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Effect of salt stress on seed germination and seedling vigour in okra

Ahmad Azeem, Qaiser Javed, Jianfan Sun*, Ikram Ullah, Noman Ali Buttar**, Muhammad Saifullah, Daolin Du***

School of the Environment and Safety Engineering, Jiangsu University, Zhenjiang, Jiangsu, China

ABSTRACT

The response of two okra cultivars (Chinese Red (var. Red velvet) and Chinese Green (var. Blondy)) were investigated against four level of salinity i.e., 0.00%, 0.06%, 0.12%, and 0.18% (control, slight, moderate and severe) that were made with equal proportional of NaCl and $CaCl_2$. Salt stress significantly reduced the germination percentage, germination energy percentage and germination speed. Chinese Red showed tolerance at moderate level of 35% reduction in germination rate but Chinese Green exhibited slight stress with 25% reduction in germination percentage. Speed of germination decreased in both the cultivars that delayed seeds germination. Seedling growth, fresh weight and dry weight were also reduced due to increasing salt stress. Plumule length, radical length, fresh weight and dry weight of Chinese Green were 4.9cm, 1.50cm, 0.31g and 0.092g at slight stress, that were higher than Chinese Red, but in moderate stress Chinese Red have better growth than Chinese Green. It was concluded that Chinese Red under these environment stress tolerant to moderate stress and Chinese Green tolerant to slight stress. This study results can be helpful to utilize saline water resources to get maximum production.

Keywords: *Abelmoschus esculentus,* germination, seedling growth, salt stress.

INTRODUCTION

Okra (*Abelmoschus esculentus*) belongs to the family *Malvaceae.* It is an annual herb and vegetable crop grown throughout the tropical and subtropical parts of the world (Habib *et al*., 4). It is mainly cultivated for its immature fruits which are cooked and eaten in countries like Pakistan, India, Turkey and China (Azeem *et al*., 1). Okra production is also affected by environmental stresses but mostly effective one is salt stress. Okra production under saline irrigation was also decreased but it also shows tolerant in some levels of salt stress (Azeem *et al*., 2).

The most harmful environmental stress that destroy agriculture productions are saline irrigation and saline soil. More than 37% of world agriculture land is under salinity (Javed *et al*., 8). Salinity problem in China is very high and more than 1/3rd of agriculture land is under salinity (Javed *et al*., 5). Salt stress effect crop in three different way like osmotic stress, ionic toxicity and soluble salt concentrations depend upon stress nature and duration (Javed *et al*., 6). The effect of salt stress on plants are different according to the plant growth stage. Researchers worked a lot on salt stress effect on plant growth, production and fruit development of okra but there is less literature on seeds germination and early seedling growth under salt stress.

*Corresponding authors: e-mail: zxsjf@ujs.edu.cn and ddl@ujs.edu.cn

**Key Laboratory of Modern Agricultural Equipment and Technology, Ministry of Education, Institute of Agricultural Engineering, Jiangsu University, Zhenjiang, Jiangsu, China

The germination process consists of two distinct phases, the first one being inhibition which mainly depends on the physiology of the seeds, whilst the 2nd phase is a growth development between emergence and inhibition (Belmehdi *et al*., 3). Salt stress restricts the seed to get water, that cause the germinating seed to die. High salt concentrations reduced water potential, subsequent that reduced accessibility of water to root cells (Azeem *et al*., 1). Salt tolerance mechanisms for plant growth during germination period were not completely understood. However higher salts concentrations interrupt various processes such as seed germination, vegetation, flowering and finally fruit yield (Belmehdi *et al*., 3). Many researchers described that seeds of maximum plants were germinated frequently in tape water but under salt stress germination was affected. Salt stress affects several physiological and biochemical attributes which result reduction in seed germination and seedling growth (Tavakkoli *et al*., 10). Therefore, the present study was conducted to check the possible effect of NaCl and $CaCl_2$ on the seed germination and early seedling growth of two okra cultivars, and to determine the tolerance limits of both cultivars.

MATERIALS AND METHODS

This experiment was performed at the School of Agricultural Equipment Engineering, Jiangsu University, Zhenjiang, Jiangsu province, China

(32.20°N, 119.45°E), in June, 2017. Two okra (*Abelmoschus Esculentus)* cultivars, Chinese Red (var. Red velvet) and Chinese Green (var. Blondy) were used in this study. Healthy, uniform seeds of both cultivars were surface sterilized with 1% mercuric chloride for 5 minutes and washed with distilled water than surface dried using tissue papers. Ten seeds for each treatment were allow to germinate in petriplates (110mm diameter, 9mm height) attach with Whatman # 1 filter paper. Each filter paper was moistened with salt solution of 0.00% (control), 0.06% (Slight), 0.12% (moderate) and 0.18% (severe). Equal proportion of NaCl and $CaCl_2$ concentration were added to Hoagland nutrient solution to make salt solution as shown in Table 1(Azeem *et al*., 2).

Moistened the filter paper, 5ml of water was used and watering of filter was done every day. The experiment treatments were design with four replicates in completely randomized design (CRD). Petriplates were placed in an incubator. Seeds were allowed to germinate at incubator temperature (25±2) with 100W bulb inside incubator. Emergence of the radicle was considered as seed germination. The number of seeds that were sprouted and germinated counting daily up to seven days. Seedling Plumule and radicle length of ten randomly selected seedlings from each replicate was measured at the time of harvest (7 days after treatment application) with a scale. Seedling fresh weight were measured at the time of harvest and dry weight were recorded after oven drying at 70°C for 72 h. After final count, speed of germination (SG), final germination percentage (FGP) and germination energy percentage (GE) were calculated by the following formulas (Ruan, 9) are shown in Equations 1, 2, 3.

All measurements were subjected to analysis of variance (ANOVA) to discriminate significant differences ($P \leq 0.05$) between group means. Data were shown as the mean ± standard error (SE). These mean data were analyzed statistically using SPSS software (version 22.0, SPSS Inc.) and mean results were compared through the LSD post hoc test at the 5% significance level ($P \leq 0.05$).

RESULTS AND DISCUSSION

Salt stress significantly effective seed germination percentage in every salt stress level as shown in Fig. 1a. Germination percentage of both cultivars were same at control (0.00%) but at slight stress (0.06%) Chinese Red showed 96% germination and reduction was very less as compared to control (0.00%). Chinese Green showed 25% reduction in slight stress (0.06%) and it was increased in severe stress (0.18%) almost 74% reduction as compared to control. In comparison, Chinese Red showed tolerance in every stress level as compared to Chinese Green. The findings of Azeem *et al*. (1) support our results as salt stress causes osmotic stress or specific ion effects, which decreased and restrict seed germination. In addition, Javed *et al*. (8), noted that increasing salt stress effect the germination of *Brassica juncea* and *Vigna mungo*).

Speed of germination was significant changing from level to level within these two cultivars as shown in Fig. 1b. At the severe salt stress (0.18%), speed of germinations was1.36 and 1.82 per day indicated that seeds can't tolerate the stress. Chinese Red showed less speed of germination then Chinese Green. At Slight stress (0.06%), 50% reduction in speed of germination was found in Chinese Red but Chinese Green showed more than 60% reduction. In moderate (0.12%) and severe stress (0.18%) both cultivars speed of germination was varying between 4.48 to 1.36 per day as shown in Fig 1b. The reduction in speed of germination maybe due to ionic stress (Azeem *et al*., 2)**.** Speed of germination also highly related to the amount of salts concentration in the irrigation solution and due to increasing salts concentration, speed of germination was reduced (Belmehdi *et al*., 3).

Germination energy percentage (GE) was observed at the 3rd day after soaking of seeds and cultivars difference were observed in relation to GE under salt stress conditions. GE was decreased with increasing concentrations of NaCl and $CaCl_2$. Both cultivars showed significant reduction in GE with increasing salt stress levels as shown in Fig. 1c. Chinese Red has 50% reduction in GE at slight

Table 1. Chemical characteristics of treatment water (Azeem *et al*., 2)

Treatment	*EC* (ds m^{-1})	pH	Ion concentration (mmol L^{-1})					
			K^+	Na^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^-
0.00%	2.08	5.55	6.00	40.00	4.00	2.00	2.00	2.05
0.06%	10.33	4.31	6.00	91.00	31.00	2.00	56.00	2.05
0.12%	18.00	4.35	6.00	142.66	58.06	2.00	110.12	2.05
0.18%	25.70	4.40	6.00	194.00	85.09	2.00	164.19	2.05

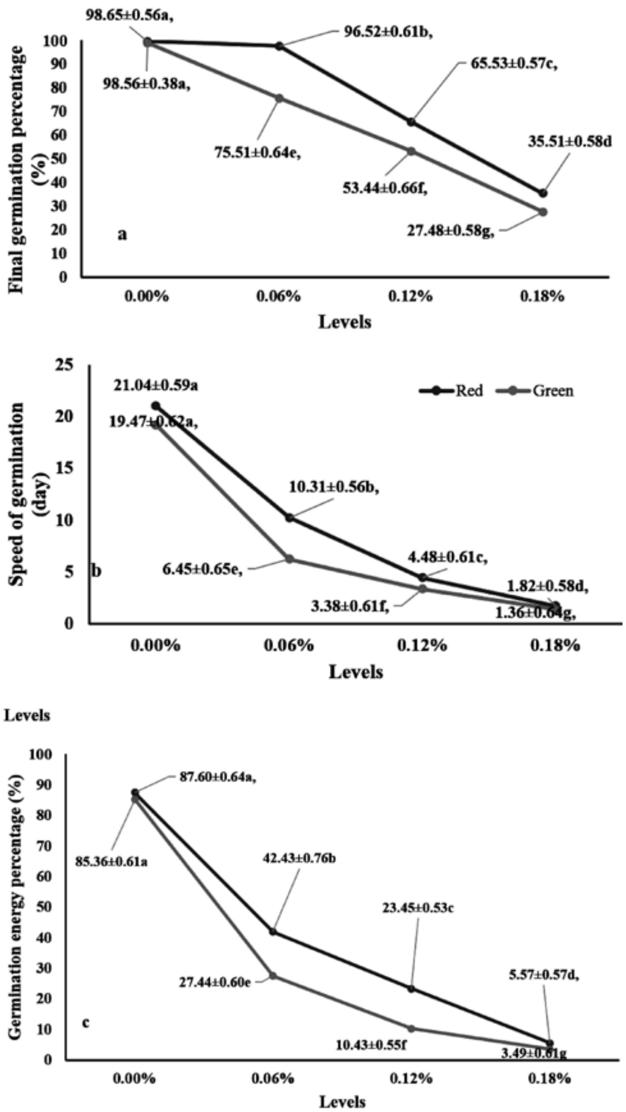

Fig. 1. Effect of salt stress treatments on the (a) Final germination percentage, (b) Speed of germination and (c) Germination energy percentage of Chinese Green and Chinese Red; values represent means ± SE, followed by different letters in the same treatment process indicating a significant difference at P≤ 0.05, according to one-way ANOVA and LSD Test.

stress (0.06%) but Chinese Green has 70% reduction at same level. For other levels (0.12% and 0.18%), other both cultivars showed same trend. According to the results Chinese Red and Chinese Green have low GE at slight stress (0.06%) but have higher FGP at slight stress (0.06%) indicates mostly seeds were germinated after 3rd days (Belmehdi *et al*., 3, Javed *et al*., 6). Decreasing GE and higher FGP described that in the beginning seeds were under salt stress effect then slowly sustain themselves under salt stress condition and finally germinated indicates tolerance nature of both cultivars (Javed *et al*., 7).

Salt stress significant effect the seedling plumule length as shown in Fig. 2a. Chinese Green showed better results as compared to Chinese Red in all stress levels. Plumule length of Chinese Red decreased as 64.04%, 63.50% and 72.04% with respect to control (0.00%) at slight (0.06%), moderate (0.12%) and severe (0.18%), respectively. These results described that effect of slight (0.06%) and moderate stress (0.12%) were almost same, indicate tolerant ability of Chinese Red (Azeem *et al*., 1). Chinese Green also showed higher reduction in plumule length at slight (0.06%), moderate (0.12%) and severe (0.18%), were 42.03%, 74.04% and 82.04% with respect to control (0.00%). In comparison, Chinese Green showed better plumule length only in Slight stress (0.06%) but Chinese Red exhibit better plumule length at slight (0.06%) and moderate stress (0.12%) Plumule length of both cultivars were decreasing with increasing concentrations of salt stress, our results were agreed with the outcomes of (Habib *et al*., 4).

Radicle length of both cultivars were decreased significantly with increasing salt stress levels as shown in Fig. 2b. Chinese Green shown more reduction with respect to control at slight (0.06%), moderate (0.12%) and severe (0.18%), were 46.33%, 69.05% and 80.8%. Similarly, Chinese Red were shown reduction 43.47%, 41.30% and 63.04% under these levels. Radicle lengths were the most important attribute for studying salt stress because roots were in direct contact with the salt's solution (Javed *et al*., 8). They absorbed water and transform through shoots to rest of the plant (Javed *et al*., 5, Javed *et al*., 6). In this study also found that salt tolerance ability of Chinese Red was greater than Chinese Green (Azeem *et al*., 2).

Salt stress significantly effect on seedling fresh and dry weight as shown in Table 2. Fresh weight and dry weight of both cultivars were decreased more than 75% with respect to control (0.00%). Both cultivars showed better tolerance at slight stress (0.06%) and rest of other levels (0.12% and 0.18%) biomass reduced very badly that's indicate inflow of stress was very high. Salt concentrations surges in the medium, plants absorb lesser water that producing biomass reduction (Javed *et al*., 5). Salt stress limit the water availability of plant cell that may be responsible for dropping fresh weight (Azeem *et al*., 1). Decreased in dry weight was relatively dependent on the reduction in shoot and root length (Javed *et al*., 8). In general, observation that the plant development was exhibit under saline conditions, which leads to reduction in yield. Salt stress leads to water deficit by decreasing

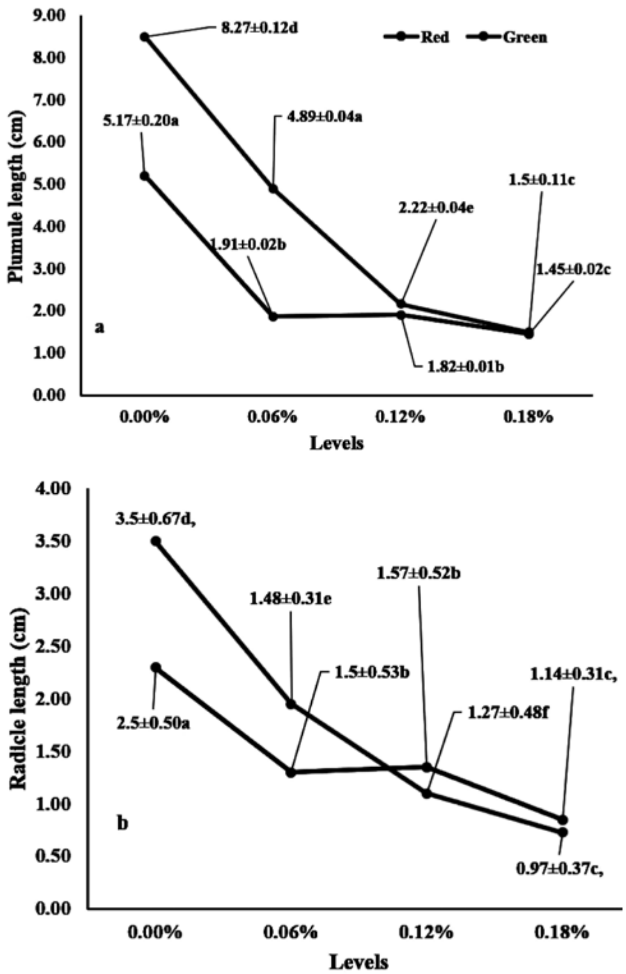

Fig. 2. Effect of salt stress treatments on the (a) Plumule length and (b) Radicle length of Chinese Green and Chinese Red; values represent means ± SE, followed by different letters in the same treatment process indicating a significant difference at P≤ 0.05, according to one-way ANOVA and LSD Test.

water potential in plants thereby reduction in fresh and dry weight (Azeem *et al*., 2).

It was concluded that germination rate and early seedling growth of both okra cultivars were exhibited due to increasing salt concentrations. Based on the performance of early seedling growth Chinese Green have more production than Chinese Red at control (0.00%) but Chinese Red was more tolerant than Chinese Green under different salt stress levels. Severe stress (0.18%) was not fit for both cultivars. Therefore, Chinese Red can grow under slight and moderate stress but Chinese Green can grow only under slight stress.

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Table 2. Effect of salt stress on seedling fresh and dry weight.

Cultivars	Levels	Fresh weight (g)*	Decrement over Control (%)	Dry weight (g) *	Decrement over Control (%)
Red	0.00%	0.31±0.01a	-	0.092±0.06a	-
	0.06%	0.22±0.01b	30.90	0.056±0.03b	39.26
	0.12%	0.10±0.01c	67.74	0.032±0.01c	65.21
	0.18%	0.07±0.01d	77.42	0.004±0.04d	95.65
Green	0.00%	0.46±0.03e	-	0.045±0.03e	-
	0.06%	0.33±0.03f	28.26	0.028±0.01f	37.77
	0.12%	0.16±0.02g	65.21	0.024±0.02g	46.66
	0.18%	0.09±0.19h	80.43	0.003±0.01h	94.04

Note: Effects of salt stress treatments on the seedling fresh and dry weight; values represent means ± SE, followed by different letters in the same treatment process indicating a significant difference at P ≤ 0.05, according to * one-way ANOVA and LSD.

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