International Journal of Agricultural Technology 2023 Vol. 19(5):2227-2236
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Genotypes sensitivity of eggplant (*Solanum melongena* L.) by sodium chloride

Sari, D. N.*, Togatorop, E. R. and Kinata, A.

Faculty of Agriculture, University of Ratu Samban, Arga Makmur, 38618, Indonesia.

Sari, D. N., Togatorop, E. R. and Kinata, A. (2023). Genotypes sensitivity of eggplant (*Solanum melongena* L.) by sodium chloride. International Journal of Agricultural Technology 19(5):2227-2236.

Abstract Results indicated that the LC_{50} for genotypes G1 (local variety), G2 (Hamas), G3 (F1 EPA 18174), G4 (F1 TM Spartan) was 6542.22 ppm, 2452.15 ppm, 2188.19 ppm, and 7019.65 ppm, respectively. The response of the four eggplant genotypes to salinity stress was a polynomial fit. The tolerance limit of eggplant to salinity stress was 6000 ppm. The genotype G4 (F1 TM Spartan) was the most salinity-tolerant genotype. There were no significant interaction effects between salt concentration and genotypes on plant height, number of leaves, leaf greenness, length of root, fresh weight, and dry weight. The salt concentration significantly affected the number of leaves and leaf greenness, but not plant height, length of root, fresh weight, and dry weight. The genotypes of eggplant significantly affected plant height, number of leaves, leaf greenness, fresh weight, and dry weight, but not the length of the root. In conclusion, the value LC_{50} for the genotype G1, G2, G3 and G4 was 6542.22, 2452.15, 2188.19, and 7019.65 ppm, respectively.

Keywords: Coastal agricultural lands, Lethal concentration, Salinity, Salt, Seedling

Introduction

Eggplant (*Solanum melongena* L.) is a very popular vegetable fruit in many countries due to its high nutritional contents. This crop contains antioxidants that able to scavenge and neutralise free radicals (Sharma and Kaushik, 2021). The vitamins, minerals, fiber, and secondary metabolites in eggplant are useful for metabolic processes in human body (Naeem and Ugur, 2019; Suzanna *et al*., 2019; Quamruzzaman *et al*., 2020). In addition, extract of eggplant peel has been reported to be able reducing gastric cancer cells (Seraj *et al*., 2017), while its petal extract is widely used as a supplement for patients with diabetes and heart disease (AL Nachar *et al*., 2017). Among the Indonesian people, eggplant has become one the most favorite vegetables which eventually bring about an increase consumer demands in the markets.

* **Corresponding Author**: Sari, D. N.; **Email:** dians2490@gmail.com

Such elevating demands needs constant supply of healthy eggplants from the production areas to the markets.

Effort to increase eggplant production is limited the the availability of fertile land due to the conversion of land into residential and industrial areas. It is estimated that every year there is about 47.000 ha of agricultural land is converted into non-agricultural activities (Nasution, 2006). Expanding the planting area by utilizing marginal land in the coastal area is therefore a promising solution to compensate the declining area of arable agricultural land. However, high salt content in coastal land is one of limitation for crop production, which further surpresses plant growth and development. According to Karolinoerita and Yusuf (2020), abiotic stress of salinity in coastal areas will continue to increase in dynamic global climate changes. It is clear that salinity stress interfered with plant growth and significantly reduced crop yields (Munns and Tester, 2008; Munns and Gilliham, 2015; Brenes *et al*., 2020a; Brenes *et al*., 2020b; Prakash and Singh, 2020; Sanwal *et al*., 2022).

The use of tolerant genotype to salinity stress is widely used to increase eggplant production grown in saline lands. Research on plant responses to salinity stress has been widely carried out in horticultural crops from the Solanaceae family, such as potatoes (Ahmed *et al*., 2020), tomatoes (Mart ńez *et al*., 2020), chili (Mustafa *et al*., 2019), cayenne pepper (Badi'ah *et al*., 2021), paprika (Giorio *et al*., 2020), and eggplant (Suliasih and Widiawati, 2016; Sobir *et al*., 2018). However, research to determine the tolerant genotypes of eggplant to salinity stress is still less investigated. The eggplant germplasms are very abundant in both commercial and local varieties. The study aimed to obtain the lethal concentrations and determine the interaction effects of genotypes and salt concentrations on growth of eggplants.

Materials and methods

The experiment was conducted from July to September 2022 at the Green House of Balai Pengkajian Teknologi Pertanian, Bengkulu. The experiment employed a randomized complete block design with two factors and three replications. The first factor was the genotypes of eggplant (G1= Local varieties, G2= Hamas, G3= F1EPA 18174, and G4= F1 TM Spartan). The second factor was the concentration of NaCl, which consisted of 4 treatment levels 0 ppm, 6000 ppm, 12000 ppm, and 18000 ppm. Each treatment unit consisted of six plants.

Prior to germination, the seeds were soaked in water for 24 hours. The media of germination in the tray used vermicompost. Seedlings were watered as necessary in the morning and affternoon. For five weeks old seedlings were transferred to the screening media (0 ppm, 6000 ppm, 12000 ppm, and 18000 ppm). The screening media used ABmix solution with each concentration of salt and water up to a volume of two liters. Each plastic box represents each treatment. The screening method used by modifying the Wick method.

Determining the LC_{50} value was carried out by calculating the percentage of plants lethal every day until the fourth day. The observations were on the growth components on the last day. The observed variables included the plant height (cm), number of leaves, leaf greenness, length of root (cm), fresh weight (g), and dry weight (g).

The effects of salt concentrations were determined with Curve Expert. Curve Expert is a statistical analysis program to find the best equation model for the percentage of lethal from a population (Sari *et al*., 2017). The data were analyzed statistically by analysis of variance using SAS ($P \geq 0.05$). Means of treatments were compared using Duncan's Multiple Range Test at $P \geq 0.05$.

Results

Lethal concentration

The result showed that all genotypes (G1= Local varieties), G2= Hamas, G3= F1 EPA 18174, and G4 = F1 TM Spartan) had the same mathematics model that fit to polynomials (Table 1). The value LC_{50} for the genotype G1 (Local variety) was 6542.22 ppm. The value LC_{50} for the genotype G2 (Hamas) was 2452.15 ppm. The value LC_{50} for the genotype G3 (F1 EPA 18174) was 2188.19 ppm. The value LC_{50} for the genotype G4 (F1 TM Spartan) was 7019.65 ppm.

Table 1. The model of mathematics and value of LC_{50} on G1 (Local varieties), G2 (Hamas), G3 (F1 EPA 18174), and G4 (F1 TM Spartan) by salt concentration

Genotypes	Model	Lethal Concentration 50% (ppm)
G1= Local varieties	$y = ax^3 + bx^2 + cx + d$	6542.22
G2= Hamas	$y = ax^3 + bx^2 + cx + d$	2452.15
G3= F1 EPA 18174	$y = ax^3 + bx^2 + cx + d$	2188.19
G4= F1 TM Spartan	$y = ax^3 + bx^2 + cx + d$	7019.65

The effect of different salt concentrations on the percentage of lethal on genotypes G1 (Local varieties), G2 (Hamas), G3 (F1 EPA 18174), and G4 (F1 TM Spartan) had a significant correlation (R2=1) with the polynomial fit

(Figures 1, 2, 3, and 4). Each genotype has functional equations (G1, G2, G3, and G4) are $y = -5E\text{-}11x^3 + 1E\text{-}06x^2 + 0.0028x - 3E\text{-}13$, $y = 5E\text{-}11x^3 - 2E\text{-}06x^2 + 0.025x - 1E\text{-}13$, $y = 6E\text{-}11x^3 - 2E\text{-}06x^2 + 0.0278x + 2E\text{-}13$, and $y = -6E\text{-}11x^3 + 1E\text{-}06x^2 - 4E\text{-}16x - 1E\text{-}13$. G1 and G3 have almost the same level of sensitivity, as well as between G1 and G4. All plants in all genotypes died at salt concentrations of 12000 ppm and 18000 ppm. The concentration of 6000 ppm showed some plants still survive.

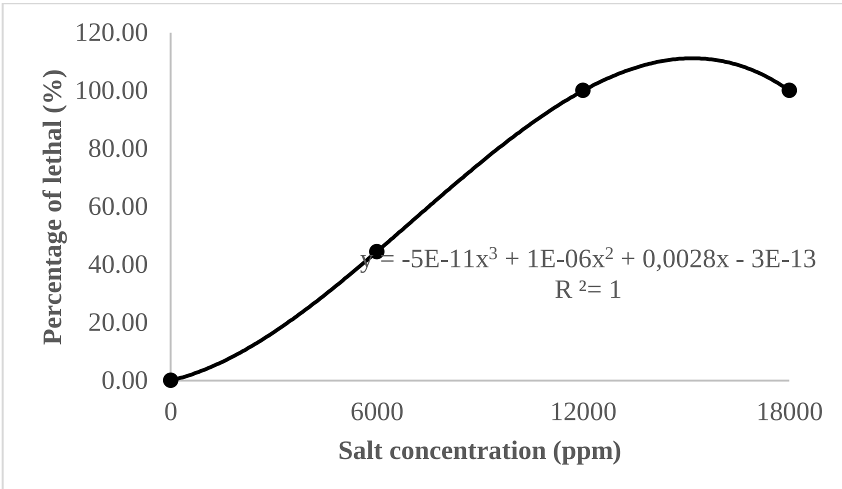

Figure 1. Relationship between salt concentration and percentage of lethal on G1 (local varieties)

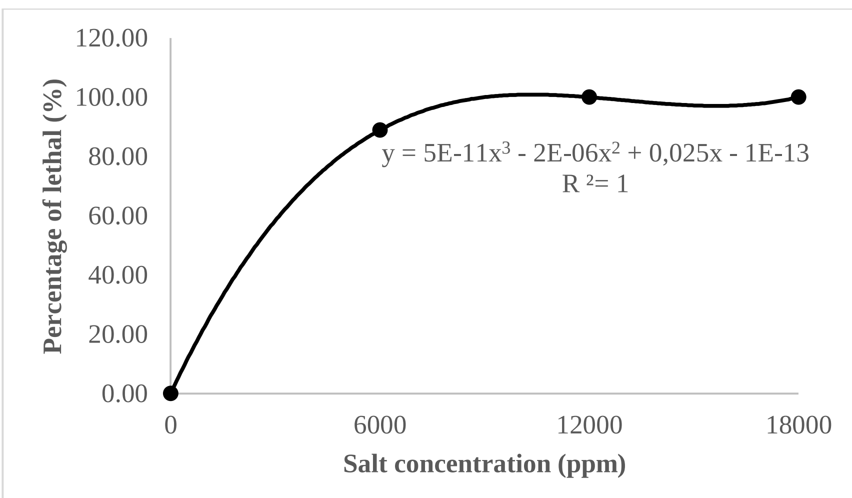

Figure 2. Relationship between salt concentration and percentage of lethal on G2 (Hamas)

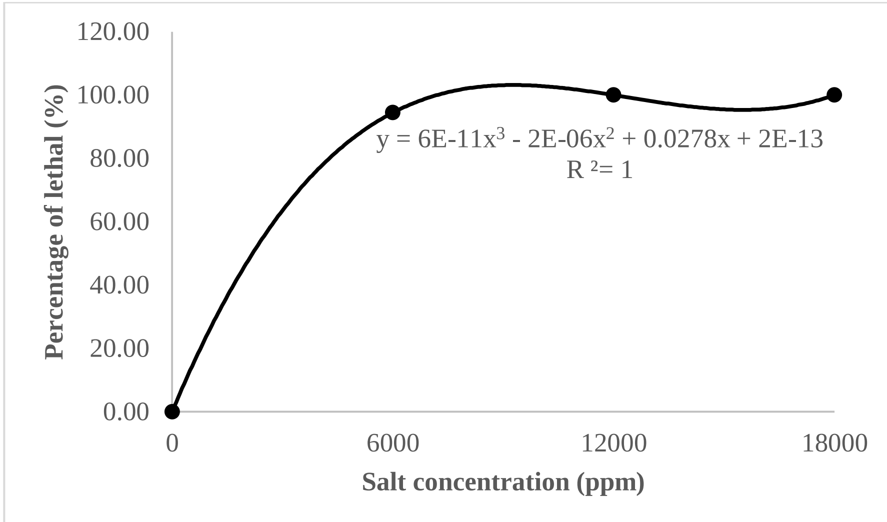

Figure 3. Relationship between salt concentration and percentage of lethal on G3 (F1 EPA 18174)

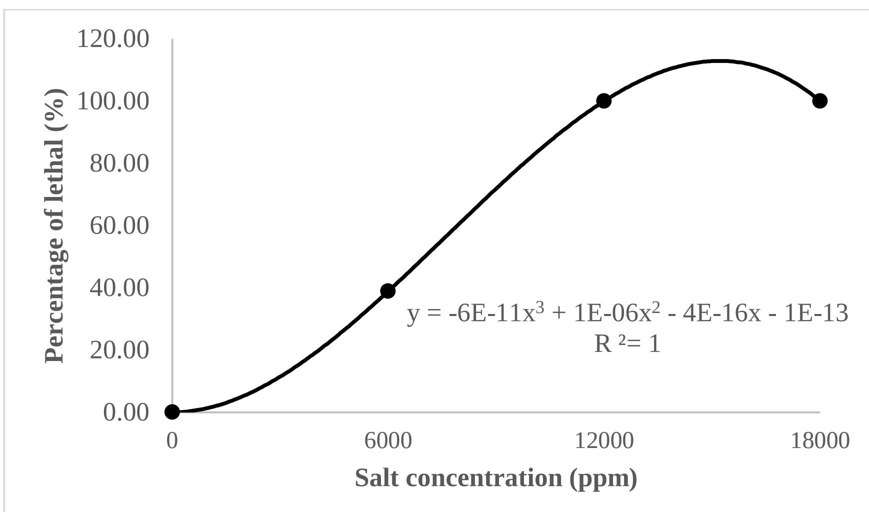

Figure 4. Relationship between salt concentration and percentage of lethal on G4 (F1 TM Spartan)

Interaction between salt concentrations and genotypes

There were no significant interaction effects between salt concentration and genotypes on plant height, number of leaves, leaf greenness, length of root, fresh weight, and dry weight. However, salt concentrations and genotypes independently significantly affect almost all observed variables.

Effect of salt concentration

The use of salt concentration significantly affected on number of leaves (P≥F=0.0005) and leaf greenness (P≥F=0.0063), but not plant height (P≥F=0.7196), length of root (P≥F=0.2872), fresh weight (P≥F=0.5355), and dry weight (P≥F=0.5764). The concentration of 6000 ppm is the tolerance limit of eggplant to salinity stress. The use of salt concentration decreased the number of leaves and leaf greenness (Table 2).

Table 2. Effect of salt concentration on plant height, number of leaves, leaf greenness, length of root, fresh weight, and dry weight

Salt concentration	Plant height (cm)	Number of leaves	Leaf greenness	Length of root (cm)	Fresh weight (g)	Dry weight (g)
P0= 0 ppm	5.26	3.86[a]	28.58[a]	6.15	0.63	0.08
P1= 6000 ppm	5.36	2.85[b]	19.65[b]	5.38	0.56	0.07

Means in the same column followed with the same letter are not significantly different according to Duncan's Multiple Range Test at 5%

Effect of genotypes

The use of genotypes significantly affected plant height (P≥F=0.00001), number of leaves (P≥F=0.0397), leaf greenness (P≥F=0.0447), fresh weight (P≥F=0.0005), and dry weight (P≥F=0.0029), but not length of root (P≥F=0.0312) (Table 3).

Table 3. Effect of genotypes on plant height, number of leaves, leaf greenness, length of root, fresh weight, and dry weight

Genotypes	Plant height (cm)	Number of leaves	Leaf greenness	Length of root (cm)	Fresh weight (g)	Dry weight (g)
G1= Local varieties	3.58[c]	3.88[a]	21.27[b]	5.08	0.35[b]	0.03[b]
G2= Hamas	4.82[b]	2.84[b]	19.41[b]	5.38	0.47[b]	0.05[b]
G3= F1 EPA 18174	5.12[b]	3.39[ab]	24.56[ab]	6.69	0.70[ab]	0.10[a]
G4= F1 TM Spartan	7.71[a]	3.30[ab]	31.21[a]	5.90	0.86[a]	0.11[a]

Means in the same column followed with the same letter are not significantly different according to Duncan's Multiple Range Test at 5%

The different varieties can provide different growth patterns indicated by higher plant height, number of leaves, leaf greenness, fresh weight, and dry weight on genotype G4 (F1 TM Spartan). The length of the root tended as well as for all genotypes.

Discussion

Plant responses to salinity stress indicated that the higher salt concentration, the higher the percentage of lethal eggplant plant would be. The results showed that eggplant survived at a salt concentration of 6000 ppm, but higher concentrations caused the lethal of eggplant. Tester and Devenport (2003); Munns and Tester (2008); Akinci *et al*. (2014); Sumera *et al*. (2015); Prakash and Singh (2020) reported that salinity interfered with the absorption of nutrient ions, disrupting nutrient water absorption system in plants. Since water was the main material needed by plants to carry out metabolic processes, the hampering of water absorption and transport bring about disruptions of cell division which eventually resulted in plant's lethal (Sobir *et al*., 2018; Brenes *et al*., 2020a; Brenes *et al*., 2020b; Pratiwi *et al*., 2021).

Results also indicated that each genotype had a different level of sensitivity to salinity stress. The G2 (Hamas) and G3 (F1 EPA 18174) genotypes were more sensitive than the G1 (Local varieties) and G4 (F1 TM Spartan) genotypes. This was in line with Prayoga *et al*. (2018) who concluded that plant responses to salinity stress is different in each genotype. Aini *et al*. (2012) also reported that the tolerance of plants to salinity stress is different for each variety. According to Kangarasu *et al*. (2014), Yunus *et al*. (2019), and Yunita *et al*. (2020) the sensitivity level of a plant to salinity stress is determined by using the LC_{50} value. Mangaiyarkarasi *et al*. (2014) and Suharjo (2018) stated that the LC_{50} value was a basic calculation to determine the concentration that causes 50% of the plant population to be lethal.

The salt concentration of 6000 ppm decreased the number of leaves and leaf greenness. The result indicated that plants that experience salt toxicity cause inhibition of the water absorption process, thus affecting turgor cells. Salinity also adversely affects the photosynthesis process, thus reducing plant growth. Garfansa and Sukma (2021) reported that salinity stress reduced the leaf length, number of leaves, and leaf chlorophyll index in maize. Nevertheless, salt concentration of 6000 ppm tended to reduce the growth of the length of root, fresh weight, and dry weight of eggplants. A similar result was reported by Kusumiyati *et al.* (2017) that the salt concentration of 7 g L^{-1} reduced the length of root and number of roots of asparagus plants. Decrease in growth components implied that plant was identified that plants experienced salt toxicity. Purwaningrahayu and Taupiq (2017) reported that increasing salinity was increased salt toxicity in all soybean genotypes, which decreased stem height, leaf chlorophyll index, and seed size. Mensah *et al*. (2020) reported that increasing salt concentration reduce all growth components of tomato plants. Saleh (2017) reported that salinity stress reduced the growth of shallots, and salinity can reduce seedling height, root length, and plant dry weight.

The G4 (F1 TM Spartan) had the highest plant height, number of leaves, greenness, fresh weight, and dry weight of plants. It appeared that the G4 (F1 TM Spartan) was more tolerant than other genotypes and more resistant to high salinity conditions. Plants tolerant to salinity stress will increase the content of dextrose or total sugar to protect plants. This content will block toxic organic and inorganic components such as leucine, isoleucine, NH3, tyrosine, methionine, phenyl, and alanine (Hashem *et al*., 2016; Zhao *et al*., 2020). Perri *et al*. (2018) and Perri *et al*. (2019) reported that plants tolerant to high salinity have an adaptive ability called osmoregulation. The osmoregulation was synthesizing and accumulating organic compounds that can reduce cell osmotic potential and increase turgor pressure.

In conclusion, the value LC_{50} for the genotype G1 (Local variety), G2 (Hamas), G3 (F1 EPA 18174) and G4 (F1 TM Spartan) was 6542.22 ppm, 2452.15 ppm, 2188.19 ppm, and 7019.65 ppm, respectively. The average LC_{50} value of the four genotypes was 4550.55 ppm. The response of the four eggplant genotypes to salinity stress was a polynomial fit. The concentration of 6000 ppm showed some plants still survive. The genotype G4 (F1 TM Spartan) was the most salinity-tolerant genotype of eggplants.

Acknowledgements

Sincerely thank to Kementerian Pendidikan, Kebudayaan, Riset, dan Teknology for providing financial supports to this project through 2022 Competitive National Research Scheme (Grant Number 154/E5/PG.02.00.PT/202 2, 1417/LL2/PG/2022, 52/VII.a-3/VI/2022). Appreciation and thanks also go to Prof. Ir. Fahrurrozi, M.Sc., Ph.D., for helping in correcting this manuscript.

References

Ahmed, H. A. A., Sahin, N. K., Akdogan, G., Yaman, C., Kom, D. and Uranbey, S. (2020). Variability in salinity stress tolerance of potato (*Solanum tuberosum* L.) varieties using in vitro screening. Ciencia e Agrotecnologia, 44:1-14.

Aini, N., Mapfumo, E., Rengel, Z. and Tang, C. (2012). Ecophysiological responses of Melaleuca species to dual stresses of water logging and salinity. International Journal of Plant Physiology and Biochemistry, 4:52-58.

Akinci, I. E., Akinci, S. Yilmaz, K. and Dikici, H. (2014). Reponse of eggplant varieties (*Solanum melongena*) to salinity in germination and seedling stages. New Zealand Journal of Crop and Horticultural Science, 32:193-200.

AL Nachar, K., Hasian, J. and Al Khatib, R. (2019). Investigation and measurement of some mineral and vitamins in eggplant fruit calyx, and the possibility of being used as food supplements and alternative medicine. Journal of Food and Nutrition, 5:1-10.

Badi'ah, B. A., Sobir., Syukur, M. and Kusumo, Y. W. E. (2021). Respon morfo-fisiologi empat genotipe cabai rawit (*Capsicum frutescens* L.) terhadap cekaman salinitas. Jurnal Agronomi Indonesia, 49:184-191.

Brenes, M., Perez, J., Gonzales-Orenga, S., Solana, A., Boscaiu, M., Prohens, J., Plazas, M., Fita, A. and Vicente, O. (2020a). Comparative studies on the physiological and biochemical responses to salt stress of eggplant (*Solanum melongena* L.) and its rootstock *S. torvum*. Agriculture, 10:1-20.

Brenes, M., Perez, J., Gonzales-Orenga, S., Solana, A., Boscaiu, M., Prohens, J., Plazas, M., Fita, A. and Vicente, O. (2020b). Physiological and biochemical responses to salt stress in cultivated eggplant (*Solanum melongena* L.) and in *S. insanum* L., a close wild relative. Agronomy, 10:1-19.

Garfansa, M. P. and Sukma, K. P. W. (2021). Translokasi asimilat tanaman jagung (Zea mays L.) hasil persilangan varietas Elos dan Sukmaraga pada cekaman garam. Jurnal Agroekoteknologi, 14:61-65.

Giorio, P., Cirillo, V., Caramante, M., Oliva, M., Guida, G., Venezia, A., Grillo, S., Maggio, A. and Albrizio, R. (2020). Physiological basis of salt stress tolerance in a landrace and a commercial variety of sweet pepper (*Capsicum annuum* L.). Plants, 9:1-13.

Hashem, A., Abd_Allah, E. F., Alqarawi, AA A., Al-Huqail, A. A. and Shah, M. A. (2016). Induction of osmoregulation and modulation of salt stress in *Acacia gerrardii* Benth. by Arbuscular Mycorrhizal fungi and *Bacillus subtilis* (BERA 71). BioMed Research International, 1-11.

Kangarasu, S., Ganesheam, S. and Joel, A. J. (2014). Determination of lethal dose for gamma rays and ethyl methane sulfonate induced mutagenesis in cassava (*Manihot esculenta* Crantz.). International Journal of Science and Research, 3:3-6.

Karolinoerita, V. and Yusuf, W. A. (2020). Salinitas lahan dan permasalahannya di Indonesia. Jurnal Sumberdaya Lahan, 14:91-99.

Kusumiyati., Onggo, T. M. and Habibah, F. A. (2017). Pengaruh konsentrasi garam NaCl terhadap pertumbuhan dan kualitas bibit lima kultivar asparagus. Jurnal Hortikultura, 27:79-86.

Mangaiyarkarasi, R., Girija, M. and Gnanamurthy, S. (2014). Mutagenic effectiveness and efficiency of gamma rays and ethyl methane sulphonate in *Catharanthus roseus*. International Journal of Current Microbiology and Applied Sciences, 3:881-889

Mart ńez, J. P., Fuentes, R., Far ás, K., Lizana, C., Alfaro, J. F. Fuentes, L., Calabrese, N., Bigot, S., Quinet, M. and Lutts, S. (2020). Effects of salt stress on fruit antioxidant capacity of wild (*Solanum chilense*) and domesticated (*Solanum lycopersicum* var. cerasiforme) tomatoes. Agronomy 10:1481.

Mustafa, M., Syahri, Y. F. and Rauf, M. (2019). Selection of chilli pepper (*Capsicum frutescens* L.) for salinity tolerance in seed germination. Agrotech Journal, 4:83-90.

Mensah, S. I., Ekeke, C. and Udom, M. (2020). Effect of salinity on the growth characteristics of *Solanum aethiopicum* L. (Solanaceae). Asian Research Journal of Agriculture, 12:17-22.

Munns, R. and Tester, M. (2008). Mechanisms of salinity tolerance. The Annual Review of Plant Biology, 59:651-681.

Munns, R. and Gilliham, M. (2015). Salinity tolerance of crops – what is the cost?. New phytologist, 208:668-673.

Naeem, M. Y. and Ugur, S. (2019). Nutritional content and health benefits of eggplant. Turkish Journal of Agriculture - Food Science and Technology, 7:31-36.

Nasution, M. (2006). Diversifikasi titik kritis pembangunan pertanian Indonesia pertanian mandiri. Penebar Swadaya, Jakarta.

Perri, S., Entekhabi, D. and Molini, A. (2018). Plant osmoregulation as an emergent water-saving adaption. Water Resources Research, 54:2781-2798.

Perri, S., Katul, G. G. and Molini, A. (2019). Xylem-phloem hydraulic coupling explains multiple osmoregulatory responses to salt stress. New Phytologist, 224:644-662.

Prakash, V. and Singh, S. (2020). Potential of biochar application to mitigate salinity stress in eggplant. HortScience, 55:1946-1955.

Pratiwi, A., Krisjayanti, E. W. and Utami, I. (2021). Respon pertumbuhan tomat cherry (*Solanum lycopersicum* var. cerasiforme) terhadap konsentrasi salinitas NaCl. Jurnal Ilmiah Biologi, 9:494-503.

Prayoga, G. I., Mustikarini, E. D. and Wandra, N. (2018). Seleksi kacang tanah (*Arachis hypogea* L.) lokal Bangka toleran cekaman salinitas. Jurnal Agro, 5:103-113.

Purwaningrahayu, R. D. and Taupiq, A. (2017). Respon morfologi empat genotip kedelai terhadap cekaman salinitas. Jurnal Biologi Indonesia 13:175-188.

Quamruzzaman, A. K. M., Khatun, A. and Islam, F. (2020). Nutritional content and health benefits of Bangladeshi eggplant cultivars. European Journal of Agriculture and Food Sciences, 2:1-7.

Saleh, I. (2017). Uji viabilitas bibit bawang merah pada cekaman salinitas. Logika, 21:6-10.

Sanwal, S. K., Mann, A., Kumar, A., Kesh, H., Kaur, G., Rai, A. K., Kumar, R., Sharma, P. C., Kumar, A., Nahadur, A., Singh, B. and Kumar, P. (2022). Salt tolerant eggplant rootstocks modulate sodium partitioning in tomato scion and improve performance under saline conditions. Agriculture, 12:1-15.

Sari, D. N., Aisyah, I. A. and Damanik, M. R. M. (2017). Sensitivitas dan keragaan tanaman coleus sp. terhadap mutasi induksi kimia menggunakan *ethyl methane sulfonate* (ems) dengan cara aplikasi rendam dan tetes. Jurnal Agronomi Indonesia, 45:56-63.

Seraj, H., Afsham F., Hashemi, Z. S., Timajchi, M., Olamafar, E. and Ghotbi, L. (2017). Effect of eggplant skin in the process of apoptosis in cancer cells. STEM Fellowship Journal, 3:7-14.

Sharma, M. and Kaushik, P. (2021). Biochemical composition of eggplant fruits: a review. Applied Sciences, 11:1-13.

Sobir., Miftahudin. and Helmi, S. (2018). Respon morfologi dan fisiologi genotipe terung (Solanum melongena L.) terhadap cekaman salinitas. Jurnal Hortikultura Indonesia, 9:131-138.

Suharjo, U. K. J., Nababan S. Y., Masdar., Pamekas, T. and Mukthasar. (2018). Responses of six tomato (*Lycopersicon esculentum* Mill.) genotypes to salinity stress at low altitudes of Bengkulu, Indonesia. Akta Agrosia, 21:19-24.

Sumera., Abid, M., Saeed, R. and Ahmed, T. (2015). Effect of salinity and root-knot nematode on growth of eggplant (*Solanum melongena* L.). Fuuast Journal of Biology, 5:93-97.

Suliasih, S. and Widawati. (2016). Pengaruh salinitas dan inokulan bakteri terhadap pertumbuhan tanaman terung (*Solanum melongena* L.). Berita Biologi, 15:17-25.

Suzanna, A., Wijaya, M. and Fadilah, R. (2019). Analisis kandungan kimia buah terong belanda (*Cyphomandra betacea*) setelah diolah menjadi minuman ringan. Jurnal Pendidikan Teknologi Pertanian, 5:S21-S36.

Tester, M. and Davenport. R. (2003). Na^+ tolerant and Na^+ transport in higher plants. Annals of Botany, 91:503-527.

Yunita, R., Dewi, I. S., Lestar, E. G. and Mastur. (2020). Development of rice mutant tolerance to salinity through combination of gamma rays irradiation and *in-vitro* selection. The 3rd International Conference on Biosciences, Atlanta, GA, US, 457 p.

Yunus, K., Jaafar, A. M. and John, A. (2019). Acute-lethal toxicity (LC_{50}) effect of Terminalia catappa Linn. leaves extract on Oreochromis niloticus (red Nile tilapia) juveniles under static toxicity exposure. Oriental Journal of Chemistry, 35:270-274.

Zhao, C., Zhang, H., Song, C., Zhu, J. K. and Shabala, S. (2020). Mechanisms of plant responses and adaptation to soil salinity. The Innovation, 1:1-41.

(Received: 12 September 2022, Revised: 15 July 2023, Accepted: 17 August 2023)