Bangladesh Agron. J. 2022, 25(1): 57-65

SALT STRESS TOLERANCE AND GERMINATION PERFORMANCE OF MUNGBEAN GENOTYPES UNDER SALT STRESS

M.S. Kobir, M.O. Ali, J. Hossain, M.S. Alam, M. Rahman, K.U. Ahammad, P. Hajong, and S. Paul
Bangladesh Agricultural Research Institute, Bangladesh
Corresponding Email: Shahriar1302027@gmail.com

(**Received:** 25 April 2022, **Accepted:** 19 May 2022)

Keywords: Germination, mungbean, seedling, NaCl stress

Abstract

Sea level rising, as a result of global warming, is a major threat to crop production; because inclusion of saline water in crop land limits the crop production. So, an experiment was undertaken to evaluate some mungbean genotypes under different levels of salt stresses in germination stage. The experiment was conducted at Regional Agricultural Research Station, Jashore during Rabi 2020-2021. The seeds of seven mungbean genotypes viz. BARI Mung-6, BARI Mung-8, BMXKI-112004-3, BMXKI-112009-21, MMAT-V07, BMMP-201524 and BMMP-201506 were collected from different sources. This experiment was conducted following factorial completely randomized design (CRD) with two replications. The experimental factors were i) mungbean genotypes (seven) and ii) salt stress (three levels: 0, 4 and 8 dSm^{-1}). The results showed that mungbean var. BARI Mung-6 at 0 dSm^{-1} and 4 dSm^{-1} showed highest value in case of germination index (9), germination percentage (100%), co-efficient of germination (40), vigor index (1950) and lowest value in case of mean germination time (2.5). BARI Mung-8 at 0 dS m^{-1} showed the inverse results. Genotype BMXKI-112009-21, MMAT-V07 and BMMP-201524 at 4 dSm^{-1} and in some extent in 8 dSm^{-1} showed highest value in case of germination stress tolerance index, plant height stress index, root length stress index, shoot fresh weight stress index, root fresh weight stress index, shoot dry weight stress index and in root dry weight stress index. The lowest values in these parameters were found in BARI Mung-8 at 8 dSm^{-1} salt stress. BARI Mung-6, MMAT-V07, BMXKI-112009-21 and BMMP-201524 genotypes were found to be more tolerant to salt stress than rest of the genotypes in germination stage.

Introduction

Mungbean is an important pulse crop in Bangladesh which is grown for its various nutritional benefits and as for green manuring purposes. Its grain is used for human consumption as it contains 19.5%-28.5% protein. Bangladesh has produced about 37,000 M Tons mungbean from 109,000 acres of land in 2019-2020 (BBS, 2021).

For crop production, biodiversity, food and nutritional security, soil salinity is a serious threat now-a-days. In 1973, salinity affected area in Bangladesh was 8330 square km whereas in 2009 it increases in around 10560 square km (SRDI, 2010). More than thirty-five million people are living in coastal region of Bangladesh in 19 districts which covers about 32% of the whole country Huq and Rabbani (2011).

The growth of most salt sensitive crop plant is inhibited due to excessive Na^+ and Cl^-ion. The effect of NaCl salt solution concentration on plant growth has been studied in different pulse crop species. At 50mM of NaCl, reduction of dry mass production in *Glycine max, Phaseolus vulgaris and Brassica juncea* in increased salt concentration was found by Taffouo *et al.* (2004) and Syeed *et al.* (2011). In

Vigna unguiculata and Mucuna poggei effect of NaCl was observed in 100mM of NaCl. Combination of osmotic and specific ion effects of Na^+ and Cl^-can reduce the dry mass in increased salinity level Munns (2002).

Salt tolerance of a plant can be defined as the plants can complete its life cycle in certain concentration of salt substrates. On the basis of morphological, physiological and biochemical indices different scientific techniques like conventional breeding, selection and transgenics can be used to mitigate the salinity stress in plants. Selection of salt tolerant genotypes in the early stage can be a very reliable strategy as this strategy is less time consuming, less laborious and less expensive Dasgan *et al*. (2002). Understanding the physiological or biochemical processes that is more sensitive to salt stress that can be used as effective selection criterion is also important, Ashraf and Harris (2004). Therefore, the objective of this study was to evaluate the influence of salt stress on germination and seedling growth of seven mungbean genotypes with a view to a better understanding of the mechanisms and capability of salt tolerance in these genotypes.

Materials and Methods

The experiment was conducted at Regional Agricultural Research Station, Jashore during Rabi 2020-21. Seven selected genotypes of mungbean viz., BARI Mung-6, BARI Mung-8, BMXKI-112004-3, BMXKI-112009-21, MMAT-V07, BMMP-201524, and BMMP-201506 was tested and evaluated *in vitro* condition in petridishes at 0, 4 and 8 ds m^{-1} Nacl salt solution. A two factorial experiment was set in following factorial completely randomized design (CRD) with two replications. The experimental factors were i) mungbean genotypes (seven) and ii) salt stress (three levels: 0, 4 and 8 ds m^{-1}). The seven genotypes were randomly assigned to seven Petri dishes (9 cm diameter) of which each petri dish contained 10 seeds of each genotype following two replications. Three salt treatments i.e., 0 (control), 4 and 8dSm^{-1}were obtained by dissolving laboratory grade NaCl in the solution until the treatment level reached to the desired EC. An EC meter was used to check the desired EC regularly. The control i.e., 0 dSm^{-1} was maintained using distilled water only. The seeds were soaked in water and imbibed for 24 hours and then placed in petri dishes containing filter paper to allow them for germination. In control, 4 mL of distilled water was added to the petri dish. Filter papers were moistened with 4 mL of respective salt solutions to develop the respective level of salt treatments (4 dS m^{-1} and 8 dSm^{-1}). The mungbean seeds were allowed to germinate at around 25°C room temperature and kept them for eight days for observation. The number of germinated seeds (2 mm radicle length) was counted every day. The final count was done on day eight and germination percentage (GP) was calculated using the following formulae stated by Almudaris (1998).

$$\text{Germination percentage (\%)} = \frac{\text{Total No. of seed germinated in final day}}{\text{Total No. of seed taken}} \times 100$$

Co-efficient of germination (CG) was calculated using the following formula Copeland (1976):

$$Co - efficientofgermination(\%) = \frac{A1 + A2 + \cdots . Ax}{A1T1 + A2T2 + \cdots AxTx} \times 100$$

where, CG = Coefficient of germination (%), A = Number of seeds germinated, T = Time corresponding to A, x = Number of days to final count.

Germination index was calculated as the product of number of days after sowing and number of germinated seeds divided by the total number of seeds sown Li (2008).

Germination Index (GI) = ∑diNi/ S

where, di = Number of days after sowing seeds under a particular treatment, Ni = the number of germinated seeds and S = the total number of seeds sown for the experiment.

The mean germination time (MGT) was calculated using the daily counts, according to the following equation described by Moradi *et al*. (2008):

$$MGT = \Sigma nD / \Sigma N$$

Where, n is the number of newly germinated seeds at day D; D = days from the beginning of the germination test; N = number of all germinated seeds (final germination).

The vigor of the seedlings was calculated according to the following formula stated by Abdul-Baki and Anderson (1973):

Vigor index= {Mean of root length + Mean of shoot length} × Seed germination (%)

plumule length (PL) was measured from shoot base to the tip of the longest leaf and radicle length (RL) was measured from root base to the root tip. Seedling fresh weight was recorded immediately after the harvest at day nine. Root length stress tolerance index (RLSI), plant height stress tolerance index (PHSI), shoot fresh weight stress tolerance index (SFSI), root fresh weight stress tolerance index (RFSI), shoot dry weight stress tolerance index (SDSI) and root dry weight stress tolerance index (RDSI) were calculated using the following formula described by Ashraf and Harris (2004):

PI = nd1 (1.00) + nd2 (0.75) + nd3 (0.50) + nd4 (0.25) Where, nd1, nd2, nd3 and nd4 = Number of seeds germinated on the 2nd, 4th, 6th and 8th day, respectively.

GSTI = (PI of stressed seeds / PI of control seeds) X 100

PHSI = (Plant height of stressed plants / plant height of control plants) X 100

RLSI = (Radicle length of stressed plants / radicle length of control plants) X 100

SFSI = (Shoot fresh weight of stressed plants / shoot fresh weight of control plants) X 100

RFSI = (Root fresh weight of stressed plants / root fresh weight of control plants) X 100

SDSI = (Shoot dry weight of stressed plants / shoot dry weight of control plants) X 100

RDSI = (Root dry weight of stressed plants / root dry weight of control plants) X 100

Data of different parameters were recorded from five seedlings of each unit petri dish and analyzed statistically by statistical software Statistix-10 and the mean separation was done by least significance difference test at 5% level of probability.

Results and Discussion

Co-efficient of germination (CG) showed significant variation among the genotypes and salt treatments (Figure 1). Results revealed that CG decreased with the increase of salt concentration for all the genotypes except BARI Mung-6 and BMXKI-112009-21. The highest CG was found by the genotype BARI Mung-6 in 4 dSm^{-1} salt solutions which is followed by genotype BMMP-201524 in 0.0 dSm^{-1} salt solutions and the lowest was found in BARI Mung-8 in 8 dSm^{-1} salt solutions (Figure 1).

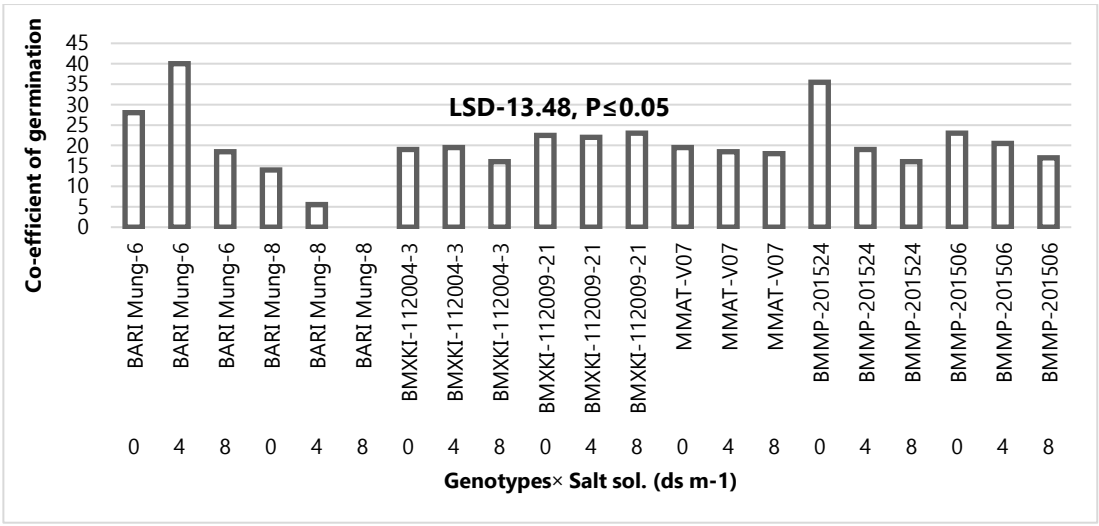

Fig. 1. Effect of different levels of salinity on selected mungbean genotypes in respect of co-efficient of germination.

Germination index (GI) showed significant differences for the genotypes and salt solutions (Figure 2). Results showed that in some genotypes GI increased in 4 dSm^{-1}salt concentration compared to control but in 8 dSm^{-1} GI again decreased compared to control and 4 dSm^{-1} concentrations. The highest GI was found by BARI Mung-6 in control dishes and the lowest by the genotype BARI Mung-8 in 4 dSm^{-1} and 8 dSm^{-1} NaCl salt solution (Figure 2). Similar results were also found by Almodares *et al*. (2007) and Khan and Weber (2008). They reported that increasing of salinity level decreases the germination index, but in some cases certain level of salinity can enhance the germination capability of some genotypes which was accordance with the present findings.

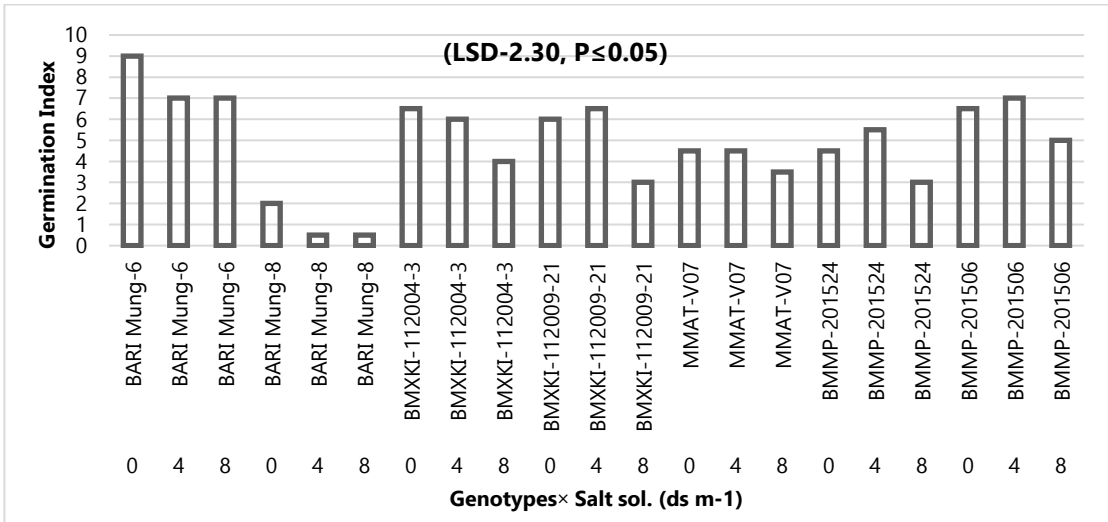

Fig. 2. Effect of different levels of salinity on selected mungbean genotypes in respect of germination index.

Germination percentage (GP) showed significant variation for genotypes and different salt concentrations (Figure 3). In case of genotype BARI Mung-6, BARI Mung-8, and BMXKI-112004-3 GP decreased with the increase of salt concentration but in case of genotype BMXKI-112009-21,

MMAT-V07, BMMP-201524 and BMMP-201506 GP increased in 4 dSm^{-1} salt concentrations compared to control and 8 dSm^{-1} concentrations (Figure 3). In controlled condition and in 8 dSm^{-1} salt concentrations the highest GP was found in BARI Mung-6 and the lowest in BARI Mung-8 (Figure 3). In 4 dSm^{-1} concentrations highest GP was found in BARI Mung-6 and in BMMP-201506 and the lowest by BARI Mung-8 (Figure 3). These findings indicated that there were genetically differences in different cultivars in respect to salt stress. Lauchli and Grattan (2007) stated that germination rates may vary with the species and genotypes in different salt stress conditions. The reduction of germination percentage might be due to alteration of enzymes and hormones that exists in the seeds Khan and Rezvi (1994). This might be also happened due to lower osmotic potential of germination media which leads to reduction of imbibition's of water by planting materials Khan and Weber (2008).

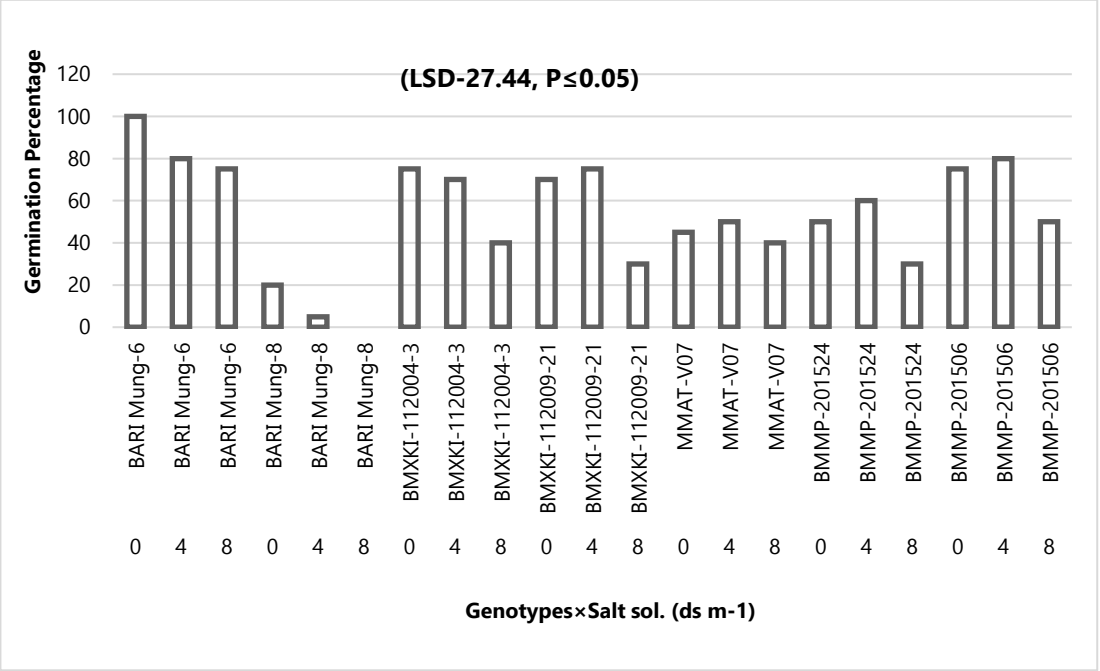

Fig. 3. Effect of different levels of salinity on selected mungbean genotypes in respect of germination percentage.

Mean germination time (MGT) showed significant variation for genotypes and salt concentrations (Figure 4). MGT was increased with the increase of salinity for all the genotypes except BARI Mung-6 and BARI Mung-8. In these two genotypes MGT decreased in 4 dSm^{-1} salt concentration but MGT again increased in 8 dSm^{-1}salt concentrations (Figure 4). The longest MGT was found by BARI Mung-8 in control dishes and in 8 dSm^{-1}salt concentration there were no germinated seeds at all and the lowest MGT was observed by BARI Mung-6 in 4 dSm^{-1}salt concentrations (Figure 4). Hapsari and Trustinah (2018) also indicated that the increasing of salinity level could reduce the speed of germination. These results were also accordance with Trustinah *et al*. (2016) and Sehrawat *et al*. (2014). The speed of germination or MGT is more important than the germination rate as MGT indicate the growing strength of seed vigor by Sadjad *et al*. (1999) and Sari *et al*. (2013).

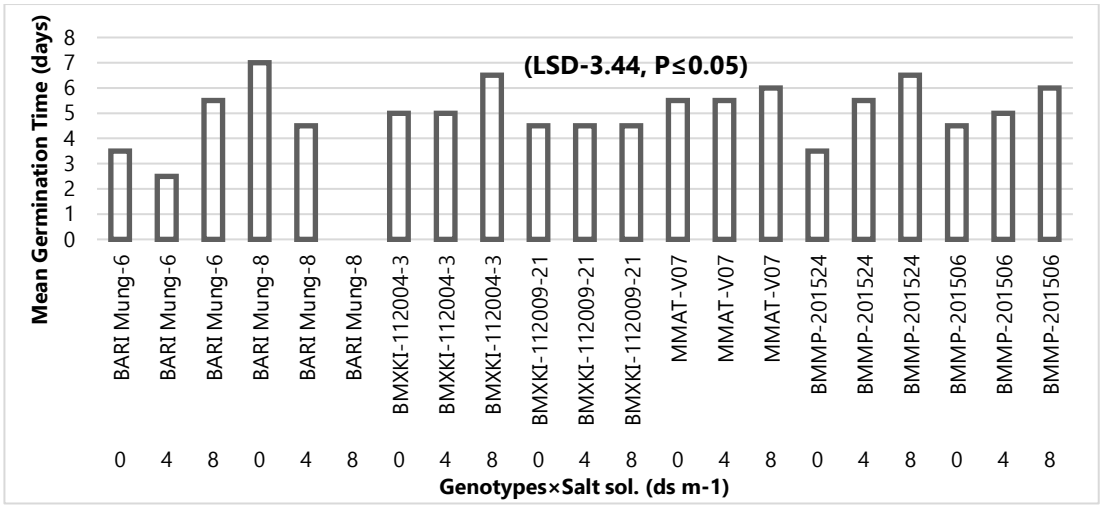

Fig. 4. Effect of different levels of salinity on selected mungbean genotypes in respect of mean germination time.

Vigor index (V_I) showed significant variations for genotypes and salt concentrations (Figure 5). Results revealed that V_I decreased with the increase of salinity for all the genotypes. The highest V_I was observed by BARI Mung-6 in 0 dSm^{-1} salt solutions and the lowest was found by BARI Mung-8 in 8 dSm^{-1} salt solutions (Figure 5). Similar trend was also reported by Hapsari and Trustinah (2018) and Sehrawat *et al*. (2014). This might be happened as salt stress may negatively affect morpho-physiological, biochemical and biometrics characters of mungbean Sunil *et al*. (2012).

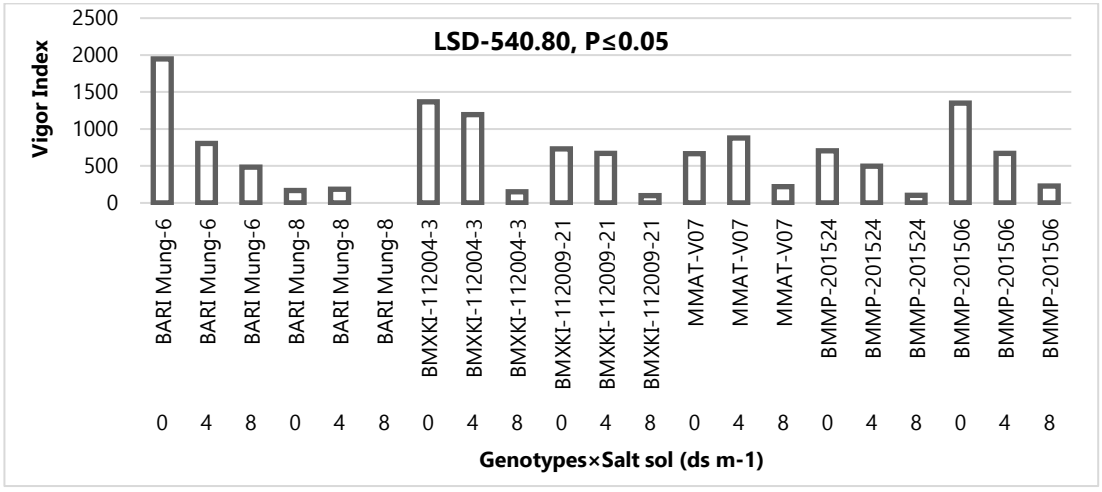

Fig. 5. Effect of different levels of salinity on selected mungbean genotypes in respect of vigor index.

Germination stress tolerance index (GSTI) showed significant variations for genotypes and NaCl salt concentrations (Table 1). The results showed that GSTI decreased with the increase of salinity for all the genotypes except MMAT-V07. The maximum GSTI was found by BMXKI-112004-3 in 4 dSm^{-1} which was followed by genotype MMAT-V07 in 8 dSm^{-1} and BARI Mung-6 in 4 dSm^{-1} (Table 1). The lowest GSTI was observed by BARI Mung-8 in both 4 and 8 dSm^{-1}.

Plant height stress index (PHSI) showed significant variations for genotypes and NaCl salt concentrations (Table 1). The results revealed that increase in salt concentration leads to decrease in PHSI. The highest PHSI was found by BMXKI-112009-21 in 4 dSm^{-1}salt concentrations and the lowest PHSI by BARI Mung-8 in 8 dSm^{-1} concentrations.

Root length stress index (RLSI) showed significant variations for genotypes and NaCl salt concentrations (Table 1). The results revealed that increase in salt concentration leads to decrease in RLSI except genotype BMMP-201524. The maximum RLSI was found by BMXKI-112009-21 in 4 dSm^{-1} salt concentrations followed by BMMP-201524 in 8 dSm^{-1} and the lowest RLSI by BARI Mung-8 in 8 dSm^{-1} concentrations.

Root dry weight stress index (RDSI) showed significant variations for genotypes and NaCl salt concentrations (Table 1). All the genotypes exhibit minimal RDSI in both the salt concentrations except BMXKI-112009-21 in 4 dSm^{-1}.

Root fresh weight stress index (RDSI) showed significant variations for genotypes and NaCl salt concentrations (Table 1). The highest RFSI was found by genotype BMMP-201506 in 4 dSm^{-1} concentrations and the lowest RFSI by BARI Mung-8 and BMMP-201524 in both the salt concentrations and in BMXKI-112004-3, BMXKI-112009-21, BMMP-201506 when salt concentration was 8 dSm^{-1}. Shoot dry weight stress index showed non-significant variations for genotypes and NaCl salt concentrations (Table 1).

Shoot fresh weight stress index (SFSI) showed significant variations for genotypes and NaCl salt concentrations (Table 1). The results revealed that increase in salt concentration leads to decrease in SFSI for all the genotypes. The highest SFSI was found by BMMP-201524 in 4 dSm^{-1} salt concentrations followed by MMAT-V07 in 4 dSm^{-1} salt stress and the lowest SFSI by BARI Mung-8 in 8 dSm^{-1} concentrations.

Table 1. Salt tolerance stress indices as influenced by genotypes and salt stresses

Genotypes	Salt sol. ($dS\ m^{-1}$)	GSTI	PHSI	RLSI	RDSI	RFSI	SDSI	SFSI
BARI Mung-6	4	115.00	52.90	49.76	0.0	51.31	50.00	66.69
BARI Mung-6	8	38.21	23.36	39.19	0.0	32.14	50.00	58.48
BARI Mung-8	4	0.00	20.00	17.44	0.0	0.00	0.00	25.00
BARI Mung-8	8	0.00	0.00	0.00	0.0	0.00	0.00	0.00
BMXKI-112004-3	4	126.00	59.76	44.22	0.0	49.99	50.00	87.8
BMXKI-112004-3	8	65.07	20.80	43.46	0.0	0.00	60.00	68.29
BMXKI-112009-21	4	78.57	80.13	71.84	50	77.50	65.91	93.36
BMXKI-112009-21	8	23.81	26.09	40.26	0.0	0.00	72.72	83.06
MMAT-V07	4	97.14	43.26	64.50	0.0	66.66	83.62	96.44
MMAT-V07	8	125.00	36.96	48.07	0.0	68.13	83.33	84.04
BMMP-201524	4	70.83	69.04	49.09	0.0	0.00	62.50	97.00
BMMP-201524	8	28.20	21.09	69.53	0.0	0.00	62.50	73.43
BMMP-201506	4	102.57	50.35	39.68	0.0	100.00	62.50	93.05
BMMP-201506	8	43.59	23.30	28.54	0.0	0.00	62.50	91.46
$LSD_{(0.05)}$		75.9	36.11	67.08	47.93	43.58	NS	40.82

GSTI= Germination Stress Tolerance Index, PHSI= plant height stress index, RLSI= Root length stress index, SFSI= Shoot fresh weight stress index, RFSI=Root fresh weight stress index, SDSI=Shoot dry weight stress index, RDSI=Root dry weight stress index, LSD= Least significance differences in 5% level of probability

Salt stresses significantly reduce the seedling shoot and root height and biomass as well. This might be happened for the reduction of the plant ability to uptake water as osmotic deficit or for inclusion of toxic ions in the transpiration streams by Munns (1993, 2005). Several studies also reported significant reduction in seed germination and seedling growth in different crops and a large genotypic variation in response to salt stresses by Farooq *et al*. (2015) and Parihar *et al*. (2015). In case of 4 dSm^{-1} salt stress in some genotypes several physiological indices showed their highest positive result in present study.

Hapsari and Trustinah (2018) also corroborates the same results. They reported that some tested genotypes showed better normal seedling dry weight compared to control. Dutta and Bera (2014) also reported the same results as root fresh weight and dry eight were increased under salinity.

Conclusion

The research work revealed significant differences among the mungbean genotypes in various salinity levels in germination and seedling stages. The germination percentage, germination index, co- efficient of germination, vigor index and different salt tolerant indices were decreased with the increase of salinity level and the mean germination time increased with the increase of salinity. In some genotypes salt stress tolerance indices were increased in $4dSm^{-1}$ after that it decreased in the onset of increasing salinity level. Mungbean var. BARI Mung-6, genotypes, MMAT- V07, BMXKI-112009-21 and BMMP-201524 were found to be more tolerant to salt stress than other genotypes. This variability of genotypes can be used later for breeding program and further study will be needed for assessing whether these genotypes are performing the same in their growth and development phases under NaCl salt stresses.

References

Abdul-Baki, A. and J.D. Anderson. 1973. Vigor determination of soybean seed by multiple criteria. Crop Sci. 3: 360– 633.

Almodares, A., M.R. Hadi and B. Dosti. 2007. Effects of Salt Stress on Germination Percentage and Seedling Growth in Sweet Sorghum Cultivars. J. Biol. Sci. 7: 1492–1495.

Almudaris, M.A. 1998. Notes on various parameters recording the speed of seed germination. Der Tropenlandwirt. 99: 147-154.

Ashraf, M. and J.C. Harris. 2004. Potential biochemical indicators of salinity tolerance in plants. Plant Sci. 166: 3–16. https://doi.org/10.1016/j.plantsci.2003.10.024.

BBS (Bangladesh Bureau of statistics). 2021. Statistical yearbook of Bangladesh. Bureau of statistics, statistics division, ministry of planning, Gov. of the people's republic of Bangladesh.

Dasgan, H.Y., H. Aktas, K. Abak, and I. Cakmar. 2002. Determination of screening techniques to salinity tolerance in tomatoes and investigation and investigation of genotypes response. Pl. Sci. 163: 695–703. https://doi.org/10.1016/S0168-9452(02)00091-2.

Dutta, P. and A.K. Bera. 2014. Effect of NaCl salinity on seed germination and seeling growth of mungbean cultivars. Agricultural research communicationcentre. Legume Res. 37(2): 161-164.

Farooq, M., M. Hussain, A. Wakeel and K.H.M. Siddique. 2015. Salt stress in maize: effects, resistance mechanisms and management – a review. Agron. Sust. Dev. 35: 461–481. https://doi.org/10.1007/s13593-015-0287-0.

Hapsari, R.T. and Trustinah. 2018. Salinity tolerance of Mungbean Genotypes at seedling stage. Biosaintifika. 10(2): 409-416.

Haque, M.A., D.E. Jharna, M.F. Hoque, M.N. Uddin and M.A. Saleque. 2008. Soil solution electrical conductivity and basic cations composition in the rhizosphere of lowland rice in coastal soils. Bangladesh J. Agric. Res. 33: 243–250.

Huq, S. and G. Rabbani. 2011. Climate change and Bangladesh: Policy and institutional development to reduce vulnerability. J. Bangladesh Stud. 13: 1–10.

Khan, M.A. and D.J. Weber. 2008. Ecophysiology of High Salinity Tolerant Plants. 1st ed. Springer, Amsterdam.

Khan, M.A. and Y. Rizvi. 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. https://doi.org/10.1139/b94-063.

Li, Y. 2008. Effect of salt stress on seed germination and seedling growth of three salinity plants. Pakistan J. Bio. Sci. 11: 1268–1272. https://doi.org/10.3923/pjbs.2008.1268.1272.

Moradi, D.P., F.S. Zadeh and M. Janmohammadi. 2008. Influence of priming technique on seed germination behavior of maize inbreed lines (*Zea mays L.*). J. Agri. Biol. Sci. 3: 22-25.

Munns, M. 2002. Comparative physiology of salt and water stress. Plant Cell Env. 25: 230-250.

Munns, R. 1993. Physiological processes limiting plant growth in saline soils: some dogmas and hypotheses. Plant Cell Environ. 16: 1524. https://doi.org/10.1111/j.1365-3040.1993.tb00840.x.

Munns, R. 2005. Genes and salt tolerance: bringing them together. New Phytologist, 167: 645–663. https://doi.org/10.1111/j.1469-8137.2005.01487.x.

Parihar, P., S. Singh, R. Singh, V.P. Singh and S.M. Prasad. 2015. Effect of salinity stress on plants and its tolerance strategies: a review. Env. Sci. Pollu. Res. Inst. 22: 4056–75. https://doi.org/10.1007/s11356-014-3739-1.

Sadjad, S., E. Murniati and S. Ilyas. 1999. Parameter Pegujian Vigor Benihdari Komparatifke Simulatif. Jakarta: Grasindo: p.21.

Sari, M., E. Widajati and P.R. Asih. 2013. Seed Coating Sebagai Pengganti Fungsi Polong pada Penyimpanan Benih Kacang Tanah. Jur. Agr. Indo. 41(3): 215-220.

Sehrawat, N., M. Yadav, K.V. Bhat, R.K. Sairam and P.K. Jaiwal. 2014. Evaluation of mungbean genotypes for salt tolerance at early seedling growth stage. Biocatalysis Agri. Biotech. 3(4): 108–113.

SRDI (Soil Resources Development Institute). 2010. Saline Soils of Bangladesh. SRDI, Ministry of Agriculture, Dhaka, Bangladesh.

Sunil, K.B., M. Prakash, N. Sathiya and J. Gokulakrishnan. 2012. Breeding for Salinity Tolerance in Mungbean. In: 2nd International Conference on Asia Agriculture and Animal (ICAAA 2012). APCBEE Procedia. 4: 30–35.

Syeed, S., N.A. Anjum, R. Nazar, N. Iqbal, A. Masood and N.A. Khan. 2011. Salicylic acid-mediated changes in photosynthesis, nutrients content and antioxidant metabolism in two mustard (*Brassica juncea L.*) cultivars differing in salt tolerance. Acta Physiol. Plant. 33: 877–886.

Taffouo, V.D., M. Kenne, T.R. Fokam, W.O. Fotsop, T. Fonkou, Z. Vondo and A. Amougou. 2004. Salt stress variation response in five leguminous plants, Agron. Afr. 16: 33 - 44.

Trustinah, R., R. Iswanto and T. Hapsari. 2016. Toleransigalur F3 kacanghijauterhadapcekamansalinitas. pp.489-497. Pros. Sem. Hasil Penelitian Tanaman Aneka Kacang dan Umbi 2015. Balitkabi, Malang.