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POTASSIUM NITRATE PRIMING TO MITIGATE THE SALT STRESS ON CUCUMBER SEEDLINGS

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ABSTRACT - Salinity is one of the abiotic stresses that further limit the seed germination and growth of plants because of low water potential of the soil. In this study, seeds of cucumber (*Cucumis sativus* L., cv. Aodai Melhorado) were used to investigate the effects of potassium nitrate priming on germination and early seedling growth under different salinity levels. It was hypothesized that priming with potassium nitrate may improve seed germination and plant establishment by mitigating the negative effects of saline stress through its role in cell osmotic balance. The seeds were soaked in distilled water or in a 2 g L^{-1} KNO_3 solution at 25 ºC for 6 hours, and after drying, were distributed in plastic boxes with blotter paper containing different salt solutions prepared with concentrations of 0 (control), 25, 50, 75 and 100 mmol NaCl L^{-1}. The plastic boxes were kept into a seed germinator, at 25 ºC for 10 days. A completely randomized design in a 2 x 5 factorial scheme with four replications of 25 seeds each was used. The results showed that the priming of cucumber seeds with potassium nitrate had little effect to improve germination capacity and growth rate of seedlings under salt stress conditions. Low salt concentrations may induce osmotic adjustment activity in the cucumber plants and lead to increases in hypocotyl and radicle length of seedlings, whereas higher concentrations cause severe inhibition of plant growth. The "Aodai Melhorado" cucumber cultivar is a moderately tolerant genotype to salt stress during the germination and seedling establishment stage by presenting yield stability index greater than 0.50 until the level of 100 mmol NaCl L^{-1}.
Key words: *Cucumis sativus* L., osmopriming, salinity, salt tolerance, seed germination.

CONDICIONAMENTO COM NITRATO DE POTÁSSIO PARA AMENIZAR O ESTRESSE SALINO EM PLÂNTULAS DE PEPINO

RESUMO - A salinidade é um dos estresses abióticos que mais limitam a germinação e o crescimento das plantas por causa do baixo potencial hídrico do solo. O presente estudo teve como objetivo avaliar os efeitos do condicionamento de nitrato de potássio (KNO_3) na germinação das sementes e no crescimento inicial das plântulas de pepino (*Cucumis sativus* L., cv. Aodai Melhorado) submetidas a diferentes níveis de salinidade. A hipótese testada é que o condicionamento com KNO_3 poderia melhorar a germinação das sementes e o estabelecimento das plântulas devido ao seu efeito em minimizar os efeitos negativos do estresse salino através da manutenção do equilíbrio osmótico das células. As sementes de pepino foram embebidas em água destilada ou em solução contendo 2 g L^{-1} de KNO_3 à 25 ºC durante 6 horas. Posteriormente, as sementes foram secas, e distribuídas em caixas plásticas tipo Gerbox com papel mata-borrão contendo as diferentes soluções salinas preparadas com as concentrações de 0 (controle), 25, 50, 75 e 100 mmol L^{-1} de NaCl. As caixas Gerbox foram mantidas em câmera de germinação com temperatura de 25 ºC durante 10 dias. O delineamento utilizado foi o inteiramente casualizado em esquema fatorial 2 x 5 com quatro repetições de 25 sementes. Os resultados mostraram que o condicionamento das sementes de pepino com nitrato de potássio teve pouco efeito para melhorar a capacidade germinativa e a taxa de crescimento de plântulas em condições de estresse salino. Baixas concentrações de salinidade podem induzir atividade de ajuste osmótico nas plantas de pepino e levar a aumentos no comprimento do hipocótilo e da radícula das plântulas, enquanto concentrações mais altas causam severa inibição do crescimento das plântulas. O cultivar de pepino "Aodai Melhorado" pode ser classificado como um genótipo moderadamente tolerante ao estresse salino durante a fase de germinação e estabelecimento de plântulas, por apresentar índice de estabilidade de rendimento maior que 0,50 até o nível de 100 mmol L^{-1} de NaCl.
Palavras-chave: *Cucumis sativus* L., condicionamento osmótico, salinidade, tolerância à salinidade, germinação das sementes.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is one of the main vegetable crops in Brazil, both in outdoor fields or greenhouses, with mean annual production around 220,000 tons in 2013 (CARVALHO et al., 2013). Among various environmental stresses, soil salinity has been a critical problem for cucumber production in many countries around the world, mainly due to its dramatic effects on plant physiology and performance. Salinity caused by excessive salts in the soil solution or in irrigation water

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currently affects one-third of the world's cultivated land, 7% of the total world land and 50% of the irrigated land (ZHU, 2001).

Excessive salt concentrations in the soil may adversely affect plant growth either through osmotic inhibition of water uptake by plant roots or specific ion effects (ASHRAF et al., 2008). Salinity generates a low water potential in the soil, making it difficult for plants to acquire water, and resulting in water deficit conditions (PORCEL et al., 2012). Salinity induces osmotic stress and ionic toxicity that leads to secondary oxidative stress in plants (AHMAD et al., 2016). Therefore, salinity negatively affects the physiology, growth, and yield of crops (LIU et al., 2015).

Salinity affects plant growth at all developmental stages; however, sensitivity varies from one growth stage to another. Seed germination is one of the most salt-sensitive plant growth stages and is severely inhibited with increasing salinity (STEINER et al., 2017). Delayed and reduced seedling emergence cause non-uniform stand establishment, which results in reduced crop yields (LAWLES et al., 2012). In this regard, several approaches including seed priming, seed soaking and seed coating have been employed to improve seed germination and plant establishment under salt stress.

Among the strategies used to mitigate the salt stress-induced adverse effects the pretreatment of seeds with salts or plant growth regulators are cited as the most appropriate, efficient and economic techniques to enhance the rate and the uniformity of germination in saline soils (ASHRAF et al., 2008; KAYA et al., 2013). Nerson and Govers (1986) suggested that nitrate-containing compounds may function more efficiently than other salts as priming agents. Indeed, seed-priming treatments using salts such as potassium nitrate (KNO_3) have been shown to have beneficial effects on germination and growth of a wide range of vegetable crops under stressful environments, as in eggplant (NASCIMENTO; LIMA, 2008), melon (NERSON; GOVERS, 1986), tomato (EBRAHIMI et al., 2014), and pepper (BATISTA et al., 2015). Ebrahimi et al. (2014) indicated that priming of tomato seeds with KNO_3 led to increasing of germination percentage and growth rate of seedlings under salinity conditions. However, the effectiveness of pretreatment of cucumber seeds with KNO_3 are still incipient and inconclusive.

The exogenous application of KNO_3 can stimulate seed germination at abiotic stress conditions due to the production of substances that release nitric oxide (NO). These substances act in membrane permeability, preventing or reversing the damage caused by environmental stresses (PEREIRA et al., 2010). Therefore, as the process of saline and water stress involves changes in osmotic potential and tension on the cell membrane, it is possible that substances NO-liberating improve the germination process under salt stress (KAISER et al., 2016). Nitric oxide is a molecule that acts as a signaler in higher plants and studies on their functions in the physiological processes of plants indicate that NO is involved in the regulation of plant growth and development, defense against pathogen and responses to abiotic stress (SANZ et al., 2015).

The objective of this study was to investigate the possibility of reducing the negative effects of salt stress on seed germination and early growth of cucumber (*Cucumis sativus* L.) by seed priming with potassium nitrate.

MATERIAL AND METHODS

Plant material and treatments

Seeds of cucumber (*Cucumis sativus* L., cv. Aodai Melhorado) were surface-sterilized in 1% (v/v) sodium hypochlorite solution for 5 min, and rinsed three times in distilled water. The sterilized seeds were then submitted to priming by direct immersion in distilled water (control) or 0.2% potassium nitrate solution (2 g L^{-1} KNO_3) for 6 h at 25 ºC, as recommended for cucurbit seeds by Barbosa et al. (2016).

After priming period, seeds were put to dry in plastic boxes (11.0 x 11.0 x 3.5 cm, type Gerbox) with blotter paper at room temperature (24-28 ºC) for 48 h, and then subjected to five levels of salinity [0 (control), 25, 50, 75 and 100 mmol NaCl L^{-1}]. Treatments were arranged in a completely randomized design in a 2 x 5 factorial: two priming techniques (0 (water) or 2 g L^{-1} of KNO_3) and five salinity levels, with four replications.

Germination and growth conditions

Four replicates of 25 seeds were evenly distributed in plastic boxes with blotter paper, properly moistened with the salt solution of each treatment, in a volume equivalent to 2.5 times the weight of dry paper. The boxes were then closed with lids to prevent evaporation and maintain the relative humidity close to 100%. Germination was carried out in a germination chamber under 12/12 h photoperiod (light/darkness), light fluence of 80 μmol m^{-2} s^{-1} photosynthetic photon flux density (PPFD) and temperature of 25 ºC for 10 days. Seeds were considered germinated when radicle were longer than 5.0 mm. Germinated seeds were recorded every 24 h for 10 days.

Measurements of germination and seedling growth

The germination (G), germination rate index (GRI), mean germination time (MGT), early growth and vigor index of cucumber seedlings were measured. The equations 1-3 and the parameters therein were employed to express the process of seed germination.

$$GC\ (\%) = S_{NG} / S_{N0} \times 100 \qquad \text{Equation 1}$$

Where GC is germination capacity, S_{NG} is the number of germinated seeds, and S_{N0} is the number of experimental seeds with viability (25 seeds).

$$GRI = \Sigma\ (n_i / t_i) \qquad \text{Equation 2}$$

Where GRI is the germination rate index (seed day^{-1}), ni is the number of germinated seeds on a given day, and ti is the time in days from the starting/sowing day (0) (Maguire 1962).

$$MGT = (\Sigma_{niti}) / \Sigma_{ni} \quad \text{Equation 3}$$

Where MGT is the mean germination time (day), ni is the number of germinated seeds on a given day, and ti is the time in days from the starting/sowing day (0) (LABOURIAU, 1983).

The hypocotyl length (HL, in mm) and radicle length (RL, in mm) was measured in ten normal seedlings randomly obtained after count of the total germination (10^{th} day) using meter scale. For the determination of dry matter of shoot and roots, all seedlings obtained at the end of the germination test (10 days) were separated into shoots and roots, dried in a forced air circulation oven for three days at 65 ºC, and then weighed. The results were expressed in mg/seedling. To determine shoot: root ratio (SRR), root dry matter obtained was divided by the shoot dry matter.

The vigor index and salt tolerance index of cucumber seedlings were calculated using the by following equations:

$$SVI = S_L \times \Sigma (n_i / t_i) \quad \text{Equation 4}$$

Where SVI is seedling vigor index, S^L is the shoot length in the tenth day (in cm), ni is the number of germinated seeds on a given day, and ti is the time in days from the starting/sowing day (0) (ZHANG et al., 2007).

$$YSI = Y_S / Y_C \quad \text{Equation 5}$$

Where YSI is the yield stability index, Y_S and Y_C are the total dry matter yield (mg per seedling) under saline stress and non-stress conditions (NaCl-free treatment), respectively (BOUSLAMA; SCHAPAUGH 1984).

Statistical analyses

The data was previously tested for normality with the Kolmogorov-Smirnov test ($p \leq 0.05$) and then submitted to analysis of variance (ANOVA), and means of two priming treatments were compared by the F test at the 0.05 level of confidence. For the five salinity levels were used regression analysis and significant equations with the higher coefficient of determination were adjusted ($p \leq 0.05$). For statistical analysis, the data expressed in percentage were previously transformed into arc $\sin\sqrt{(x/100)}$. All analyses were performed using Sisvar version 5.3 software for Windows (Statistical Analysis Software, UFLA, Lavras, MG, BRA).

RESULTS AND DISCUSSION

A summary of the analysis of variance for the measurements of germination process, seedling growth and vigor index of wheat is shown in Table 1. The results of the analysis of variance showed significant effects ($p < 0.05$) for the main effects of seed priming with KNO_3 and salinity levels, as well as for interaction, for the majority of the traits measured (Table 1). The significant interaction between the main effects of KNO_3 priming and salt stress for most of the evaluated characteristics indicates germination and growth of wheat seedlings from seeds subjected to priming of KNO_3 have different behavior with regard to the salinity level compared seeds primed with water (control).

TABLE 1. Summary of the analysis of variance for the germination capacity (GC), germination rate index (GRI), mean germination time (MGT), hypocotyl length (HL), radicle length (RL), shoot dry matter (SDM), root dry matter (RDM), total dry matter (TDM), shoot: root ratio (SRR) and seedling vigor index (SVI) for the effects of potassium nitrate priming and saline stress.

Causes of variation	Probability > F									
	GC	GRI	MGT	HL	RL	SDM	RDM	TDM	SRR	SVI
Priming (P)	0.893	0.225	0.813	0.009	0.077	0.074	0.079	0.045	0.738	0.481
Salinity (S)	< 0.000	< 0.000	< 0.000	< 0.000	< 0.000	< 0.000	< 0.000	< 0.000	0.005	< 0.000
P x S	< 0.000	0.038	0.722	0.040	< 0.000	0.303	0.005	0.032	0.047	0.204
C.V. (%)	3.03	5.61	4.60	3.79	3.80	6.02	6.52	5.36	8.91	6.11

Effect of KNO_3 priming and salt stress on seed germination

The germination percentage of cucumber seeds was higher than the standard values used as reference for the commercialization of cucumber seeds in Brazil (i.e., 80%). This inference indicates that seeds used in this study were of high physiological quality.

The germination response of cucumber seeds submitted to hydropriming (control) was significantly affected by salt stress induced by NaCl solutions (Figure 1A). The highest percentage of germination was obtained at the 31 mmol NaCl L^{-1} level, whereas higher concentrations caused reduction in the germination percentage. However, when the seeds were submitted to KNO_3 priming, the germination percentage was not significantly affected by saline stress induced by NaCl solutions (Figure 1A).

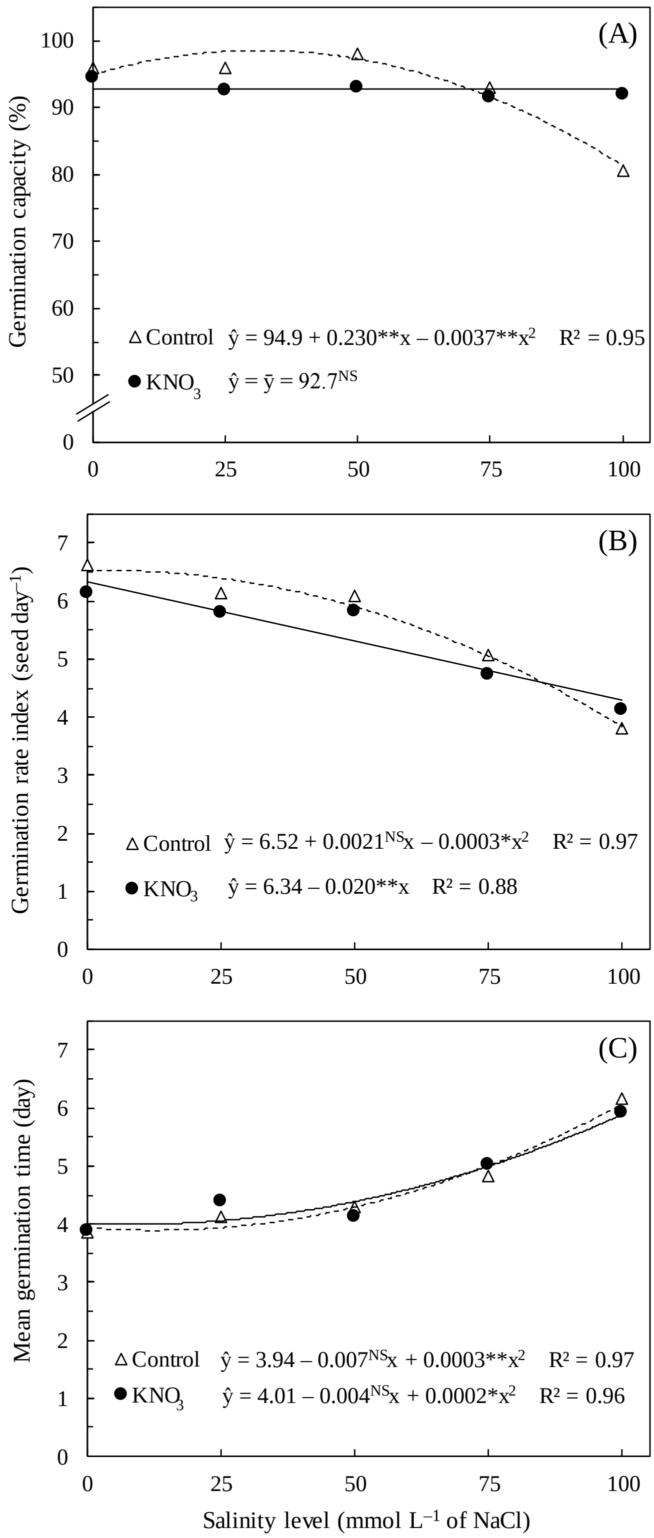

FIGURE 1 - Effects of salt stress on germination capacity (A), germination rate index (B), and mean germination time (C) of cucumber (*Cucumis sativus* L., cv. Aodai Melhorado) from seeds subjected to priming with water (control) or KNO_3 solution. ^{NS}: not significant. * and **: statistical significance at 5% and 1%, respectively.

At 100 mmol NaCl L^{-1} the germination percentage was 80.9% for seeds primed with water (control), and was significantly lower (92.7%) compared to the seeds primed with KNO_3 (Figure 1A). These results show that priming of cucumber seeds with KNO_3 can have significant improvements of germination under conditions of high salt levels. Fuller et al. (2012) concluded that the use of priming techniques may enhance the germination of seeds under high salinity conditions. These findings agree with Kubala et al. (2015) who found that seeds primed with an osmotic solution may improve germination performance through metabolic activation involving the synthesis of proteins, nucleic acids, and enzymes, and increasing water uptake, respiratory activity and reserve mobilization. Therefore, in field or greenhouse conditions where the soil or substrate is affected by salinity, the use of cucumber seeds primed with KNO_3 could make the difference between successful field germination and establishment or substantial crop failure (Ashraf et al., 2008).

The KNO_3 priming can improve seed germination at salt stress conditions due to the production of substances that release nitric oxide (NO) (KAISER et al., 2016). According to Pereira et al. (2010), these substances NO-liberating act in membrane permeability, preventing or reversing the damage caused by osmotic stresses. Nitric oxide is a molecule that acts as a signaler in higher plants and it is involved in the regulation of plant growth and development, defense against pathogen and responses to abiotic stress (SANZ et al., 2015).

The germination rate index (GRI) of cucumber seeds was significantly affected by salt stress induced by NaCl solutions in both priming treatments (water or KNO_3) (Figure 1B). The highest GRI values were obtained at the 3.5 mmol NaCl L^{-1} level, whereas higher concentrations caused progressive reduction in this germination index. On the other hand, when the seeds were submitted to KNO_3 priming, the GRI was reduced linearly with increasing salt levels up to 100 mmol L^{-1} NaCl (Figure 1B). The decrease in GRI was due to lower capacity of water uptake by the seeds with highly negative osmotic potential. According to Feijão et al. (2011), the lower germination rate and growth inhibition due to salinity are caused by low external water potential, ion imbalance and specific ion toxicity. Under these conditions, there is a decrease in water uptake and an excessive uptake of ions (AKRAM et al., 2010). Osmotic stress affects the starch synthesis reactions and energy production process (adenosine triphosphate – ATP) through respiration, resulting in reduced of germination percentage (Figure 1A), germination rate index (Figure 1B) and thus in delay of germination time (Figure 1C).

The mean germination time (MGT) was delayed with the rise of salinity levels (Figure 1C). At 100 mmol NaCl L^{-1} the MGT was delayed 2.3 days (from 3.94 to 6.24 days) for the seeds primed with water (control), against 1.6 days (from 4.01 to 5.61 days) for the KNO_3 priming compared to the NaCl-free treatment. A delay in the mean time to germination may be disadvantageous for successful establishment, since the delayed germination leaving the seeds more vulnerable to attack from predators (pests and pathogens) and, therefore, compromise the establishment of a uniform stand.

The delay of germination was due to salinity affect the water uptake of the seeds, which is the first step to occur germination process (i.e., imbibition). According to Marcos-Filho (2005), it is necessary that the seeds reach an adequate level of hydration during the imbibition phase, to occur reactivation of seed metabolic processes and growth of embryonic axis. Seeds subjected to osmotic stress require more time to adjust the internal osmotic potential in accordance with the external environment (PARIDA; DAS, 2005; MUNNS; TESTER, 2008). Meneses et al. (2011) reported that highly negative osmotic potential may affect the seeds water uptake, making germination not possible. Additionally, the osmotic potential of the external medium can affect the enzymatic reactions in the seed, therefore, the delay in germination is due to delay of enzymatic reactions (MARCOS-FILHO, 2005), caused by the break of the imbibition period. This result is in agreement with other observations in wheat seeds, where salinity has been shown to negatively affect the rate of starch remobilization by causing a decrease in α-amylase activity (ALMANSOURI et al., 2001). The most common responses of plants to reduction of osmotic potential are a delay in initial germination and a reduction in the rate and total germination (OlIVEIRA; GOMES-FILHO, 2009; GORDIN et al., 2015). The result of these changes is unevenness in the germination process and stand establishment.

Effect of KNO_3 priming and salt stress on early seedling growth

The growth of cucumber seedlings was improved in low salinity conditions; however, with increasing salt stress level the growth of shoots and roots were severely inhibited (Figure 2). When the seeds were primed with KNO_3, the hypocotyl length increased from 59.0 mm in the NaCl-free treatment to maximum of 62.8 mm with the 30 mmol NaCl L^{-1} solution (Figure 2A). In turn, the largest values of the radicle length were obtained at the 7 mmol NaCl L^{-1} level (Figure 2B). When the seeds were primed with water, the largest values of the hypocotyl and radicle length were obtained at the levels of 16 and 18 mmol NaCl L^{-1}, respectively (Figures 2A and 2B).

These results confirm the findings of Memon et al. (2010) with their study on pak choi seedlings [*Brassica campestris* L.], and finally by Qados (2011) in their study on fava bean [*Vicia faba* L.] where they indicated that the use of low sodium chloride concentrations led to increases in plants lengths, whereas higher concentrations caused inhibition. In general, may be infer that, the elongation of the hypocotyl when treated with low salt concentrations may induce osmotic adjustment activity in the plants, which may improve growth. On the other hand, excessive salt concentrations reduce the solution water potential, causing toxic effects and injuries and disorders in the metabolism of plants (MUNNS; TESTER, 2008).

Under high salinity an irreversible impairment of the photosynthetic apparatus, associated with a reduction of ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) activity, occurs when the stress is prolonged and salt continues to accumulate in the leaves (ZHU, 2001). On the other hand, the noticed decrease in the length of the hypocotyl could be due to the negative effect of this salt on the changes in enzyme activity (that subsequently affects protein synthesis), and also the decrease in the level of carbohydrates and growth hormones, both of which can lead to inhibition of the growth (MAZHER et al., 2007).

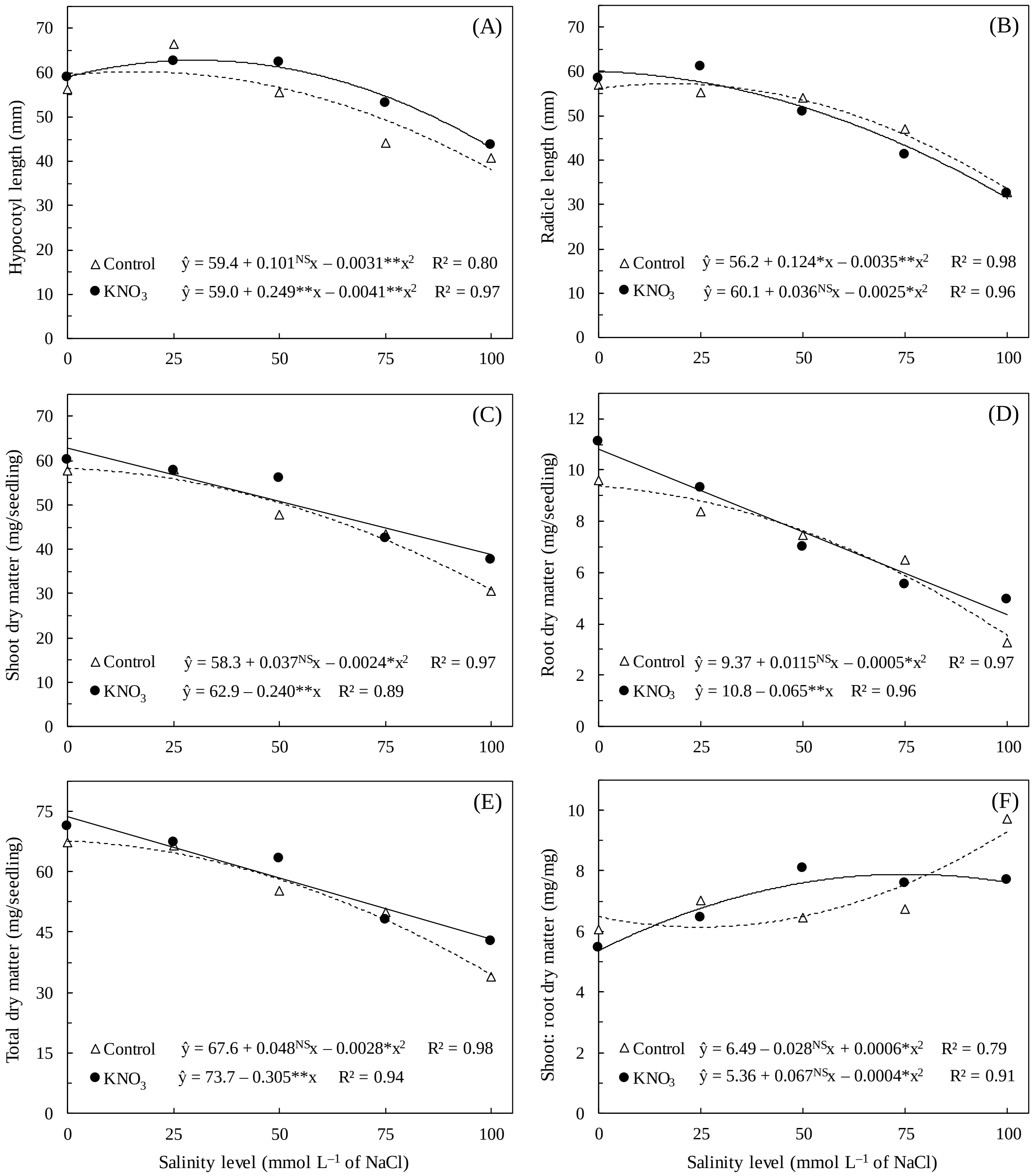

FIGURE 2 - Effects of salt stress on hypocotyl length (A), radicle length (B), shoot dry matter (C), root dry matter (D), total dry matter (E) and shoot: root dry matter (F) of cucumber (*Cucumis sativus* L., cv. Aodai Melhorado) from seeds subjected to priming with water (control) or KNO_3 solution. ^{NS}: not significant. * and **: statistical significance at 5% and 1%, respectively.

When the seeds were primed with KNO_3, the dry matter yield of shoots and roots were reduced linearly with increasing salinity levels up to 100 mmol L^{-1} (Figures 2C and 2D). In turn, the largest values of the shoot and root dry matter for the seeds primed with water were obtained at the levels of 7.7 and 11.5 mmol NaCl L^{-1}, respectively (Figures 2C and 2D). The lower dry matter yield of shoots and roots due to increasing salinity level was caused by low external water potential, ion imbalance and specific ion toxicity (FEIJÃO et al., 2011). One of the initial effects of salt stress on plant is the reduction of growth rate and dry matter accumulation. Oliveira et al. (2016) reported that salinity decreases the growth and dry matter accumulation of potato plants, and the salt level of 100 mmol L^{-1} decreased the shoot dry matter at around of 75%. In soybean plants, Dolatabadian et al. (2011) reported that salinity stress significantly decreased shoot and root dry matter, plant height and leaf number per plant.

The total dry matter of cucumber seedlings was significantly affected by salt stress induced by NaCl solutions (Figure 2E). The inhibiting action of salt stress on early seedling growth was increased with the rise of salinity levels, and the exposure of seeds to 100 mmol L^{-1} NaCl reduced the total dry matter yield in 34% and 41% compared to the NaCl-free treatment, respectively, for the seeds primed with water or KNO_3.

Root: shoot ratio is one of several ratios, which give estimates of dry matter partitioning into root and shoot of plants, and it is a good indicator for abiotic stress effects on root and shoot dry matter (BOUTRAA et al., 2010). In general, the results showed that the root:shoot ratio of cucumber seedlings was increased with the rise of salinity levels in both priming treatments (Figure 2F). When the seeds were primed with KNO_3, the root:shoot ratio increased from 5.36 mg mg^{-1} mm in the NaCl-free treatment to maximum of 8.16 mg mg^{-1} with the 84 mmol NaCl L^{-1} solution. In turn, the exposure of seedlings to 100 mmol NaCl L^{-1} increased the root:shoot ratio in 36% (from 6.16 to 9.69 mg mg^{-1}) compared to the 23 mmol NaCl L^{-1} solution – i.e., concentration that resulted in the lowest root:shoot ratio (Figure 2F). These results suggests that shoot growth was affected more than the root system under salt stress. Such increase in root:shoot ratio indicates that the proportion of dry matter allocated to shoots was decreased compared to the roots. Studies have shown that shoot is more likely to be affected by saline stress than other traits, as reported by Wang et al. (2015) for cucumber plants. Assimilate partitioning is a complicated process that can be controlled simultaneously by sources and sinks. In general, plants exposed to high salt levels often partition photosynthate occurs preferentially to the roots, thereby maintaining a balance between processes required in roots (e.g.; water and nutrient uptake) and those required in shoots (e.g., photosynthesis).

The vigor index of cucumber seedlings was improved in low salinity conditions; however, with increasing salt stress level the seedling vigor was drastically reduced (Figure 3). When the seeds were primed with KNO_3, the seedling vigor index increased from 36.1 units in the NaCl-free treatment to maximum of 37.1 units with the level of 18.5 mmol NaCl L^{-1}, whereas the largest values of the seedling vigor index for the seeds primed with water were obtained at the 7.0 mmol L^{-1} NaCl level (Figure 3). The seedling vigor index has been used as a tolerance index to evaluate the effect of salt stress on seedling growth (ASHKAN; JALAL, 2013). Seedling vigor is a measure of the extent of damage that accumulates as viability declines, and the damage accumulates in seeds until the seeds are unable to germinate and eventually die (MARCOS-FILHO, 2005). The lower seedling vigor index obtained with increased salinity level was due to the salt stress inhibit the initial growth of seedlings. The reduction in vigor index of seedlings under water restriction conditions is usually reported by other research (ZHANG et al., 2007; ASHKAN; JALAL, 2013; LIU et al., 2015; SINGH et al., 2015).

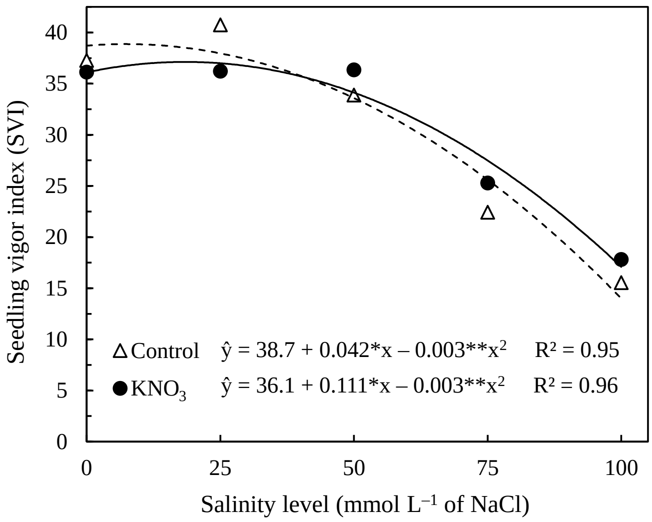

FIGURE 3 - Effects of salt stress on vigor index of cucumber (*Cucumis sativus* L., cv. Aodai Melhorado) seedlings from seeds subjected to priming with water (control) or KNO_3 solution. * and **: statistical significance at 5% and 1%, respectively.

The yield stability index of cucumber seedlings ranged from 1.00 to 0.51 and 0.95 to 0.60 for the seeds submitted to priming with water or KNO_3, respectively (Figure 4). The yield stability index was suggested by Bouslama and Schapaugh (1984) in order to evaluation the stability of crops or genotypes in the both stress and non-stress conditions and has been considered a good salt tolerance index. When the yield stability index in response to addition of 25, 50, 75 and 100 mmol NaCl L^{-1} is greater than 0.95; 0.85; 0.65 and 0.50, respectively, the plant species is classified as moderately tolerant to salt stress (MASS, 1986). Therefore, results presented here suggest that cucumber cultivar used in this study is a moderately tolerant genotype to the negative effects of high salt levels during the stage of seed germination and seedling establishment.

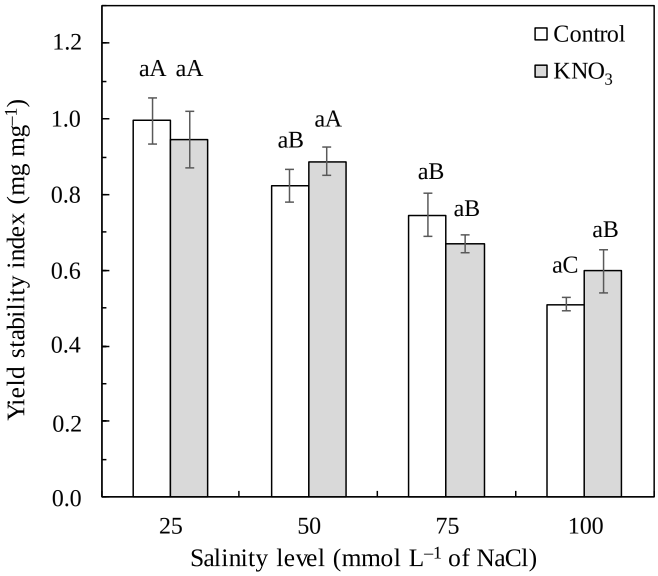

FIGURE 4 - Effects of salt stress on the yield stability index (YSI) of cucumber (*Cucumis sativus* L., cv. Aodai Melhorado) seedlings from seeds priming with water (control) or KNO_3 solution. Bars followed by the same lower case letters, between the priming or same upper case letters, for the salinity levels are not significantly different by Tukey test at the 0.05 level of confidence. Data refer to mean values (n = 4) ± mean standard error.

CONCLUSION

The priming of cucumber seeds with potassium nitrate had little effect to improve germination capacity and growth rate of seedlings under salt stress conditions.

Low salt concentrations may induce osmotic adjustment activity in the cucumber plants and lead to increases in shoot and root length of seedlings, whereas higher concentrations cause severe inhibition of plant growth.

The "Aodai Melhorado" cucumber cultivar is a moderately tolerant genotype to salt stress during the germination and seedling establishment stage by presenting yield stability index greater than 0.50 until the level of 100 mmol NaCl L^{-1}.

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