academicJournals

Vol. 8(30), pp. 1420-1423, 11 August, 2013
DOI 10.5897/SRE2013.5600
ISSN 1992-2248 © 2013 Academic Journals
http://www.academicjournals.org/SRE

Scientific Research and Essays

Full Length Research Paper

Saline stress on seed germination

M. Ameer Junaithal Begum*, P. Selvaraju and B. Venudevan

Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, 641003, India.

Accepted 25 July, 2013

Salinity is one of the major abiotic stresses in arid and semi-arid regions and it affects 7% of the world's land area of about 930 million ha (Munns et al., 2006). Salinity reduces the ability of plants to take up water, leading to metabolic effect that reduces plant growth. It may reduce crop yield by upsetting water and nutritional balance of plant. The deleterious consequences of high salt concentrations in the external solution of plant cells are hyperosmotic shock and ionic imbalance. Although, salt stress affects all growth stages of a plant, seed germination and seedling growth stages are known to be more sensitive for most plant species. Germination failures on saline soils are often the results of high salt concentrations in the seed planting zone. Salinity causes not only differences between the mean yield and the potential yield, but also causes yield reduction from year to year. This review is expected to give valuable information about the effects of salinity on seed germination.

Key words: Salinity, stress, seed germination.

INTRODUCTION

Environmental stresses are the most limiting factors to crop production. Worldwide agricultural productivity is subjected to increasing environmental constraints (Bartels and Sunkar, 2005) in the form of abiotic and biotic stresses that adversely influence plants (Hussain et al., 1990). In fact, abiotic stresses are the principle cause of crop failure, decreasing average yields for major crops by more than 50% (Buchanan et al., 2000) and threatening the sustainability of the agricultural industry (Mahajan and Tuteja, 2005). Drought and salinity are two major abiotic determinants (Wang et al., 2009) due to high magnitude of their impact and wide occurrence (Bartels and Sunkar, 2005). Severe drought and high salinity could promote the desertification and salinization of land processes which are rapidly increasing on a global scale. More than 10% of arable land has become desertified or salinised. An extensive problem in agriculture is the accumulation of salts from irrigation water. When irrigation water contains a high concentration of solutes, salts can rapidly reach injurious levels vis-à-vis salt-sensitive species. Evaporation and transpiration remove pure water and concentrates solutes in the soil. The progressive salinization of irrigated land produces vast amounts of uncultivable soils (Ashraf, 1994). Salinity is one of the major abiotic stresses in arid and semi-arid regions and it affects 7% of the world's land area of about 930 million ha (Mendham and Salisbury, 1995).

Salinity reduces the ability of plants to take up water, leading to growth reduction as well as metabolic changes similar to those caused by the water stress (Munns, 2002). High salt concentration in the roots affects the growth and yield of many important crops. Salinity may reduce crop yield by upsetting water and nutritional balance of the plant (Khan et al., 2007). Water availability and nutrient uptake by plant roots can be limited by high osmotic potential and toxicity of Na and Cl ions (Al-Karaki, 1997). It affects plant growth directly through its interaction with metabolic rates and pathways within the plants. The deleterious consequences of high salt

*Corresponding author. E-mail: junaifathi@gmail.com.

concentrations in the external solution of plant cells are hyperosmotic shock and ionic imbalance (Niu et al., 1995; Zhu et al., 1997).

Seeds are the main way through which plants propagate, and a seed contains all of the genetic material of the plant. As seed germination is the beginning of the life cycle of plants, seedling emergence is critical for the establishment of plant populations (Khan and Gulzar, 2003). Although salt stress affects all growth stages of a plant, seed germination and seedling growth stages are known to be more sensitive for most plant species (Cuartero et al., 2006) and germination has been reported to decline with increasing salinity levels (Houle et al., 2001). Poor germination in saline soils leads to poor crop establishment and hence low productivity (Ayman, 1995). Germination failures on saline soils are often the results of high salt concentrations in the seed planting zone because of upward movement of soil solution and subsequent evaporation at the soil surface. Soil salinity affects germination by either an osmotic stress or ion toxic effect (Bewley and Black, 1982). Salinity may create an external osmotic potential limiting water absorption by the seeds, or sodium and chloride ions may accumulate in the germinating seed, resulting in a toxic effect. Under drought and salt stress, the mobilisation of stored reserves is prevented or reduced in seeds (Bouaziz and Hicks, 1990), and the structural organisation and synthesis of proteins are restricted in germinating embryos (Ramagopal, 1990). Seed weight and consequently viability percentage and germination rate decreases as salinity increases. Salinity causes not only differences between the mean yield and the potential yield, but also causes yield reduction from year to year. Hence the study of salt stress on seed germination is of prime importance.

SALT STRESS ON SEED GERMINATION

Shokohifard et al. (1989) reported that salt stress negatively affected seed germination; either osmotically through reduced water absorption or ionically through accumulation of Na and Cl causing an imbalance in nutrient uptake and a toxic effect. Furthermore, Younis et al. (1991) reported that low moisture content under salt stress caused a cessation of metabolism or inhibition of certain steps in metabolic sequences of germination. Conversely, salt stress increased the intake of toxic ions that may have altered certain enzymatic or hormonal activity in seeds during germination (Smith and Comb, 1991).

Moreover, salinity perturbs a plant’s hormone balance (Khan and Rizvi, 1994) and reduces utilization of seed reserves (Ahmad and Bano, 1992). Decreasing germination due to increased salinity can be connected to the nature of salinity that reduces imbibitions of water due to lowered osmotic potential of the medium and changes in metabolic activity (Yupsanis et al., 1994). Salt induced inhibition of seed germination could be attributed to osmotic stress or to specific ion toxicity (Huang and Reddman, 1995). It appears that a decrease in germination is related to salinity-induced disturbance of the metabolic process leading to an increase of phenolic compounds (Ayaz et al., 2000).

Germination and early seedling growth of many crop plants are the most sensitive stages to environmental stresses (Cook, 1997; Jones, 1986). Werner and Finkelstein (1995) demonstrated that elevated salinity slowed down water uptake by seeds, thereby inhibiting germination and root elongation. Significant reduction in seed germination was observed in canola seeds grown under salinity conditions (Zheng et al*.,* 1998; Puppala et al., 1999).

Both NaCl and KCl have been reported to reduce the final germination percentage and germination rate of two arid-land varieties of wheat (*Triticum aestivum* L.); furthermore, the salt had increased the production of abnormal seedlings (Al-Ansari, 2003). The seed germination of *Panicum turgidum* has been significantly reduced and slowed at high concentrations of both NaCl and KCl and was completely inhibited at 300 and 400 mM (El-Keblawy, 2004).

In another report, four lentil (*Lens culinaris* M.) genotypes were treated with salt stress (0, 50, 100, 150 or 200 mM NaCl), and it was reported that the increasing NaCl concentration reduced the germination percentage, the growth parameters and the relative water content (Sidari et al., 2007). Pratap and Sharma (2010) reported that germination percentage and all of the seedling growth parameters showed inhibition with an increase in osmotic potentials generated by polyethylene glycol (PEG) 6000 in black gram (*Phaseolus mungo*).

The concentration limits for germination in *Dianthus chinensis* L. have been reported to be 150 mM for NaCl and -1.66 MPa for PEG 6000; again, it was reported that NaCl had exerted less effect than PEG on the final germination percentage (He et al., 2009). Similarly, both NaCl and PEG-6000 have been shown to inhibit the germination and seedling growth in two *P. mungo* varieties, where the effect of NaCl was also shown to be less than PEG-6000 (Garg, 2010).

Seed germination and the growth of young seedlings of sugar beet (*Beta vulgaris* L.) have been reported to be inhibited by NaCl treatment (Wang et al., 2011). Bahrami and Razmjoo (2012) studied that sesame seed germiantion was strongly affected to 98, 95.7, 87.4, 78.5, 50.65 and 15.02% with the salinity levels of 0, 5.3, 8.5, 12.05, 14.65 and 18.45 dSm^{-1}, respectively.

SALT STRESS ON SEEDLING LENGTH

Root and shoot lengths are the most important indicators of salt stress because roots are in direct contact with the soil and absorb water from soil and then shoots enable its supply to the rest of the plant. For this reason, root and shoot lengths provide important indications of a plant's response to salt stress (Jamil and Rha, 2004).

Root length as well as shoot length is affected by salinity. Bahrami et al. (2012) found that 0, 5.3, 8.5, 12.05, 14.65 and 18.45 dSm^{-1} salinity levels decreases the radicle length of 2.6, 2.34, 1.6, 1, 0.6, 0.3 cm, respectively. According to them plumule length was more sensitive than radicle length. Mean plumule length of the cultivars studied varied between 3.1 and 4.3 cm and between 6.2 and 0.42 cm for salinity level.

Xiong and Zhu (2002) explained that salt stress inhibited the efficiency of translocation and assimilation of stored materials and might have caused a reduction in shoot growth. The reduction in root and shoot development may be due to toxic effects of the NaCl used as well as unbalanced nutrient uptake by the seedlings. It may be due to the ability of a root system to control entry of ions to the shoot, which is of crucial importance to plant survival in the presence of NaCl (Hajibagheri et al., 1989).

SALT STRESS ON SEEDLING DRY WEIGHT

Findings of EL-Melegi et al. (2004) on tomato under salinity stress showed that, dry weight of plants had a positive correlation with root length and these plants were more tolerate to salinity stress. Similar results were reported by François and Bahizire (2007) in canola under salinity stress.

Bahrami et al. (2012) reported that under increasing stress levels, radicle dry weight significantly decreased from 6, 5.4, 3.2, 2.7, 2.1 and 1.5 mg and plumule dry weight also decreased from 11.2, 8.3, 6.1, 5, 2.6 and 1 mg at the salt levels of 0, 5.3, 8.5, 12.05, 14.6 and 18.45 dSm^{-1}, respectively.

MECHANISM OF SALT STRESS ON GERMINATION

Salinity reduces the ability of plants to take up water, leading to growth reduction as well as metabolic change similar to those caused by the water stress (Munns, 2002). High salt concentration in root affects the growth and yield of many important crops. The salinity may reduce the crop yield by upsetting water and nutritional balance of plant (Khan et al., 2007). Water availability and nutrient uptake by plant roots is limited because of high osmotic potential and toxicity of Na and Cl ions (Al-Karaki, 1997).

SEED MANAGEMENT TECHNIQUES FOR SALINE SOIL

Sugarbeet (*Beta vulgaris* L.) is among the most salt tolerant crops, but is reported to be less tolerant during germination and emergence. Seed priming before sowing reduces the effects of salinity on emergence rates (Kaffka and Hempree, 2004). Presoaking seed treatment of groundnut seeds with GA_3 (100 ppm) and IAA (200 ppm) for 2 h overcomes the effects of salinity (Senthil et al., 2005).

Pre-sowing seed treatment of *Brassica* seeds treated with ascorbic acid @ 100 mg/L induces salinity tolerance (Khan et al., 2010). Wheat varieties primed with 30 mM NaCl for 12 h at 25°C produced significantly higher shoot fresh weight per plant, shoot dry weight per plant, shoot Na^+ content (mg/g dry weight), shoot K^+ content (mg/g dry weight) and shoot K^+/Na^+ ratio under salinity level up to 120 mM (Jamal et al., 2011).

Rapid seed germination and stand establishment are critical factors to crop production under salt-stress conditions. In many crop species, seed germination and early seedling growth are the most sensitive stages to salinity stress. Salinity may delay the onset, reduce the rate, and increase the dispersion of germination events, leading to reductions in plant growth and final crop yield. The adverse effects of salt-stress can be alleviated by various measures, including seed priming (pre-sowing seed treatment) (Ashraf, 1994).

Pepper seeds treated with 10 mM glyciebetaine (GB), an organic osmolyte accumulates in variety of plants in response to abiotic stress, for 24 h in darkness improved germination and synchrony of germination under salt stress. Glyciebetaine decreases the Melonoldehyde (MDA) and increases the proline content and SOD activity in seeds. The enhanced tolerance to salt stress may be due to reduced lipid peroxidation and elevated SOD enzyme activity (Korkmaz and Sirikci, 2011). Isabgol seeds primed with 0.8% KNO_3 for 4 h at 15°C showed better tolerance to salinity and recorded higher yield and other quality parameters under salinity levels of up to 12 dSm^{-1} (Ghassemi et al., 2012).

CONCLUSION

All germination indices decreased under an increased salt level. One way to use the salt affected lands is by reclamation but this is a cost effective process. An alternative approach is to grow salt tolerant species and cultivars and seed treatment. But salt tolerance is highly variable between and within species. Identification and selection of the most salt tolerant cultivars of a species would therefore be of immense value for agriculture.

REFERENCES

Ahmad J, Bano M (1992). The effect of sodium chloride on physiology of cotyledons and mobilization of reserved food in *Cicer arietinum*. Pak. J. Bot. 24:40–48.

Al-Ansari FM (2003). Salinity tolerance during germination in two arid-land varieties of wheat (*Triticum aestivum* L.). Seed Sci. Technol.

31:597-603.
Al-Karaki GN (1997). Barley responce to salt stress at varied levels of phosphorous. J. Plant Nutr. 20:1635-1643.
Ashraf M (1994). Breeding for salinity tolerance in plants. Crit. Rev. Plant Sci. 13: 17-42.
Ayaz FA, Kadioglu A, Turgut R (2000). Water stress effects on the content of low molecular weight carbohydrates and phenolic acids in *Ctenanthe setosa* (Rose.) Eichler, Can. J. Plant Sci. 80:373-378.
Ayman S (1995). M.Sc., (Ag.). Thesis, I. Ag. Sc. SHU. Varnasi, India.
Bahrami H, Razmjoo J, Ostadi Jafari A (2012). Effect of drought stress on germination and seedling growth of sesame cultivars (*Sesamum indicum* L.). Int J. Agric. Sci. Vol. 2(5):423-428.
Bartels D, Sunkar R (2005). Drought and salt tolerance in plants. Crit. Rev. Plant Sci. 24:23-58.
Bewley JD, Black M (1982). Physiology and Biochemistry of Seeds in Relation to Germination. Vol. 2. Viability, Dormancy and Environmental Control. Springer-Verlag. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiol. Rockville, MD.
Bouaziz A, Souty N, Hicks D (1990). Emergence force exerted by wheat seedlings. Soil Till. Res. 17:211–219.
Buchanan BB, Gruissem W, Jones RL (2000). Subsequent Effect on Embryonic Protein Synthesis in Barley. J. Plant Physiol. 136:621-625.
Cook RE (1997). Patterns of juvenile morbidity and recruitment in plants. In: Solbrig OT, Jain S, Johnson FB and Raven P (eds.), Topics in plant population biology. Columbia University Press, Los Angeles pp. 207-301.
Cuartero J, Bolarin MC, Asins MJ, Moreno V (2006). Increasing salt tolerance in the tomato. J. Exp. Bot. 57(5):1045-1058.
El-Keblawy A (2004). Salinity Effects on Seed Germination of the Common Desert Range Grass, *Panicum Turgidum*. Seed Sci. Technol. 32:873-878.
EL-Melegi, El-sayed A, Mahdia FG, Fouad HM, Mona AI (2004). Responses to NaCl salinity of tomato cultivated and breeding lines differing in salt tolerance in callus cultures. Int. J. Agric. Biol. 6(1):19-26.
François B, Bahizire (2007). Effect of salinity on germination and seedling growth of canola (*Brassica napus* L.). The degree of Master of Agricultural Sciences at the University of Stellenbosch.
Garg G (2010). Response in Germination and Seedling Growth in *Phaseolus mungo* under Salt and Drought Stress. J. Environ. Biol. 31:261-264.
Ghassemi K, Zafarani-Moattara P, Chadordooz-Jeddia A (2012). Improving isabgol (P*lantago ovata* forsk) performance under salinity by seed priming. Int. J. Plant, Anim. Environ. Sci. 2(3):16-21.
Hajibagheri MA, Yeo AR, Flowers TJ, Collins JC (1989). Salinity resistance in *Zea mays* uses of potassium, sodium and chloride, cytoplasmic concentrations and microsomal membrane lipids. Plant Cell Environ. 12:753-757.
He XQ, Du C, Shao Z, Li Q (2009). Effect of Salt and Water Stress on Seed Germination of *Dianthus Chinensis* L. Academic Conference of Horticultural Science and Technology Proceedings pp. 60-62.
Houle G, Morel L, Reynolds CE, Siegel J (2001). The effect of salinity on different developmental stages of an endemic annual plant, *Aster laurentianus* (Asteraceae). Am. J. Bot. 88:62-67.
Huang J, Redmann RE (1995). Salt tolerance of *Hordeum* and *Brassica* species during germination and early seedling growth. Can. J. Plant Sci. 75:815-819.
Hussain S, Ghaffar A, Aslam M (1990). Biological control of Macrophomina phaseolina charcoal rots of sunflower and mung bean. Egypt. J. Phytopathol. 130:157-160.
Jamal Y, Muhammad S, Jehan B (2011). Effect of seed priming on growth and biochemical traits of wheat under saline conditions. Afr. J. Biotechnol. 10(75):17127-17133.
Jamil M, Rha ES (2004). The effect of salinity (NaCl) on the germination and seedling of sugar beet (*Beta vulgaris* L.) and cabbage (*Brassica oleracea capitata* L.). Kor. J. Plant Res. 7:226-232.
Jones RA (1986). High salt-tolerance potential in *Lycopersicon* species during germination. Euphytica 35:576-582.
Kaffka S, Hembree K (2004). The effects of saline soil, irrigation, and seed treatments on sugarbeet stand establishment. J. Sugar Beet Res. 41(3):61-72.
Khan A, Iqbal I, Shah A, Nawaz H, Ahmad F, Ibrahim M (2010). Alleviation of adverse effects of salt stress in brassica (*Brassica campestris*) by pre-sowing seed treatment with ascorbic acid. Am-Eur. J. Agric. Environ. Sci. 7(5):557-560.
Khan MA, Gulzar S (2003). Germination Responses of *Sporobolus ioclados*: A Saline Desert Grass. J. Arid Environ. 53:387-394.
Khan MA, Rizvi Y (1994). Effect of salinity, temperature and growth regulators on the germination and early seedling growth of *Atriplex griffithii* var. Stocksii. Can. J. Bot. 72:475–479.
Khan MA, A Qayyum, Noor E (2007). Assessment of wheat genotypes for salinity tolerance. Proceeding of 8th African Crop Science Conference, Oct. 27-31, El-Minia, Egypt. pp. 75-78.
Korkmaz A, Sirikci R (2011). Improving salinity tolerance of germinating seeds by exogenous application of glycinebetaine in pepper. Seed Sci. Technol. 39:377-388.
Mahajan S, Tuteja N (2005). Cold, Salinity and Drought Stresses: An Overview. Arch. Biochem. Biophys. 444:139-158.
Mendham NJ, Salisbury PA (1995). Physiology of crop development in: Growth and yield. CAB Int. pp. 11-67.
Munns R (2002). Comparative physiology of salt and water stress. Plant Cell Environ. 25:239-250.
Munns R, James KA, Lauchli A (2006). Approaches to increasing the salt tolerance of wheat and other cereals. J. Exp. Bot. 57(5):1025-1043.
Niu X, Bressan RA, Hasegawa PM, Pardo JM (1995). Ion homeostasis in NaCl stress environments. Plant Physiol. 109:735–742.
Pratap V, Sharma YK (2010). Impact of Osmotic Stress on Seed Germination and Seedling Growth in Black Gram (*Phaseolus Mungo*). J. Environ. Biol. 31:721-726.
Puppala N, Fowler JL, Poindexter L, Bhardwaj HL (1999). Evaluation of salinity tolerance of canola germination. In: J. Janick (Ed.), Perspectives on new crops and new uses pp. 251-253.
Ramagopal S (1990). Inhibition of Seed Germination by Salt and Its Niu X, Bressan RA, Hasegawa PM, Pardo JM, 1995. Ion homeostasis in NaCl stress environments. Plant Physiol. 109:735-742.
Senthil A, Djanaguiraman M, Vijayalakshmi C (2005). Influence of seed treatment of growth regulators on some enzyme activity in groundnut under salinity. Agricultura Tropica et Subtropica 38(2):88-90.
Shokohifard G, Sakagam KH, Matsumoto S (1989). Effect of amending materials on growth of radish plant in salinised soil. J. Plant Nutr. 12:1195-1294.
Sidari M, Muscolo A, Anastasi U, Pretti G, Santonoceto C (2007). Response of Four Genotypes of Lentil to Salt Stress Conditions. Seed Sci. Technol. 35:497-503.
Smith PT, Comb BG (1991). Physiological and enzymatic activity of pepper seeds (*Capsicum annuum*) during priming. Physiol. Plant 82:71-78.
Wang K, Liu Y, Dong K, Dong J, Kang J, Yang Q, Zhou H, Sun Y (2011). The effect of NaCl on proline metabolism in *Saussurea amara* seedlings. Afr. J. Biotechnol. 10:2886-2893.
Wang L, Zhang DY, Huang ZY, Tian CY (2009). Factors Influencing Seed Germination of *Kalidium caspicum* (Chenopodiaceae), a Halophytic Desert Shrub of Xinjiang, China. Seed Sci. Technol. 37:281-290.
Xiong L, Zhu JK (2002). Molecular and genetic aspects of plant responses to osmotic stress. Plant Cell Environ. 25:131–139.
Younis SA, Shahatha HA, Hagop PG, Al-Rawi FI (1991). Effect of salinity on the viability of rice seeds. Plant growth, drought and salinity in the Arab region pp. 235-244.
Yupsanis T, Moustakas M, Eleftherrious P, Damalanidou K (1994). Protein phosporylation-dephosphorylation in alfalfa seeds germinating under salt stress. J. Plant Physiol. 143:234-240.
Zhu JK, Hasegawa PM, Bressan RA (1997). Molecular aspects of osmotic stress. Crit. Rev. Plant Sci. 16:253-277.