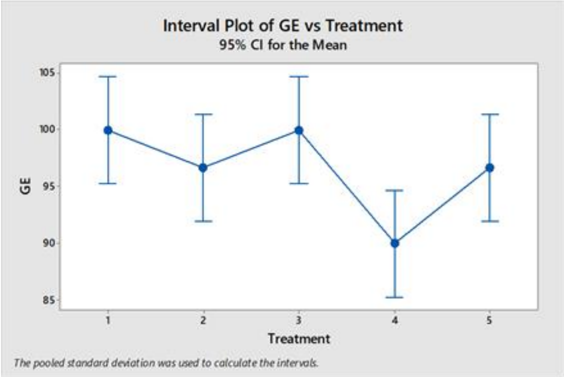

Figure 7. Effect of salinity on germination energy of Bg 357 rice variety.

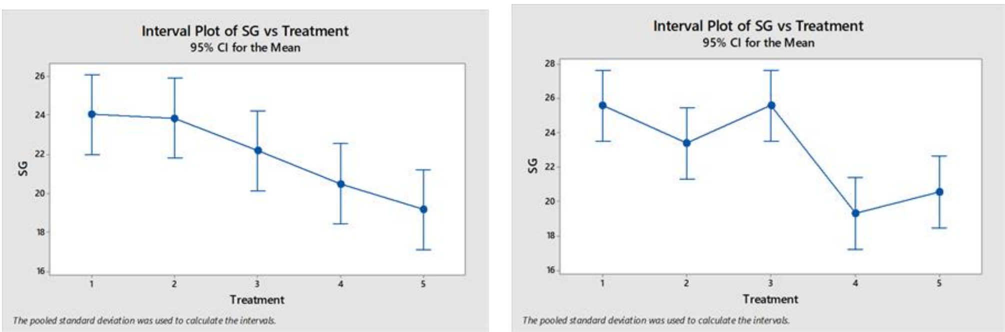

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Figure 8. Effect of salinity on speed of germination of Bg 300 and Bg 357 rice variety.
(a, and b represent the speed of germination of Bg 300 and Bg 357 rice varieties respectively).

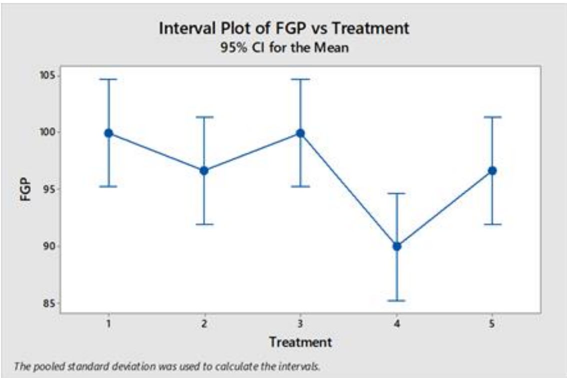

Figure 9. Effect of salinity on final germination percentage of Bg 357 rice variety.

CONCLUSION

Growth and germination variables considered in this study were affected by increasing salinity. Marked reduction in all the variables except dry weight of seedlings were observed at 16 dS/m, the highest salinity used in this study.

Among the rice varieties used, Bg 357 rice variety was tolerant to salt by having higher root length, shoot length, fresh weight of seedlings, germination energy, speed of germination and final germination percentage.
Some or all the variables were lower in all other rice varieties compared to Bg 357 indicating different degrees of sensitivity to salinity during their germination and early seedling stage.

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