Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.7, No.9, 2017

Effect of Halopriming on Seed Germination and Seedling Vigor of Solanaceous Vegetables

Zaheer Ahmed[1] Sumera Anwar[3] Abdul Raziq Baloch[2] Shabeer Ahmed[2] Fazal Muhammad[2]
Nazeer Ahmed Alizai[2] Manzoor Ahmed[1] Shahbaz Khan[2] Shah Faisal[2]
1.Sindh Agriculture University Tandojam, Pakistan
2.Agriculture Research Institute (ARI) Sariab Road Quetta, Pakistan
3.G C University, Faisalabad, Pakistan

Abstract
Present study was conducted on seed priming of solanaceous vegetables to explore effects of seed priming on seed germination and vigor of the seedlings. The part of the seed priming was done at the Postgraduate laboratory and another part of seedling growth at the Orchard, Department of Horticulture, Sindh Agriculture University, Tandojam. The seeds were halo primed with NaCl solution (w/v) by maintaining EC at 1, 2, 3 and 4 dS m-1 for 18 hours. The seeds were also primed with distilled water (Hydropriming) and unprimed seeds were taken as control treatment. The experiment was laid out in Completely Randomized Design (CRD) with three replications. The data was recorded on seed germination (%), mean germination time (days), germination index (GI), seedling vigor index (SVI), shoot length (mm), root length (mm), fresh weight of shoot, fresh weight of root and electrolyte leakage of leaf (%). The results revealed that all the observed parameters in the present study were significantly ($P<0.05$) affected by seed priming treatments and solanaceous vegetables. The results reveals that most of the germination and growth related attributes of the seedlings were observed decreased with increasing levels of NaCl. The best mean results for germination (96.66%), seedling vigor index (1190.9), shoot length (122.48 mm), root length (32.77 mm), fresh weight of shoot (1.99 g) and fresh weight of root (0.60 g) were observed from the treatment where seeds were primed in NaCl solution by maintaining EC of 1 dS m-1. However, minimum mean germination time (4.44 days) and leakage of the electrolytes was observed from hydro and unprimed seeds, respectively. The interactive effect of seed priming and solanaceous vegetables was also observed highly significant. On the basis of interaction, tomato and chillies produced statistically similar results for germination percentage (100; 100%), germination index (7.73; 8.13) seedling vigor index(1264; 1302), shoot length (126.10; 129.87 mm), root length (34; 33.66 mm), and fresh weight of shoot (2.80; 2.38 g) in response to the treatment where seeds were primed in NaCl solution had EC level of 1 dS m-1. Regarding comparison of the solanaceous vegetables, tomato exhibited the best mean results for most of the parameters included germination percentage (65.56), seedling vigor index (663.02), shoot length (93.61 mm), fresh weight of shoot (1.75 g) and fresh weight of root (0.46 g). The lowest leakage of the electrolytes (10.50%) and minmum mean days to germination (6.22 days) were recorded in Chillies. However, fresh weight of root had statistically no differences among solanceous vegetables.
Keywords: Vegetables, seed vigor, priming, Germination

Introduction
Solanaceous vegetables belong to the family Solanacea with three important genera are Solanum, Lycopersicon and Capsicum. The name Solanaceae derives from the genus Solanum nightshade plant" and consists of 98 genera and 2700 species (Olmstead and Bohs, 2007). Among vegetable crops solanaceous vegetables like tomato, brinjal and chilli have high demand in country as well as throughout the world. Tomato (Lycopersiconesculentum) is one of the most important edible and nutritious vegetable crops in the world. It ranks next to potato and sweet potato with respect to world vegetable production. It ranks third in terms of world vegetable production (Arjenaki et al., 2011). The demand for the crop is year round, owing to the versatility of its usages both in fresh and processed food preparation. It gains more popularity due to its antioxidant property. It is a very good source of vitamin A and C (Armin et al. 2010). The different species of the three genera viz. Solanum, Lycopersicon and Capsicum are cultivated through nursery raising of the seedlings. Seed germination and early seedling growth are the most sensitive stages to environmental stresses (de Souza et al., 2014; Natale et al., 2010). Salinity is one of the main environmental constrains that limits agricultural production in the world and in particular in arid and semi-arid regions of the world. However, plant species differ in their sensitivity or tolerance to salt stress.

Generally, plants are stressed in three ways in salinity a) low water potential of the root medium leads water deficit, b) the toxic effects of the Na^+ and Cl^- and c) nutrient imbalance by depression in uptake and/or shoot transport. Toxic accumulation of Na^+ and Cl^- in the leaves has also been correlated with stomatal closure and reduction of total chlorophyll content in leaves both of which limit the amount of photosynthetic production. Most of crop species i.e. bean, eggplant, onion, pepper, corn, sugarcane, potato and cabbage are sensitive to salinity (ECe 1.0-1.8 dS m-1), which reduce crop productivity about 6-19%. In general, biochemical, physiological, morphological and anatomical characteristics of crop species directly affected by salinity are well established (Katerji et al., 2008). Sodium chloride (NaCl) in the seed causes the inhibitory effects on germination and significantly reduces the rate and the final percentage of germination (Kaveh et al., 2011). Plants need minerals to grow and develop; however, salt in excess can be extremely dangerous to plants (Xiong and Zhu, 2002). The successful development of some species subjected to salt stress depends on their ability species to tolerate such conditions. Seeds with better germination and salt tolerance can survive more effectively. Germination is a critical part of plant life histories. The ability of their seeds to germinate at high salt concentration in the soil is therefore of crucial importance for the survival and perpetuation of these species. In saline habitats, seed germination takes place after high precipitation, i.e., under conditions of reduced soil salinity (Khan and Rizvi, 2008). The ability of the soil seed bank to remain quiescent at a high salt level and to germinate immediately after salinity reduction (Bajji et al., 2012) is very significant not only to halophytes, but also to other species in colonizing their environment. Although salinity stress mostly reduces the germination percentage and delays the onset of germination, its effects are modified by interactions with other environmental factors as temperature and light. Salinity can affect germination by affecting the osmotic component, which the ionic component, i.e., Na and Cl accumulation (Zivkovic et al., 2007).

Seed priming has been recommended as a pregermination treatment for the production of cultivars in order to increase the rate of germination and seedling establishment under adverse conditions (de Souza et al.,2014).Seed priming prior to sowing is known as an efficient way to increase germination and emergence rate (Sivritepe, 2000). This technique may also improve uniformity of seed germination and germination percentage (Basra et al., 2005, Farooq et al., 2006). Numbers of priming treatments are generally in use including hydro, halo, osmo, hermo, nutriand matrix priming (Basra et al., 2005; McDonald, 2000; Ghiyasi et al., 2008, Memon et al., 2013). Each type of priming responds differently in different crops.

Materials and Methods

The experiment was conducted on seed priming of solanaceous vegetables to explore effects of seed priming on seed germination and vigor of the seedlings. The part of the seed priming was done in petri dishes at the Postgraduate laboratory, Department of Horticulture, Sindh Agriculture University, Tandojam. The seeds of three solanaceous vegetable seeds viz. tomato (Rio grande), chillies (talhari) and brinjal (violet king) were halo primed in the NaCl solution (w/v) @1, 2, 3 and 4 dS m-1 for 18 hours. The seeds were also primed with distilled water (Hydropriming) and unpirmed seeds were took as control treatment. The seeds were then dried at room temperature on filter paper for 24 h up to their original moisture contents. The primed seeds were planted in earthen pots contained canal silt and placed at the Orchard, Department of Horticulture, Sindh Agriculture University, Tandojam for further study of seedling attributes. The experiment was laid out in Completely Randomized Design (CRD) with three replications.

Seed germination percentage

Some parameters of economic importance were studied included: seed germination (%), mean germination time (days), germination index (GI), seedling vigor index (SVI), shoot length (mm), root length (mm), fresh weight of shoot, fresh weight of root and electrolyte leakage of leaf (%).

Seed germination percentage -Germination was checked on every alternative day for upto 6th day of plantation and the germination percentage was calculated by using following equation as described by Larsen and Andreasen (2004).

$GP = \Sigma n / N \times 100$

Where n is number of germinated seeds at each counting and N is total seeds in each treatment.

Mean Germination Time (MGT)

Mean Germination Time (MGT) was calculated by using following equation of Ellis and Roberts (1981)

$$MGT = \frac{\sum Dn}{\sum n}$$

Where n is the number of seeds germinated on day D and D is the number of days as counted from the beginning of germination.

Germination index (GI)

Germination index (GI) was calculated by the formula given by the Association of Official Seed Analysts (1983)

$$GI = \frac{\text{Number of germinated seeds}}{\text{Days of first count}} + \text{----------} + \text{----------} + \frac{\text{Number of germinated seeds}}{\text{Days of last count}}$$

Seedling Vigor Index (SVI)

Seedling Vigor Index (SVI) was calculated by using following formula, Abdul-Baki and Anderson (1970)

Vigor index (VI) = [seedling length (cm)× germination percentage]

One and half months old seedlings were kept under observation for length and weight of shoot and root and electrolyte leakage of leaf. Fresh weigh of shoot and root were recorded in digital weighting balances.

Electrolyte leakage of leaf

Electrolyte leakage of leaf was measured by taking leaf discs of size 1 cm2 and weight 0.5 g from random samples of leaf. The leaf discs were rinsed well with deionized water prior to incubation in 25 ml of deionized water for 3 h at room temperature. After incubation, the conductivity (value A) of the bathing solution was measured with the conductivity meter. The petal discs were boiled with bathing solution for 15 min to lyse all cells. After cooling at room temperature, the conductivity (value B) of the bathing solution was again measured. The electrolyte leakage was expressed as percent value according to the formula given below.

Electrolyte leakage of leaf % = (Value A/Value B) 100

Statistical analysis:

The data was statistically analyzed using Statistix-8.1 computer software (Statistix, 2006). The LSD test was applied to compare treatment means superiority, where necessary.

RESULTS

Germination (%)

A significant decrease in germination percentage was observed with the increasing levels of NaCl (Table 1). The minimum mean seed germination (22.22%) was observed from the treatment where seed were primed with Nacl @4.0 ds m-1. More than 90% mean seed germination was observed from the seed primed in NaCl solution @ 1.0 dS m-1 and distilled water. The data in Table-1 shows that maximum mean seed germination (96.66%) was observed from the seeds primed in NaCl solution at 1.0 dS m-1. On the basis of interaction, complete (100%) germination was observed in tomato and chillies where seed were primed with Nacl @1.0 dsm-1.On the basis of solanaceous vegetables, tomato seeds had the best germination (65.56) as compared to brinjal (54.44%) and chillies (53.33%).

Mean germination time (days)

The interaction of seed priming treatments and solanaceous vegetables depicts that unprimed seeds of brinjal took maximum days (12.33) to germination followed by the results 10.66 in tomato (Table 2). On the basis of mean seed germination, unprimed seeds took 11 days for seed germination followed by the results 8.00 days obtained from the seeds primed in NaCl solution had EC of 4 dS m-1. To compare solanaceous vegetables, tomato (7.66 days) and brinjal (7.16 days) seeds took statistically similar days to germination. The trend of germination time was observed increased with the increasing EC levels of NaCl solution i-e from 1 to 4.0 dS m-1.

Germination index (GI)

The data in Table 3 shows that mean germination index (7.32) was observed stable up to the EC level of 1 dS m-1. These results are statistically similar with the results (7.48) obtained from the seeds primed in distilled water. The seeds primed in NaCl solution with EC at 3 (4.41) and 4 (3.95) exhibited statistically similar results with each other for mean germination index. To compare solanaceous vegetables, Chillies had more germination index (6.45) as compared to Tomato (5.81) and Brinjal (4.90). On the basis of interaction of seed priming treatments and solanaceous vegetables, the highest germination index (8.13) was observed in chillies from the seeds primed in NaCl solution had EC of 1 dS m-1.

Seedling vigor index (SVI)

The data in Table 4 depicts that seedling vigor index was greatly affected by the increasing EC levels of NaCl in priming solutions. The highest mean seedling vigor index (1190.9) at 1 dS m-1was reduced up to the 110.2 when EC of NaCl solution was maintained at 4 dS m-1. This reduction is more than 90%. On the basis of varietal comparison, Tomato had maximum seedling vigor index (663.02) in comparison to Chillies (574.97) and Brinjal (510.80). The interactive effect of seed priming and solanaceous vegetables depicts that the highest seedling vigor index (1264.4) was observed in tomato where seed were primed with NaCl @1.0 dS m-1.

Shoot length (mm)

The data in table-5 shows that shoot length of solanaceous vegetables was significantly affected by seed priming treatment ($P<0.05$). The interaction of solanaceous vegetable seed and seed priming treatments was also significant. On the basis of interaction, the highest shoot length (126.10 mm) was observed in tomato where seed were primed with NaCl @1.0 dS m-1.The trend of mean shoot length was observed decreased with the increasing salinity level i-e from 1 dS m-1 to 4.0 dSm-1. The minimum mean shoot length (47.64 mm) was observed from the treatment where seed were primed with NaCl @ 4.0 dS m-1. The best shoot length (122.48 mm) was observed from the treatment where seed were primed with NaCl @1.0 dS m-1. On the basis of solanaceous vegetables, Tomato seeds had the best shoot length (93.611 mm) as compared to Chillies (90.11 mm) and Brinjal (85.48 mm).

Root length (mm)

The interaction of Solanaceous vegetable seeds and seed priming treatments was also significant. On the basis of interaction, maximum root length (34.00 mm) was observed in Tomato where seeds were primed with NaCl @1.0 dS m-1. All the seed priming treatments had mean root length of more than 10 mm with the highest 32.77

mm from the plants where seeds were primed in NaCl solution had EC level 1 dS m-1. Unpirmed seeds (21.33 mm) and hlydro primed (20.44 mm). The minimum mean root length (10.11 mm) was observed from the treatment where seeds were primed in NaCl solution had EC level of 4 dS m-1. On the basis of varietal comparison, Chilllies seedlings had the best root length (19.11 mm) as compared to Brinjal (18.33 mm) and Tomato (17.94 mm).

Fresh weight of shoot (g)

The data in Table-7 shows that first four seed priming treatments produced mean fresh weight of shoot more than one gram and the rest of the treatments had less than one gram. The seedlings of the treatment where seeds were primed in NaCl solution had EC of 3 and 4 dS m-1 produced similar and minimum mean results for fresh weight of shoot 0.87 g and 0.86 g respectively. The maximum mean fresh weight of shoot (1.99 g) was observed from the treatment where seeds were primed in NaCl solution had EC level of 1 dS m-1. On the basis of interaction, the seedlings of tomato from the seed priming treatment where seeds were primed in NaCl solution with EC level of 1 dS m-1 had the highest fresh weight of the shoot (2.80 g). On the basis of varietal compression tomato seedling produced maximum fresh weight of shoot (1.75 g) as compared to chillies (1.45 g) and brinjal (0.53 g).

Fresh weight of root (g)

The data in Table 8 shows that tomato seedlings had maximum fresh weigh of the root in response to the treatment where unprimed seeds were planted. These results followed by the results (0.62 g) obtained from the brinjal seedlings where seeds were primed in NaCl solution with EC of 1 dS m-1. To compare seed priming treatments, the seedlings of the treatment where seeds were primed in NaCl solution had EC of 3, 4 and 5 dS m-1and the seedlings of distilled water produced statistically similar results 0.37, 0.32 and 0.29 and 0.35 g, respectively. The seedlings of unprimed seeds produced fresh weight of root (0.51 g) as compared to the treatment where seeds were primed with NaCl had EC of 1 dS m-1 (0.60 g). This is 15% increase from unprimed seeds and 41% increased from the hydropriming treatment where distilled water was used for seed priming. To compare solanaceous vegetables, Chillies (0.36 g) and Brinjal (0.39 g) had similar fresh weight of root as compared to Tomato (0.46 g).

Electrolyte leakage of leaf (%)

The data in Table 9 reveals that all halopriming treatments had statistically similar results for leakage of the electrolytes. However, halopriming was observed significant from unpimred seeds (12.65%). The seedlings of the hydropriming treatment had more leakage of electrolytes (19.61%) as compared to control. The lowest leakage of the electrolytes was observed from the treatment where seeds were primed with NaCl at 3 dS m-1. The interactive effect shows that maximum leakage of electrolytes (34.46%) was recorded from hydropriming seedlings. To compare solanaceous vegetables, maximum leakage was observed in tomato (22.16%) followed by brinjal (12.35%) and chillies (10.50%).

DISCUSSION

Non-uniform germination and seed emergence are the main problems in solanaceous vegetables. The beneficial effects of seed priming with NaCl have been successfully reported by various researchers in many vegetables such as peppers, tomato, cucumber asparagus, fenugreek and fennel (Amjad et al., 2007; Cano et al., 1991; Passam and Kakouriotis, 1994; Neamatollahi et al., 2009; Souguir et al., 2013). The scientists proved that seed priming enahance the uniformity of germination and seed performance under both normal and saline conditions (Basra et al., 2002; Souguir et al., 2013).

In present study halopriming treatments improved germination percentage, germination index, seedling vigor index, shoot length, root length, fresh weight of shoot and fresh weight of root in three solanaceous vegetables viz. tomato, chillies and brinjal. The germination percentage was observed decreased with the increasing levels of NaCl. But the germination was higher in primed seeds as compared to control. These findings are similar with the findings of Alou et al. (2014). They found primed seeds better over control for seed germination and observed reduction on total emergence of the seeds due to increased levels of salinity (0 to 12 g L-1) in three varieties viz. Beldi, Baklouti and Anaheim Chili. Khan et al. (2009) reported that seed priming reduces the adverse effects of salinity on chilli emergence over non-primed seeds. They also reported that seed priming with NaCl reduced the germination time for emergence in hot pepper. Andreoli and Khan (1999) reported that time to germination was observed reduced by two to three days by primed seeds of tomato and pepper.

The seedling vigor index was also observed increased with the primed seeds over control and hydro primed seeds. However the lowest level of NaCl i.e 1 dS m-1 was observed better for seedling vigour index as compared to other concentrations of NaCl. These results are in agreement with the results of Raikanta et al. (2013). They studied seed priming in different varieties of tomato and chillies. They reported that seed priming improved seedling vigor, growth and yield of tomato and chillies. They further reported that halopriming increased emergence rate, seedling vigor index, root and shoot length in comparison to hydropriming in tomato and chillies. The improved seedling vigor index was also reported by Maiti et al. (2011) in chillies. Khan et al. (2009) reported that seed priming with an 1 mM of sodium chloride (NaCl) was evaluated for improved seedling vigour index.

Khan et al. (2009) reported that fresh weight of the seedlings in hot pepper was not affected by salinity levels however priming with NaCl partially relieves the adverse effects of salinity. Truong et al. (2015) reported that tomato is a salt sensitive crop. They also reported that tolerance of NaCl in tomato was recorded at early seedling stage. Tzortzakis (2009) showed that pre-sowing treatment with KNO3significantly increased fresh weight of shoot and root.

Conclusions

The seeds primed with NaCl at 1.0 dS m-1 produced optimum values for germination and seedling related attributes of solanaceous vegetables. However, all three vegetables could not sustain priming of the seeds with the higher concentrations of NaCl.

Suggestions

A detailed study related to the physiological and yield related attributes may be considered The primed seeds of the solanaceous vegetables may be considered for detailed physiological and yield related attributes.

References

Abdul-baki, A.A. and J.D. Anderson. 1970. Viability and leaching of sugars from germinating barley. Crop Sci., 10:31-34.

Afzal, I., S.M.A. Basra and N. Ahmad. 2011. Hormonal priming induces salt tolerance in wheat through enhanced antioxidant defense system. Cereal Res. Commun. 39: 334–342.

Aloui, H., M. Souguir, S. Latique and C. Hannachi. 2014. Germination and growth in control and primed seeds of pepper as affected by salt stress. Cercetări Agronomice în Moldova, 3(159):83-95.

Amjad, M., K. Ziaf, Q. Iqbal, I. Ahmad, M. Atif and Z.A. Saqib. 2007. Effect of seed priming on seed vigour and salt tolerance in hot pepper. Pak. J. Agric. Sci., 44(3):408-416.

Anantharaju, P. and A.R. Muthiah. 2007. Effect Of Nacl Salinity Stress On Seed germination And Seedling Growth Of Chick Pea (Cicer arietinum L.). Legume Res., 30 (2): pp. 141-144.

Andreoli, C. and A. Khan. 1999. Matriconditioning integrated with gibberellic acid to hasten seed germination and improve stand establishment of pepper and tomato. Pesquisa Agropecuaria Brasileira 34(10):1953-1958.

Aqib, Z., R. Khan, A. Khan, M. F. Abbasi1 and F. Muhammad. 2014. Effect of kinetin on tomato seed germination. Journal of Plant Science. 89 (4) : 541-546.

Arjenaki, F.G., M.A. Dehaghi and R. Jabbari. 2011. Effects of priming on seed germination of marigold (calendula officinalis). Advantage Environmental Biology, 51 (2) : 276-280.

Armin, M., M. Asgharipour and R. M. Omrani. 2010. The effect of seed priming on germination and seedling growth of watermelon (Citrullus lanatus). Advanced Environmental Biology. 14 (4) : 501-505.

Ayaz, F.A., A. Kadioglu and R.T. Urgut. 2010. Water stress effects on the content of low molecular weight carbohydrates and phenolic acids in cienanthesetosa. Canadian. J. Plant Sci., 80: 373 378.

Association of Official Seed Analysis (AOSA). 1983. Seed vigor testing handbook. Contribution No. 32 to the Handbook on Seed Testing

Bajji, M., J.M. Kinet and S. Lutts. 2012. Osmotic and ionic effects of NaCl on germination, early seedling growth and ion content of Atriplex halimus. Can. J. Bot. 80, 297-304.

Basra, S.M.A., M. Farooq and R. Tabassum. 2005. Physiologycal and biochemical aspects of seed vigour enhancement treatments in fine rice (Oryza sativa L.). Seed Sci. Technol., 33:623-628.

Basra, S.M.A., M.N. Zia, T. Mahmood, I. Afzal and A. Khaliq. 2002 - Comparison of different invigoration techniques in wheat (Triticum aestivum L.) seeds. Pak. J. Arid. Agric., 5:11-16.

Cano, E.A., M.C. Bolarin, F. Perez-Alfocea and M. Caro. 1991 - Effect of NaCl priming on increased salt tolerance in tomato. J. Hort. Sci., 66:621–628.

Chrysargyris, A. and N. Tzortzakis. 2015. Municipal solid wastes and mineral fertilizer as an eggplant transplant medium. Journal of Soil Science and Plant Nutrition. 15 (1) : 11-23.

Dagobiet, M., L. Garcia, K. A. Stewart and P. Seguin. 2008. Effects of saline water on growth and physiology of bell pepper seedlings. International Journal of Vegetable Science. 50 (2) : 121-138.

de Souza, C.L.M., M.O. de Souza, L.M. deoliveira and C.R. Pelacani. 2014. Effect of priming on germinability and salt tolerance in seeds and seedlings of Physalis peruviana (L.). African J. Biotechnol., 13(19):1955-1960.

Eisa, S.S., A.M. Ibrahim, H.S. Khafaga and S.A Shehata. 2012. Alleviation of adverse effects of salt stress on sugar beet by pre-sowing seed treatments. Journal of Applied Sciences Research. 8 (2) : 799-806.

Ellis, R.H. and E.H. Roberts. 1981. The quantification of ageing and survival in orthodox seeds. Seed Sci. Technol., 9:373-409.

Ertan, Y., H. Karlidag and A. Dursun. 2011. Salt tolerance of physalis during germination and seedling growth. Pak. J. Bot., 43(6): 2673-2676.

Gulzar, S. and M.A. Khan. 2011.Germination of a halophytic grass Aehropus lagopoides. J. Ann. Bot. 87: 3119 3329.

Hadas, A. 2012. Water uptake and germination of leguminous seeds in soils of chaging matrix and osmotic water potential. J. Exp. Bot. 28: 977-985.

Jabeen, M., M. Ibrar, Azim, F. Hussain and I. Ilahi. 2013.The effect of sodium chloride salinity on germination and productivity of Mung bean (Vigna mungo Linn.) J. Sci. & Tech. Univ. Peshawar, 27: 1-5.

Juan, S., G. Yong, C. Wang and W. Wang. 2012. Effects of priming treatments on germination and biochemical characteristics of Pinus bungeanaseeds. Journal of Plant Science. 14 (3) : 200-204.

Kaveh, H., H. Nemati, M. Farsi and S. V. Jartoodeh. 2011. How salinity affect germination and emergence of tomato lines. J. Biol. Environ. Sci. 15 (3): 159-163.

Kaya, M., G. Kaya, M.D. Kaya, M. Atak, M. Saglam, S. Khawar and C.Y. Ciftci, 2008.Interaction between seed size and NaCl on germination and early seedling growth of some Turkish cultivars of chickpea (Cicer arietinum L.).J Zhejiang Univ Sci B (5): 371-377.

Keiffer, C.H. and I.A. Unger. 2007. The effect of extended exposure to hyper saline conditions on the germination of five inland halophyte species. Am. J. Bot. 84: 104– 111.

Keshavarzi, M.H.B. 2011. Effect of Salt Stress on Germination and Early Seedling Growth of Savory (Saturejahortensis).Australian Journalof Basic and Applied Sciences 5(2): 3274-3279.

Khan, A. M. and Y. Rizvi. 2008: Effect of salinity, temperature and growth regulators on the germination and early seedling growth of Atriplex griffthii. Can. J. Bot. 72 (4) : 475-479.

Khan, H.A., C.M. Ayub, M.A. Pervez, R.M. Bilal, M.A. Shahid and K. Ziaf. 2009. Effect of seed priming with NaCl on salinity tolerance of hot pepper (Capsicum annuum L.) at seedling stage. Soil Environ., 28(1):81-87.

Khan, M.S.A., A. Hamid, A.B. Salahuddin, M., Quasem and M.A. Karim. 2007. Effect of sodium chloride on growth, photosynthesis and mineral ion accumulations of different type of rice (Oryza sativa L.).J. Agron. CropSci.,179: pp. 149-161.

Lacerda, C.F., G. Campraia, J. Cano and H.A. Ruiz. 2011. Plant growth and solute accumulation and distribution in two Sorghum genotype under NaCl stress. R. Bras. Fisiol. Veg., 13(3):270- 284.

Larsen, S.U. and C. Andreasen. 2004. Light and heavy turf-grass seeds differ in germination percentage and mean germination thermal time. Crop Sci., 44:1710-1720.

Maiti, R. K, P. Vidyasagar, D. Rajkumar, A. Ramaswamy and H. G. Rodriguez. 2011. Seed Priming Improves Seedling Vigor and Yield of few Vegetable Crops. Journal of Agric. Sci. 125-130.

Maiti, R., D. Rajkumar, M. Jagan, K. Pramanik and P. Vidyasagar. 2013. Effect of seed priming on seedling vigour and yield of tomato and chilli. Int. J. Bio-resource and stress management. 4(2):119-125.

Mavi, K., S. Ermis and I. Demir. 2015. The effect of priming on tomato rootstock seeds in relation to seedling growth. Asian Journal of Plant Sciences. 55 (1) : 940-947.

McDonald, J.J., and Ward, L.M. 2000. Involuntary listening aids seeing: evidence from human electrophysiology. Psychol. Sci. 11, 167–171.

Mohamedin, A.A.M., A. Kader and B. Nadia. 2006. Response of sunflowers (Heliannthu sannus L.) plants to salt stress under different water table Depth. J. App. Sci. Res., 2(12): 1175-1184.

Mohammed, T.M.S. and S.M.A. Elgafa. 2015. Study the effects of different concentrations of NaCl on germination Lycopersicun esculentum. Int. J. Life Sci. Engin., 1(4):189-191.

Mostafavi, K., H. SadeghiGeive, M. Dadresan and M. Zarabi. 2011. Effects of drought stress on germination indices of corn hybrids (Zea mays L.). International Journal of Agri. Science, 1(2): 10-18.

Moud, A.M., and K. Maghsoudi. 2008. Salt stress effects on respiration and growth of germinated seeds of different wheat (Triticum aestivum L.) cultivars. World J. Agric. Sci. 4: 351–358

Nasim, M., R. Qureshi, R. Aziz, T. Saqib, M. Nawaz, S. Sahi and S.T. Pervaiz. 2008. Growth and ionic composition of salt stressed Eucalyptus camaldulensis and Eucalyptus teretcornis. Pakistan Journal of Botany 40: 799-805.

Natale, E., S.M. Zalba, A. Oggero and H.R. Reinoso. 2010. Establishment of Tamarixramosissima under different conditions of salinity and water availability: Implications for its management as an invasive species. J. Arid Environ., 7:1399-1407.

Navin, R., L. Pradhan and P. Prakash. 2015. Seed priming in tomato (Osmopriming with PEG 6000 on salt tolerance of tomato genotypes). Journal of Agricultural Sciences. 87 (1) : 222-230.

Nawaz, A., M. Amjad, S. M. Khan, I. Afzal, T. Ahmed, Q. Iqbal and J. Iqbal. 2013. Tomato seed invigoration with cytokinins. The Journal of Animal & Plant Sciences. 23 (1) : 121-128.

Nawaz. A., M. Amjad, M. A. Pervez and I. Afzal 2011. Effect of halopriming on germination and seedling vigor of tomato. African J. Agric. Res.6(15): 3551-3559.

Neamatollahi, E., M. Bannayan, A. Ghanbari, M. Haydari and A. Ahmadian. 2009. Does hydro and osmo-priming improve fennel (Foeniculum vulgare) seeds germination and seedlings growth? Notulae Botanicae Horti Agrobotanici, Cluj-Napoca, 37(2).

Passam, H.C. and D. Kakouriotis. 1994. The effects of osmoconditioning on the germination, emergence and early plant growth of cucumber under saline conditions. Hort. Sci., 57:233- 240.

Ratikanta, M., R. Dasari, J. Mangalarapu, K. Pramanik and P.V. Yasagar. 2013. Effect of seed primin on seedling viogour and yield of tomato and chilli. Int. J. Bio. Resource Stress Manag., 4(2):119-125.

Shahbaz, M., M. Ashraf , F. Al-Qurainy and P. J. C. Harris. 2012. Salt tolerance in selected vegetable crops. Journal of Plant Science. 35 (1) : 154-162.

Souguir, M., F. Hassiba and C. Hannachi. 2013 - Effect of NaCl priming on seed germination of Tunisian fenugreek (Trigonella foenumgraecum L.) under salinity conditions. J. Stress Physiol. Biochem., 9(2):86- 96.

Sozharajan, S. and S. Natarajan. 2014. Germination and seedling growth of Zea mays L. under different levels of sodium chloride stress. International Letters of Natural Sciences. 12 (2):5-15.

Troung, N.N., S. Rangaiah and D.L. Savithramma. 2015. Germination and seedling vigour index as a phenotypical marker for the selection of NaCl tolerant in T3 generation transgenics (PgNHXI) of tomato (Lycopersicon esculentum L.). Int. J. Tropical Agric., 33(2):1469-1473.

Tzortzakis, N.G. 2009. Effect of pre-sowing treatment on seed germination and seedling vigour in endive and chicory. Hort. Sci. Prague, 36(3):117-125.

Olmstead, R.G. and L. Bohs. 2007. A summary of molecular systematic research in Solanaceae: 1982–2006. Pp. 255– 268 in: Spooner, D.M., Bohs, L., Giovannoni, J., Olmstead, R.G. & Shibata, D. (eds.), Solanaceae VI: Genomics Meets Biodiversity. Proceedings of the Sixth International Solanaceae Conference. Acta Horticulturae 745. International Society for Horticultural Science, Leuven.

Sardoei, A.S., M. Nik, M. S. Fazel, B. A. Gerdeh and M. Shahvardi. 2013. Effect of salinity stress on germination in Lycopersicon esculentum L. var Cal-ji. International Journal of Advanced Biological and Biomedical Research. 12 (1) : 1543-1550.

Selvarani, K. and R. Umarani. 2011. Evaluation of seed priming methods to improve seed vigour of onion (Allium cepa cv. aggregatum) and carrot (Daucus carota). Journal of Seed Science and Technology. 7 (3) : 857-867.

Singh, J., E. V. Divakar and V. Singh. 2012. Effect of salinity on tomato (Lycopersicon esculentum Mill.) during seed germination stage. Journal of Plant Science. 18 (1) : 45-50.

Sivritepe, H.O. 2000. The effects of osmotic conditioning treatments on salt tolerance of onion seeds. III. National symp. on vegetable production, Isparta, Turkey, pp. 475-481.

Soubhagya, B. 2016. A study the effect of salt priming (KNO3, NA2HPO4, PEG) on seed quality parameters of solanaceous vegetables. Journal of Agriculture and Technology. 30 (1) : 216-225.

Statistix, 2006. Statistics 8 user guide, version 1.0. Analytical software, P.O. Box 12185, Tallahassee fl 32317 USA. Copyright @ 2006 by Analytical Software.

Tzortzakis, N. G. 2015. Effect of pre-sowing treatment on seed germination and seedling vigour in endive and chicory. Journal of Vegetable Science. 68 (1) : 125-132.

Venkatasubramanian, A. and R. Umarani. 2007. Evaluation of seed priming methods to improve seed performance of tomato (Lycopersicon esculentum), egg plant (Solanum melongena) and Chilli (Capsicum annum). Seed Sci. Technol., 35(2):487-493.

Xiong, L. and J.K. Zhu. (2002). Molecular and genetic aspects of plant responses to osmotic stress. Plant Cell Environ., 25:131-139.

Zivkovic, S., M. Devic, B. Filipovic, Z. Giba and D. Grubisic. 2007. Effect of NaCl on seed germination in some Centaurium Hill. Species (Gentianaceae). Arch. Biol. Sci. 59 (3) : 227-231.

Table-1 Germination (%) as influenced by seed priming levels and solanaceous vegetable

Seed priming Treatments	Solanaceous vegetable seeds			Mean
	Tomato	Chillies	Brinjal	
P_1= Unprimed seeds (control)	66.67 d	53.33 e	56.67 e	**58.88 B**
P_2 = Seeds primed with distilled water	96.67 ab	96.67 ab	86.87 c	**93.33A**
P_3 = Seeds primed with NaCl @1.0 dS m^{-1}	100.00 a	100.00 a	90.00 bc	**96.66 A**
P_4 = Seeds primed with NaCl @ 2.0 dS m^{-1}	50.00 ef	40.00 g	40.00 g	**43.33 C**
P_5 = Seeds primed with NaCl @ 3.0 dS m^{-1}	43.33 fg	26.67 h	26.67 h	**32.22 D**
P_6 = Seeds primed with NaCl @ 4.0 dS m^{-1}	36.67 g	3.33 i	26.67 h	**22.22 E**
Mean	**65.56 A**	**53.33 B**	**54.44 B**	

Table-2 Mean germination time (days) as influenced by seed priming levels and solanaceous vegetable

Seed priming Treatments	Solanaceous vegetable seeds			Mean
	Tomato	Chillies	Brinjal	
P_1= Unprimed seeds (control)	10.66 b	10.00 bc	12.33 a	**11.00 A**
P_2 = seeds primed with distilled water	6.33 fg	4.00 h	4.00 h	**4.77 D**
P_3 = Seeds primed with NaCl @1.0 dS m^{-1}	4.66 h	4.00 h	4.66 h	**4.44 D**
P_4 = Seeds primed with NaCl @ 2.0 dS m^{-1}	6.66 fg	6.00 g	6.66 fg	**6.44 C**
P_5 = Seeds primed with NaCl @ 3.0 dS m^{-1}	8.66 d	6.33 fg	7.33 ef	**7.44 B**
P_6 = Seeds primed with NaCl @ 4.0 dS m^{-1}	9.00 cd	7.00 efg	8.00 de	**8.00 B**
Mean	**7.66 A**	**6.22 B**	**7.16 A**	

Table-3 Germination index (GI) as influenced by seed priming levels and solanaceous vegetable

Seed priming Treatments	Solanaceous vegetable seeds			Mean
	Tomato	Chillies	Brinjal	
P_1= Unprimed seeds (control)	5.26 efg	6.00 cde	5.23 efg	**5.50 B**
P_2 = Seeds primed with distilled water	7.73 a	8.13 a	6.60 c	**7.48 A**
P_3 = Seeds primed with NaCl @1.0 dS m^{-1}	7.50 ab	8.23 a	6.23 cd	**7.32 A**
P_4 = Seeds primed with NaCl @ 2.0 dS m^{-1}	6.70 bc	5.73 def	4.56 gh	**5.66 B**
P_5 = Seeds primed with NaCl @ 3.0 dS m^{-1}	4.20 hi	5.50 def	3.50 ij	**4.41 C**
P_6 = Seeds primed with NaCl @ 4.0 dS m^{-1}	3.50 ij	5.13 fg	3.23 j	**3.95 C**
Mean	**5.81 B**	**6.45 A**	**4.90 C**	

Table-4 Seedling vigor index (SVI) as influenced by seed priming levels and solanaceous vegetable

Seed priming Treatments	Solanaceous vegetable seeds			Mean
	Tomato	Chillies	Brinjal	
P_1= Unprimed seeds (control)	717.8 cd	598.8 ef	634.7 de	**650.5 C**
P_2 = Seeds primed with distilled water	986.2 b	995.7 b	787.6 c	**923.2 B**
P_3 = Seeds primed with NaCl @1.0 dS m^{-1}	1264.4 a	1302.0 a	1006.3 b	**1190.9 A**
P_4 = Seeds primed with NaCl @ 2.0 dS m^{-1}	525.6 f	385.7 g	313.1 g	**408.1 D**
P_5 = Seeds primed with NaCl @ 3.0 dS m^{-1}	303.6 g	153.5 h	186.9 h	**214.7 E**
P_6 = Seeds primed with NaCl @ 4.0 dS m^{-1}	180.6 h	14.0 i	136.1 h	**110.2 F**
Mean	**663.02 A**	**574.97 B**	**510.80 C**	

Table-5 Shoot length (mm) as influenced by seed priming levels and solanaceous vegetable

Seed priming Treatments	Solanaceous vegetable seeds			Mean
	Tomato	Chillies	Brinjal	
P_1= Unprimed seeds (control)	107.10 bc	111.53 b	112.07 b	**110.23 B**
P_2 = Seeds primed with distilled water	102.20 bcd	102.67 bcd	90.60 de	**98.49 C**
P_3 = Seeds primed with NaCl @1.0 dS m^{-1}	126.10 a	129.87 a	111.47 b	**122.48 A**
P_4 = Seeds primed with NaCl @ 2.0 dS m^{-1}	106.00 bc	96.07 cd	78.50 ef	**93.52 C**
P_5 = Seeds primed with NaCl @ 3.0 dS m^{-1}	70.17 f	57.80 g	70.17 f	**66.04 D**
P_6 = Seeds primed with NaCl @ 4.0 dS m^{-1}	50.10 gh	42.73 h	50.10 gh	**47.64 E**
Mean	**93.61 A**	**90.11 AB**	**85.43 B**	

Table-6 Root length (mm) as influenced by seed priming levels and solanaceous vegetable

Seed priming Treatments	Solanaceous vegetable seeds			Mean
	Tomato	Chillies	Brinjal	
P_1= Unprimed seeds (control)	15.66 d	23.66 bc	24.66 b	**21.33 B**
P_2 = Seeds primed with distilled water	21.00 bc	20.00 c	20.33 c	**20.44 B**
P_3 = Seeds primed with NaCl @1.0 dS m^{-1}	34.00 a	33.66 a	30.66 a	**32.77 A**
P_4 = Seeds primed with NaCl @ 2.0 dS m^{-1}	14.66 de	14.66 de	14.33 de	**14.55 C**
P_5 = Seeds primed with NaCl @ 3.0 dS m^{-1}	10.66 ef	12.00 def	12.00 def	**11.55 D**
P_6 = Seeds primed with NaCl @ 4.0 dS m^{-1}	11.66 def	10.66 ef	8.00 f	**10.11 D**
Mean	**17.94 A**	**19.11 A**	**18.33 A**	

Table-7 Fresh weight of shoot (g) as influenced by seed priming levels and solanaceous vegetable

Seed priming Treatments	Solanaceous vegetable seeds			Mean
	Tomato	Chillies	Brinjal	
P_1= Unprimed seeds (control)	1.73 c	0.9 gh	0.74 hij	**1.12 C**
P_2 = Seeds primed with distilled water	2.56 ab	1.51 cd	0.52 ijk	**1.53 B**
P_3 = Seeds primed with NaCl @1.0 dS m^{-1}	2.80 a	2.38 b	0.78 hi	**1.99 A**
P_4 = Seeds primed with NaCl @ 2.0 dS m^{-1}	1.36 de	1.45 de	0.48 jk	**1.10 C**
P_5 = Seeds primed with NaCl @ 3.0 dS m^{-1}	1.00 fgh	1.23 ef	0.39 k	**0.87 D**
P_6 = Seeds primed with NaCl @ 4.0 dS m^{-1}	1.06 fg	1.23 ef	0.30 k	**0.86 D**
Mean	**1.75 A**	**1.45 B**	**0.53 C**	

Table-8 Fresh weight of root (g) as influenced by seed priming levels and solanaceous vegetable

Seed priming Treatments	Solanaceous vegetable seeds			Mean
	Tomato	Chillies	Brinjal	
P_1= Unprimed seeds (control)	0.65 a	0.45 bc	0.44 bcd	**0.51 B**
P_2 = Seeds primed with distilled water	0.42 bcd	0.33 de	0.30 e	**0.35 CD**
P_3 = Seeds primed with NaCl @1.0 dS m^{-1}	0.70 a	0.48 b	0.62 a	**0.60 A**
P_4 = Seeds primed with NaCl @ 2.0 dS m^{-1}	0.38 bcde	0.36 bcde	0.38 bcde	**0.37 C**
P_5 = Seeds primed with NaCl @ 3.0 dS m^{-1}	0.34 cde	0.27 e	0.34 cde	**0.32 CD**
P_6 = Seeds primed with NaCl @ 4.0 dS m^{-1}	0.30 e	0.28 e	0.30 e	**0.29 D**
Mean	**0.46 A**	**0.36 B**	**0.39 B**	

Table-9Electrolyte leakage of leaf (%)as influenced by seed priming levels and solanaceous vegetable

Treatments	Solanaceous vegetable seeds			Mean
	Tomato	Chillies	Brinjal	
P_1= Unprimed seeds (control)	18.42 bcd	9.95 ef	9.58ef	**12.65 C**
P_2 = Seeds primed with distilled water	34.46 a	10.65 ef	13.71 def	**19.61 A**
P_3 = Seeds primed with NaCl @1.0 dS m^{-1}	21.42b	11.98 ef	14.78 cde	**16.06 B**
P_4 = Seeds primed with NaCl @ 2.0 dS m^{-1}	23.21 b	8.65 f	11.98 ef	**14.61 BC**
P_5 = Seeds primed with NaCl @ 3.0 dS m^{-1}	15.02 cde	10.38 ef	12.79 def	**12.73 BC**
P_6 = Seeds primed with NaCl @ 4.0 dS m^{-1}	20.44 bc	11.39 ef	11.26 ef	**14.36 BC**
Mean	**22.16 A**	**10.50 B**	**12.35 B**	