D-5912
[1-9]

RESEARCH ARTICLE | Agricultural Science Digest, Volume Issue : ()

Mitigation of Salinity Combined with Vermicompost on Growth, Antioxidant Enzymes and Macro Nutritional Changes in *Solanum melongena* L.

Sarah Thimothy[1], Debasish Dikshit[1], A. Venkatesan[1]

10.18805/ag.D-5912

ABSTRACT

Background: The main abiotic stress affecting crop production and productivity is due to the salinity stress, which has a very serious adverse effectiveness on plant development and production. At higher concentrations, salt stress provokes the accumulation of reactive oxygen species ROS, which are toxic to cells.

Methods: The goal of the current study was to determine how different sodium chloride (NaCl) concentrations affected Solanum melongena growth, antioxidant enzymes and macronutrients through the use of vermicompost. Vermicompost (VC) (%) (0, 10, 25, 50, 10 mM+5%, 25 mM+10%, 50 mM+25% and 100% VC) was used in the germination investigation and the data were evaluated 30- and 60-days following germination.

Result: In 50 mM of NaCl plus 25% VC, the greatest increases in the length of the shoot, length of roots, both dry and fresh weight and leaf area were noted. On both days, the maximum enzyme activity was observed at 50 mM NaCl + 25% VC. The use of vermicompost in NaCl stress enhanced the nutritional contents up to 50 mM + 25% VC, while the accumulation of macronutrient content increased at an extreme level of 100% VC.

Key words: Antioxidant enzymes, Macro nutrients, Salinity, *Solanum melongena*, Vermicompost.

INTRODUCTION

The herbaceous vegetable aubergine (*Solanum melongena*), Solanaceae family, is highly produced in both subtropical and tropical areas for its palatable fruits. The fifth most commercially significant species of Solanaceous crop after potatoes, tomatoes, pepper and tobacco are aubergine according to (Tasher *et al*., 2017). In the nation, aubergine is frequently grown on recently reclaimed ground. However, the majority of these recently reclaimed soils are salinized, have low fertility and have a poor soil structure, which inhibits plant growth and development and causes low yield. The growth of sustainable agriculture has received a lot of attention recently. Some methods, such as soil amendments, have been employed to reduce the effectiveness of salt (Bacilio *et al*., 2004).

Salinization affects almost 1/3rd of the 260 million hectares of land under irrigation that are used for 40% of the world's food output (United Nations, 2011). Countries like Australia, Egypt, India, Pakistan and the United States are dealing with severe salt and drainage issues that affect anywhere between 15 and 36% of their irrigated areas. According to Yassin *et al.* (2019), A major ecological factors impacting plant growth and production is soil salinity. According to numerous research salt resistant crops have higher oxidative stress resistance of antioxidant enzyme activity, which is significantly connected with salinity stress in plants (Pakar *et al*., 2016). According to research, plants that are more capable of producing antioxidants than other plants can thrive in saline conditions (Alhasnawi *et al*., 2014).

[1]Department of Botany, Annamalai University, Annamalainagar-608 002, Tamil Nadu, India.

Corresponding Author: A. Venkatesan, Department of Botany, Annamalai University, Annamalainagar-608 002, Tamil Nadu, India. Email: drvenkatesans@gmail.com

How to cite this article: Thimothy, S., Dikshit, D. and Venkatesan, A. (2024). Mitigation of Salinity Combined with Vermicompost on Growth, Antioxidant Enzymes and Macro Nutritional Changes in *Solanum melongena* L. Agricultural Science Digest. doi: 10.18805/ag.D-5912.

Submitted: 07-11-2023 **Accepted:** 13-02-2024 **Online:** 18-03-2024

Chemical fertilizer use in agricultural areas has led to environmental issues such water resource contamination, a decline in the quality of agricultural output and a decrease in soil fertility (Chaulagain *et al*., 2017). Vermicompost is also recognized as an organic fertilizer that is safe for the environment. Vermicompost fertilizers are typically recommended by industry professionals as sources for soil enhancement and concurrently for the production of healthy crops (Belliturk, 2016). According to Belliturk *et al.* (2015), Vermicomposting is a natural fertilizer that can prevent a number of plant diseases and increase crop productivity, quality and soil humus content. By introducing a variety of advantageous bacteria into the soil, the vermicompost was like soil conditioner, plant development medium and to improve soil microbial biodiversity (Broz *et al*., 2016).

The use of vermicompost in sustainable agriculture, according to Koozehgar Kaleji and Ardakani (2017), boosts the population and activity of earth-friendly microbes like the mycorrhizal fungus and Solubilizing phosphate microbes as well as the nutrients that plants need, such as N, P and K, which in turn optimizes crop yield and growth.

The interaction of vermicompost with Synthetic ammonia, urea, ammonium nitrate (NH_4 NO_3) and nitric acid (HNO_3) has been shown to be statistically significant for plant height at 1% and increased aubergine fruit yields by 5% in a study on aubergine grown from different dosages conducted in Iran. However, the effect on fruit length has been found to be not significant at all by (Moraditochaee *et al*., 2011). According to a different study (Gandhi and Sundari, 2012), vermicompost's biochemical characteristics significantly influence proper development of aubergine. According to the findings of a study conducted by Adilolu *et al.* (2015), substantial gains were seen in the yield, wet weight, diameter of plant, number of leaves on the plant, leaf length and width when vermicompost was applied in increasing doses to cucumber plants. Significant alterations were also found in the plant's macronutrient components such nitrogen, phosphorus, potassium, calcium and magnesium. A different study on the effects of various amounts of vermicompost (0-, 5- and 10-tons ha^{-1}) on both the qualitative and quantitative features of *Matricaria chemmomilla* found that 10 tonnes ha^{-1} vermicompost were sufficient to achieve the maximum height, fresh mass and dry weight of the plants (Seyyed Hadi *et al*., 2013).

MATERIALS AND METHODS

Morphological studies

On the thirtieth day, five seedlings were meticulously taken out of each plastic tray and given a water bath in order to examine the morphological characteristics. A scale was used to measure the length of the root and shoot. Measurements of the length, width and number of leaves were used to determine the total leaf area, which was then multiplied by the correlation factor (0.66) obtained using Yoshida *et al*. (1972) technique.

Fresh weight

The seedlings were taken out of the plastic trays and given a good cleaning. The stem and root components of the leaf were removed and weighed in order to estimate the fresh weight of the leaf.

Dry weight

Seedlings were removed from plastic containers and cleaned thoroughly. They spent all day at 80°C in the hot oven after being split up into roots and shoots. Using an electrical balance with a single pan, the drying weight of the plants was determined.

Biochemical studies

The root and shoots of *Solanum melongena* were separated at 30 and 60 days and used for the analysis of the antioxidant enzyme using the following methods. The protocol outlined by Chandlee and Scandalios (1984) was followed in order to estimate the catalase activity. The Reddy *et al*. (1985) protocol was followed when performing the peroxidase activity. Superoxide dismutase activity was carried out by Giannopolitis (1977) technique. The method outlined by Asada and Takahashi (1987), was followed in order to estimate the ascorbate peroxidase activity. Complete randomized block design was used to statistically analyses the data (ANOVA one-way method).

Estimation of macronutrients

The estimation of total nitrogen was carried out by Jackson, 1958 quoted by (Yoshida *et al*., 1972). The phosphorus content was estimated according to Black, 1965 quoted by (Yoshida *et al*., 1972). The total Potassium was present estimated by Williams and Twine (1960).

RESULTS AND DISSCUSSION

Length of seedlings

The findings demonstrated that Table 1 displays the length of seedlings of S*olanum melongena* cultivated under varied salt concentrations in conjunction with vermicompost. Up to 50 mM NaCl, the length of the seedling steadily reduced and when vermicompost was added, the length of the shoots and roots gradually grew. Optimum level of shoot length and root length were measured in 50mM NaCl + 25% vermicompost on 30^{th} and 60^{th} days *i.e*., 19.8 cm $plant^{-1}$, 5.1 cm $plant^{-1}$ and 30.9 cm $plant^{-1}$, 7.9 cm $plant^{-1}$ respectively when compared to control. According to Hussain *et al*. (2017), the shoot length was presumably raised as a result of the function of biochar and vermicompost in raising minerals, particularly the Potassium availability, which promotes root development and absorption of nutrients.

Fresh and dry weight

Fig 1 displays the findings about the impact of salinity and vermicompost on the fresh weight of seedlings. With increasing NaCl content, the seedling's fresh weight steadily dropped and with vermicompost added, it gradually grew. Maximum increasing in fresh weight of shoot and root in 50mM + 25% Vermicompost on 30^{th} (14.98±0.99 g $plant^{-1}$ and 6.01±0.67 g $plant^{-1}$) and 60^{th} (20.23±0.79 g $plant^{-1}$ and 8.63±0.41 g $plant^{-1}$) days at the treatment when compared to control. The 100% vermicompost the fresh weight was moderately higher when compared to control. The results on the effect of salt stress in addition with vermicompost gradually decreased dry weight upto 50 mM NaCl and gradually increased in addition with vermicompost. Maximum increased in dry weight of shoot and root in 50 mM + 25% Vermicompost 30^{th} (3.01±0.29 g $plant^{-1}$ and 1.21±0.14 g $plant^{-1}$) and 60^{th} (6.98±0.22 g $plant^{-1}$ and 2.19±0.15 g $plant^{-1}$) days at the treatment when compared to control. The 100% vermicompost the dry weight was moderately higher when compared to control Fig 2. Numerous studies have shown that vermicompost improves morphological characteristics such as vigour index, leaf area, stem and root length, fresh and dry weight of root shoots and dry weight per plant, as well as salinity tolerance. *i.e Solanum melongena* (Gnanamani *et al*., 2024) *Silybum marianum* L. (Ebrahimi *et al*., 2019); *Cotinus coggygria* Scop. (Banadkooki, 2019); *Dracocephalum moldavica* L. (Gohari *et al*., 2019).

Leaf area

Table 1 displays the data about the efficacy of applying vermicompost to the leaf area of Solanum melongena. When concentration increased up to 50 mM NaCl, the leaf area decreased; when vermicompost was added, the leaf area steadily increased. Maximum increase in the leaf area was recorded 30th (48.48±1.19 cm^2 plant^{-1}) and 60th (75.76±2.17 cm^2 plant^{-1}) days when compared to control. The 100% vermicompost the dry weight was moderately higher when compared to control and it was observed in 43.19±0.95 cm^2 Plant^{-1} and 68.98±1.7 cm^2 plant^{-1} respectively on 30th and 60th days. Furthermore, it has been commonly reported that the application of vermicompost and biochar has increased plant area of leaf, number of leaf, length of root and biomass from both shoots and roots (Alvarez *et al*., 2017). In Medicago plant NaCl with application of vermicompost increases the leaf area (Akhzari *et al*., 2016).

Enzyme activities

Catalase

The catalase activity resulted in a decrease with increasing salinity up to a 50 mM NaCl level and a progressive increase with increasing vermicompost addition. When compared to the control, the 30th and 60th days showed the greatest increase in catalase activity (15.518±1.431 units min^{-1} mg protein and 21.238±2.01 units min^{-1} mg protein, respectively) in 50 mM NaCl + 25% vermicompost. Additionally, on the 30th and 60th, at 18.852±1.24 units min^{-1} mg protein and 12.011±0.92 units min^{-1} mg protein, respectively, it was noted that catalase activity in 100% vermicompost was moderately greater than control (Fig 3). Catalase is one of the most significant antioxidant enzymes in plants, according to Hameed *et al*. 2008. In a variety of plants exposed to salinity stress, catalase enzyme activity has been shown to be increased by (Kahrizi *et al*., 2012). If the concentration of hydrogen peroxide in the surrounding medium is increased, catalase functions in plant and animal cells It's also considered to be one of the proteins containing iron. Catalase protects cells from the harmful effect of hydrogen peroxide, according to Lokhande *et al.* (2011). Catalase enzyme promotes plant survival by removing reactive oxygen species and stopping damage to the walls of plants, (Jiang and Zhang, 2001). The activity of antioxidant enzymes, such as glutathione peroxidase (GPX), catalase (CAT), superoxide dismutase (SOD), ascorbate peroxidase (APX) and malondialdehyde, rose dramatically with salinity whereas photosynthetic pigments decreased (Sorkhi, 2021).

Peroxidase

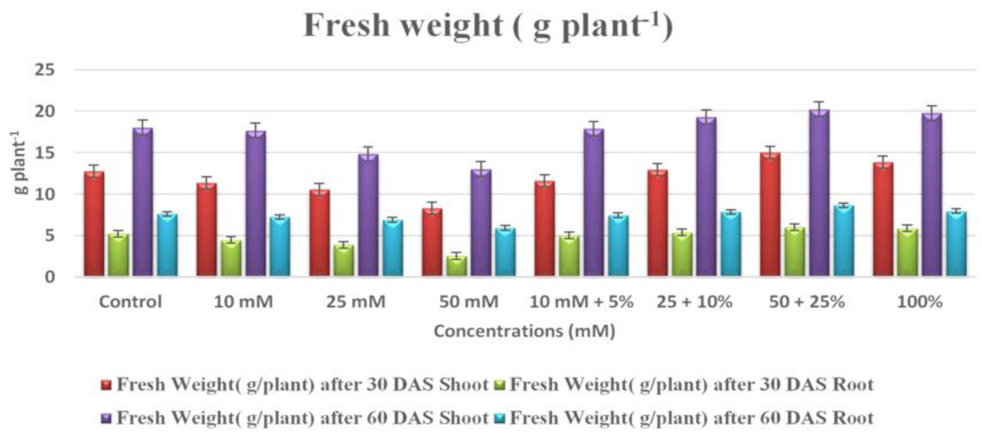
The findings showed that the peroxidase activity steadily rose with vermicompost addition and decreased with

Table 1: Impact of NaCl and vermicompost on growth and leaf area of *Solanum melongena* on 30th and 60th day after germination.

Concentration (mM)	Growth parameter (cm plant^{-1}) after 30 DAS		Growth parameter (cm plant^{-1}) after 60 DAS		Leaf area (cm^2 plant^{-1}) after 30 DAS			Leaf area (cm^2 plant^{-1}) after 60 DAS		
	Shoot length	Root length	Shoot length	Root length	Length	Breath	Leaf area	Length	Breath	Leaf area
Control	17.8	5.8	28.5	8.9	8.416	6.527	36.25±1.011	11.812	8.122	63.32±1.48
10 mM	16.6	5.3	27.3	7.8	7.9	5.661	29.52±1.21	11.622	8.011	61.45±1.33
25 mM	16.1	4.3	26.2	6.9	7.316	4.75	22.94±0.8	11.124	7.87	57.78±1.13
50 mM	15.3	3.8	23.1	5.9	6.33	4.561	19.05±0.77	9.89	6.73	43.93±0.98
10 mM + 5%	17	6	27.9	8.3	8.216	5.966	32.35±1.11	11.715	7.983	61.73±2.01
25 + 10%	17.4	5	28.3	10.1	8.888	6.752	39.61±1.29	11.98	8.303	65.65±1.88
50 + 25%	19.8	4	30.9	12.3	9.883	7.432	48.48±1.19	12.91	8.891	75.76±2.17
100%	18.3	3	28.7	11.6	9.073	7.212	43.19±0.95	12.011	8.701	68.98±1.7
F							268.345**			95.75**

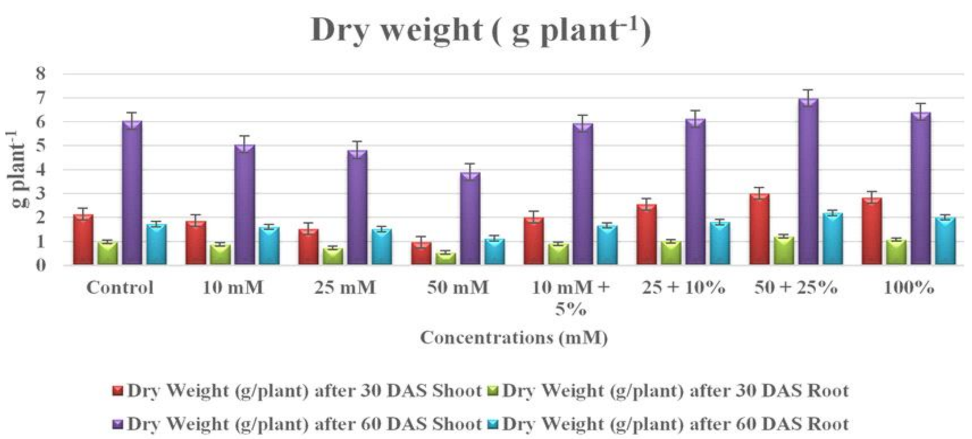
± Standard error

**The F values were significant at 5% level.



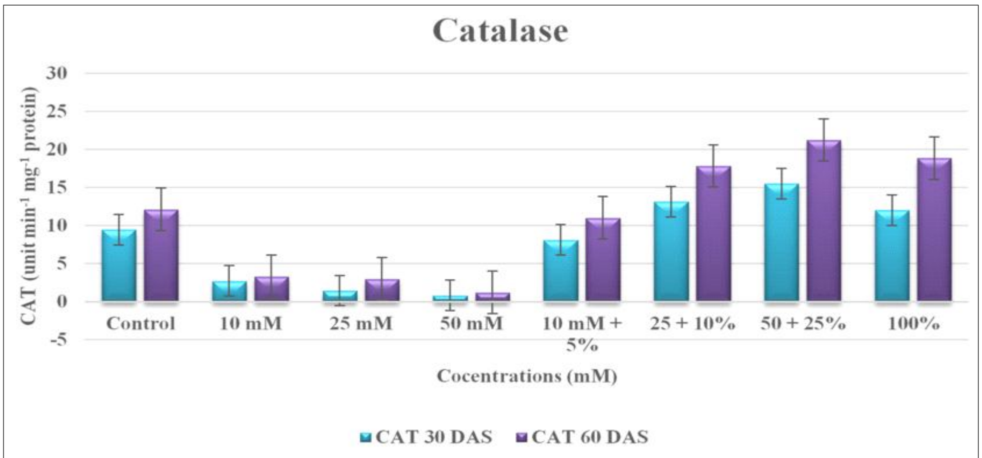
30 DAS- Shoot- 21.26* and root- 18.004*; 60 DAS- Shoot- 41.367* and root- 20.34*; The F values were significant at 1% level.

Fig 1: Impact of NaCl and vermicompost on fresh weight of *Solanum melongena* on 30th and 60th day after germination.



30 DAS- Shoot- 34.033* and root- 16.16*; 60 DAS- Shoot- 76.304* and root- 27.498*; The F values were significant at 1% level.

Fig 2: Impact of NaCl and vermicompost on dry weight of *Solanum melongena* on 30th and 60th day after germination.



30 DAS- 179.19*; 60 DAS- 129.94*; The F values were significant at 1% level.

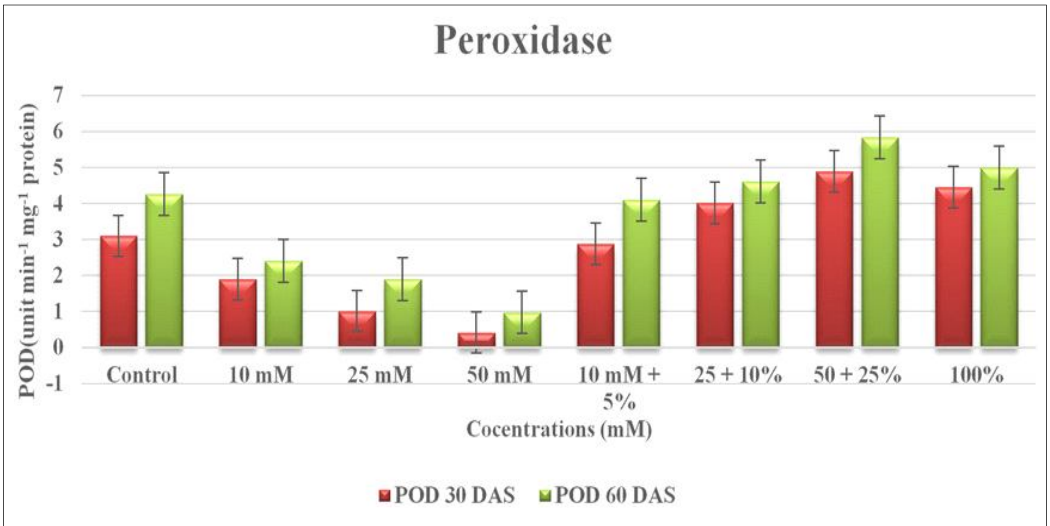
Fig 3: Impact of NaCl and vermicompost on Catalase enzyme activity of *Solanum melongena* on 30th and 60th day after germination.

increasing doses up to 50 mM NaCl. In comparison to the control, the highest increase in peroxidase activity was recorded on the 30th day (4.891±0.315 units min^{-1} mg protein) and 60th day (5.831±0.278 units min^{-1} mg protein) in 50 mM NaCl + 25% vermicompost. The extreme level of 100% vermicompost peroxidase activity was moderately higher than control on both 30th (4.456±0.299 unit min^{-1} mg protein) and 60th (4.989±0.33 unit min^{-1} mg protein) (Fig 4). The use of vermicompost and sorghum water extract has contributed to the growth of maize seed. This was attributed to an increase in photosynthetic pigments and antioxidant (SOD, POD and CAT) activities (Alamer *et al*., 2022).

Superoxide dismutase

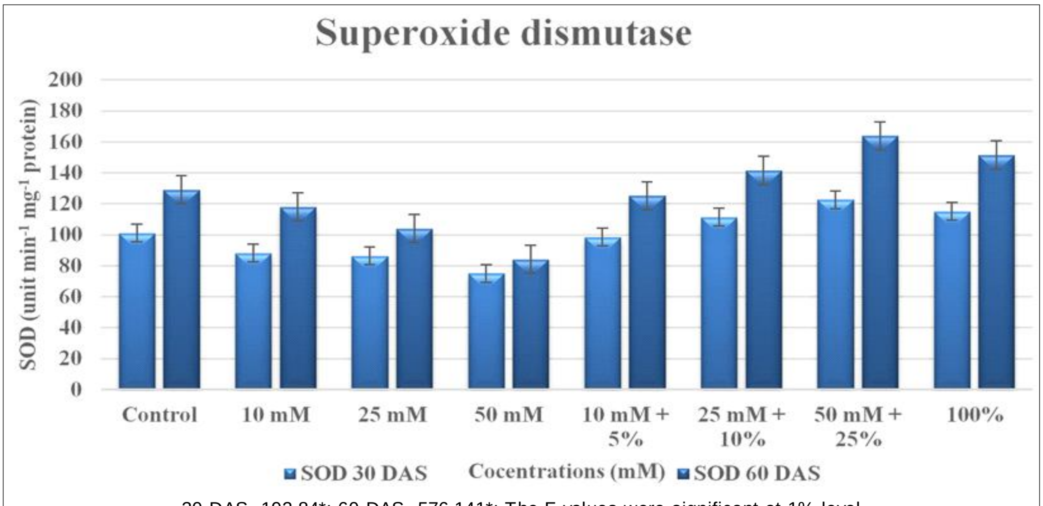
Superoxide dismutase activity was found to progressively increase with vermicompost and to decrease with higher concentrations up to 50 mM NaCl. Maximum increase in the peroxidase activity was recored in 50 mM NaCl + 25% vermicompost on 30th (122.71±2.11 unit min^{-1} mg protein) and 60th (163.87±2.15 unit min^{-1} mg protein) day when compared to control. The extreme level of 100% vermicompost peroxidase activity was moderately higher than control on both 30th (115.124±2.2 unit min^{-1} mg protein) and 60th (151.559±1.89 unit min^{-1} mg protein) (Fig 5). In order to reduce the effects of oxidative stress in saline conditions, plants increase the superoxide dismutase enzyme (Yaghubi *et al*., 2014).

Ascorbate peroxidase



30 DAS- 142.59*; 60 DAS- 116.66*; The F values were significant at 1% level.

Fig 4: Impact of NaCl and vermicompost on peroxidase enzyme activity of *Solanum melongena* on 30th and 60th day after germination.



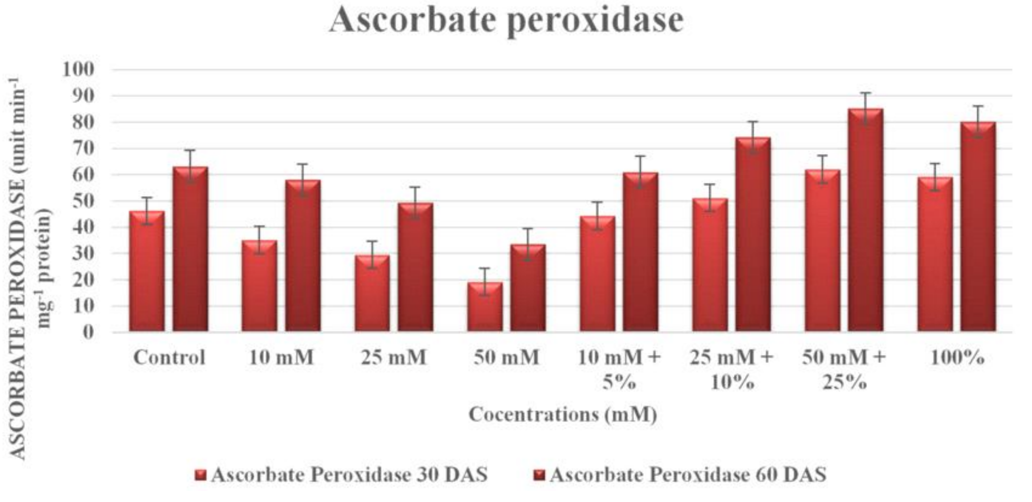
30 DAS- 192.84*; 60 DAS- 576.141*; The F values were significant at 1% level.

Fig 5: Impact of NaCl and vermicompost on superoxide dismutase enzyme activity of *Solanum melongena* on 30th and 60th day after germination.

Fig 6 provides information on the ascorbate peroxidase activity at different salinity concentrations when mixed with vermicompost. As salinity increased up to a 50 mM NaCl level, the ascorbate peroxidase result fell and then steadily increased as more vermicompost was added. Maximum increase in ascorbate peroxidase enzyme was recorded in 50 mM NaCl + 25% vermicompost on 30th (62.021±1.01 unit min^{-1} mg protein) and 60th (85.121±1.11unit min^{-1} mg protein) when compared to control. At extreme level of 100% vermicompost ascorbate peroxidase activity was moderately higher than control on both 30th (59.11±0.69unit min^{-1} mg protein) and 60th (80.188±0.91unit min^{-1} mg protein) days. Acorbate peroxidase is also used as a reducing agent of many free radicals, in particular hydrogen peroxide, besides playing an important role in plant growth, development and metabolism. Thus, ascorbate peroxidase can reduce oxidative stress damage, according to (Gholinejad *et al*., 2014). According to Adamipour *et al.* (2016) stated the increasing of Catalase and ascorbate peroxidase activity by addition of vermicompost to *Festuca arundinaceacv* Queen plant in salinity.

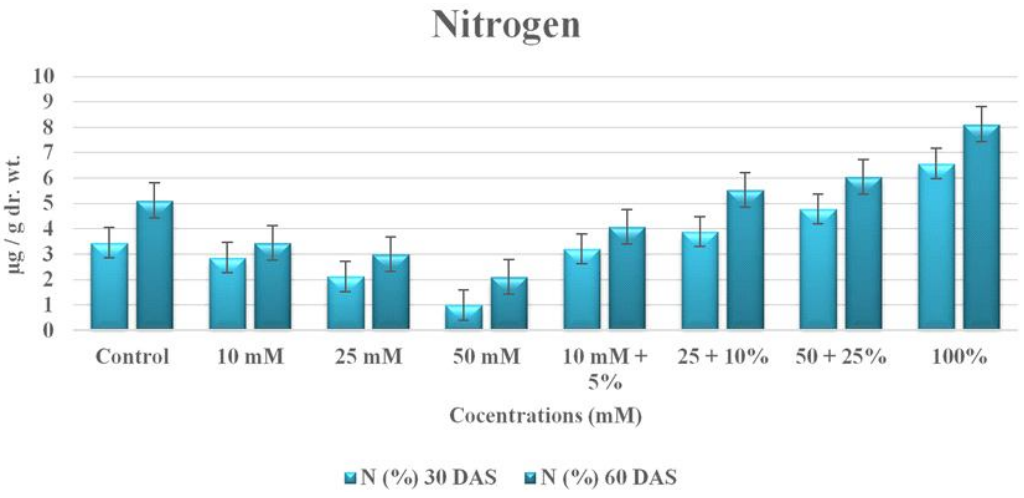
Macro nutrients

A higher concentration of NaCl indicates a decrease in the amount of nutrients present. Furthermore, vermicompost



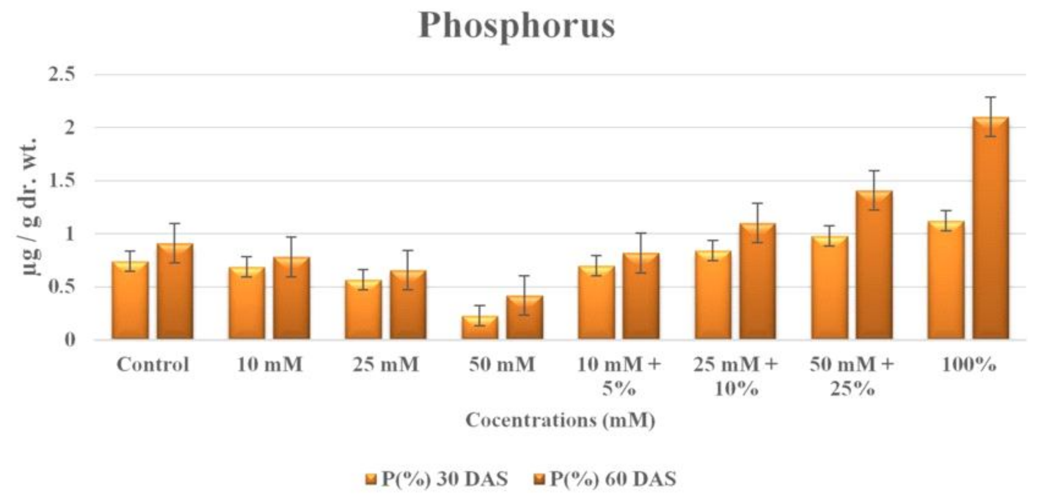
30 DAS- 1115.73*; 60 DAS- 1322.84*; The F values were significant at 1% level.

Fig 6: Impact of NaCl and vermicompost on ascorbate peroxidase enzyme activity of *Solanum melongena* on 30th and 60th day after germination.



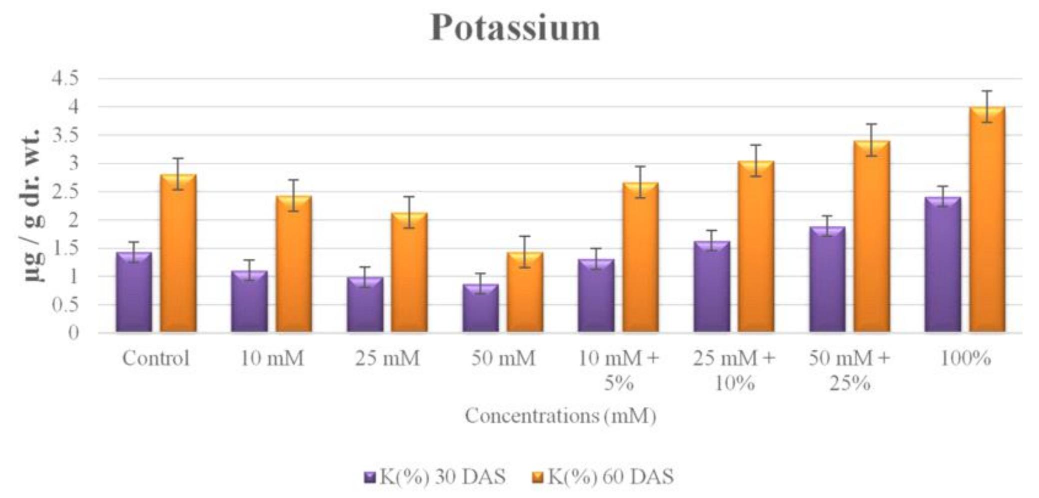
30 DAS- 86.08*; 60 DAS- 140.30*; The F values were significant at 1% level.

Fig 7: Impact of NaCl and vermicompost on nitrogen of *Solanum melongena* on 30th and 60th day after germination.



30 DAS- 27.88*; 60 DAS- 84.46*; The F values were significant at 1% level.

Fig 8: Impact of NaCl and vermicompost on phosphorus of *Solanum melongena* on 30th and 60th day after germination.



30 DAS- 87.04*; 60 DAS- 96.16*; The F values were significant at 1% level.

Fig 9: Impact of NaCl and vermicompost on potassium of *Solanum melongena* on 30th and 60th day after germination.

exhibits a progressive rise in nutrient content, reaching 50 mm of NaCl plus 25% vermicompost. The data shows the highest Nutrients (N, P, K) was observed in 100% vermicompost *i.e.*, Nitrogen-6.571±0.39 μg g^{-1} dr. wt., Phosphorus- 1.12±0.19 μg g^{-1} dr. wt., Potassium- 2.411±0.09 μg g^{-1} dr. wt. and Nitrogen- 8.123±0.37 μg g^{-1} dr. wt., Phosphorus- 2.1±0.19 μg g^{-1} dr. wt., Potassium- 4.001±0.21 μg g^{-1} dr. wt. on 30th and 60th day respectively. But it was also observed that with the NaCl concentration the highest nutrient content was found to be in 50mm NaCl + 25% vermicompost *i.e.*, Nitrogen- 4.781±0.259 μg g^{-1} dr. wt., Phosphorus- 0.98±0.08 μg g^{-1} dr. wt., Potassium- 1.888±0.1 μg g^{-1} dr. wt. and Nitrogen- 6.054±0.238 μg g^{-1} dr. wt., Phosphorus-1.41±0.15 μg g^{-1} dr. wt., Potassium- 3.411±0.115 μg g^{-1} dr. wt. on 30th and 60th day respectively (Fig 7, Fig 8 and Fig 9). Increased P, K, Mg, Fe, Mn and Zn concentrations with the application vermicompost in salinity on *Lactuca sativa* (Demir and kiran, 2020). Djajadi *et al*. (2020) indicate that the application of nitrogen fertilizer (50, 75 and 100 kg N/ha) and vermicompost (0-,10-, 20-, t/ha) enhanced N and K uptakes, sugarcane growth and decreased the harmful effects of saltwater. According to Meena *et al*., (2016) stated that available nitrogen (kg ha^{-1}), phosphorus (kg ha^{-1}) and potassium (kg ha^{-1}) may be due to an increase in levels of organic and inorganic fertilizers.

CONCLUSION

So, we conclude that the salinity with application vermicompost (50 mM NaCl + 25% VC) promoted the growth and other antioxidant enzymes when compared to control. So, the soil salinity redempted used as vermicompost and used as a cultivation.

Conflict of interest

The authors whose names are listed declared that the work is original and they have no conflict of interest.

REFERENCES

Adamipour, N., Heiderianpour, M.B. and Zarei, M. (2016). Application of vermicompost for reducing the destructive effects of salinity stress on tall fescue turfgrass (*Festuca arundinacea* Schreb. 'Queen'). J. Soil Plant Interact. Isfahan Uni. Technol. 7: 35-47.

Adiloğlu, F., Açıgöz, E., Adiloğlu, S. and Solmaz, Y. (2015). Akuakültür atiği ve solucan gübresi uygulamalarinin salata [*Lactuca sativa* (L.) var. crispa[bitkisinin verim, Bazı Bitki Besin Elementi İçeriği ile Bazı Agronomik Özellikleri Üzerine Etkisi. Namık Kemal Üniversitesi Araştırma Projesi. 24(15): 11.

Akhzari, D., Pessarakli, M. and Khedmati, M. (2016). Effects of vermicompost and salinity stress on growth and physiological traits of *Medicago rigidula* L. Journal of Plant Nutrition. 39: 2106-2114.

Alamer, K.H., Perveen, S., Khaliq, A., Zia Ul Haq, M., Ibrahim, M. U. and Ijaz, B. (2022). Mitigation of salinity stress in maize seedlings by the application of vermicompost and sorghum water extracts. Plants. 11(19): 2548. doi: https://doi.org/10.3390/plants11192548.

Alhasnawi, A.N., Kadhimi, A.A., Isahak, A., Mohamad, A., Doni, F., Mohtar, W., Yusoff, W. and Zain, C.R. (2014). Salinity stress in plant and an important antioxidant enzyme. Life Science Journal. 11(10): 913-920.

Álvarez, J.M., Pasian, C., Lal, R., López Núñez, R. and Martínez, M.F. (2017). Vermicompost and biochar as substitutes of growing media in ornamental-plant production. Journal of Applied Horticulture. 19(3): 205-214.

Asada, K. and Takahashi, M. (1987). Production and Scavenging of Active Oxygen in Chloroplasts. In: [Kyle, D.J., Osmond, C.B. and Arntzen, C.J. (Eds.)], Photoinhibition, Elsevier, Amsterdam. 227-287.

Bacilio, M., Rodriguez, H., Moreno, M., Hernandez, J.P. and Bashan, Y. (2004). Mitigation of salt stress in wheat seedlings by a gfp-tagged *Azospirillum lipoferum*. Biol. Fertil. Soil. 40: 188-193.

Banadkooki, A.M., Ardakani, M.D., Shirmardi, M. and Momenpour, A. (2019). Effects of cow manure and vermicompost on growth characteristics of smoke tree (*Cotinus coggygria* Scop.) under salt stress under greenhouse. Iranian J. Poplar Res. 26: 483-495.

Bellitürk, K. (2016). Sürdürülebilir tarýmsal üretimde katı atık yönetimi için vermikompost teknolojisi. Çukurova Tarım ve Gıda Bilimleri Dergisi. 31(3): 1-5.

Belliturk, K., Görres, J.H., Turan, H.S., Göçmez, S., Bağdatlı, M.C., Eker, M. and Aslan, S. (2015). Environmental quality of compost: Can composting earthworms (*Eisenia fetida*) help manage compost nutrient ratios? in Proc. International Conference on Civil and Environmental Engineering, Cappadocia. May: 159-162.

Broz, A.P., Verma, P.O. and Appel, C. (2016). Nitrogen dynamics of vermicompost use in sustainable agriculture. Journal of Soil Science and Environmental Management. 7(11): 173-183.

Chandlee, J.M. and Scandalios, J.G. (1984). Analysis of variants affecting the catalase developmental program in maize scutellum. Theoretical and Applied Genetics. 69: 71-7.

Chaulagain, A.P., Dhurva and Lamichhane, J. (2017). Vermicompost and its role in plant growth promotion. International Journal of Research. 4(8): 849-864.

Demir, Z. and Kiran, S. (2020). Effect of vermicompost on macro and micro nutrients of lettuce (*Lactuca sativa* var. Crispa) under salt stress conditions. Kahramanmara¸s. Sütçü. ˙Imam. Üniversitesi. Tarım. Do˘ga. Dergisi. 23: 33-43.

Djajadi, D. Syaputra, R. Hidayati, S.N. and Khairiyah, Y. (2020). Effect of vermicompost and nitrogen on N, K, Na uptakes and growth of sugarcane in saline soil. Agrivita Journal of Agricultural Science. 42: 110-119.

Ebrahimi, M.H., Taghvaei, M., Sadeghi, H. and Zarei, M. (2019). Effect of organic coats with superabsorbent polymers on improving the germination and early vigor milk thistle (*Silybum marianum* L.) seeds under salinity stress. Desert. 24: 207-215.

Gandhi and Sundari, U.S. (2012). Effect of vermicompost prepared from aquatic weeds on growth and yield of eggplant (*Solanum melongena* L.). Biofertilizers and Biopesticides. 3(5): 1000128. doi: 10.4172/2155-6202.1000128.

Gnanamani, K., Vijayalakshmi A. (2024). Efficient utilization of agro-industrial waste through vermicomposting and its impact on growth and yield of brinjal (*Solanum melongena* L.). Agricultural Science Digest. 43(6): 824-828. doi: 10.18805/ag.D-5775.

Gholinejad, R., Sirousmehr, A. and Fakheri, B. (2014). Effect of drought stress and organic fertilizer on activity of some antioxidant enzymes, photosynthetic pigments, proline and yield of Borage (*Borago officinalis*). Journal of Horticulture Science. 3(28): 338-346.

Giannopolitis, C.N. and Ries, S.K. (1977). Superoxide dismutases. I. Occurrence in higher plants. Journal of Plant Physiology. 59: 309-314.

Gohari, G., Mohammadi, A. and Duathi, K.H. (2019). Effect of vermicompost on some growth and biochemical characteristic of *Dracocephalum moldavica* L. under water salinity stress. J. Agric. Sci Sustain. Prod. 29: 151-168.

Hameed, A., Naseer, A., Iqbal, T. and Syed, H. (2008). Effects of NaCl salinity on seedling growth, senescence, catalase and protease activities in two wheat genotypes differing in salt tolerance. Pakistan Journal of Botany. 40(3): 1043-1051.

Hussain, M., Farooq, M., Nawaz, A., Al-Sadi, A.M., Solaiman, Z.M., Alghamdi. S.S., Ammara, U., Ok, Y. and Siddique, K.H.M. (2017). Biochar for crop production: potential benefits and risks. Journal of Soils Sediments. 17: 685-716.

Jiang, M. and Zhang, J. (2001). Effect of abscisic acid on active oxygen species, antioxidative offence system and oxidative damage in leaves of maize seedlings. Plant Cell Physiology. 42: 1265-1273.

Kahrizi, S., Sedghi, M. and Sofalian. O. (2012). Effect of salt stress on proline and activity of antioxidant enzymes in ten durum wheat cultivars. Annals of Biological Research. 3(8): 3870-3874.

Koozehgar, K.M. and Ardakani, M.R. (2017). Effects of vermicomposting and compost tea on nitrogen, phosphorus and potassium yield and uptake of *Mentha aquatic* L. inoculated with mycorrhizal fungi *Glomus moseae*. Plant Environmental Physiology. 13(51): 95-107.

Lokhande, V.H., Nikam, T.D., Patade, V.Y., Ahire, M.L. and Suprasanna, P. (2011). Effects of optimal and supra-optimal salinity stress on antioxidative defence, osmolytes and *in vitro* growth responses in *Sesuvium portulacastrum* L. Plant Cell Tissue and Organ Culture. 104: 41-49.

Meena, S., Swaroop, N. and Dawson, J. (2016). Effect of integrated nutrient management on physical and chemical properties of soil. Agric. Sci. Digest. 36(1): 56-59. doi: 10.18805/asd.v35i1.9312.

Moraditochaee, M., Bozorgi, H.R. and Halajisani, N. (2011). Effects of vermicompost applictaion and nitrogen fertilizer rates on fruit yield and several attributes of eggplant (*Solanum melongena* L.) in Iran, World Applied Sciences Journal. 15(2): 174-178.

Pakar, N., Anosheh, H.P., Emam, Y. and Pessarakli, M. (2016). Barley growth, yield, antioxidant enzymes and ion accumulation affected by PGRs under salinity stress conditions. Journal of Plant Nutrition. 39(10): 1372-1379.

Reddy, K.P., Subhani, S.M., Khan, P.A. and Kumar, K.B. (1985). Effect of light and benzyladenine on dark-treated growing rice (*Oryza sativa*) leaves II. Changes in peroxidase activity. Plant and Cell Physiology. 26(6): 987-994.

Seyyed, M.R., Darzi, M.T., Riazi, G.H. and Ghandarhari. Z. (2013). Evaluation of effect of vermicompost and aminoacids on yield and yield components of *Matricaria chemmomilla*. Iranian Journal of Plant and Ecosystem. 33: 67-80.

Sorkhi, F. (2021). Effect of vermicompost fertilizer on antioxidant enzymes and chlorophyll contents in *Borago officinalis* under salinity stress. Iranian Journal of Plant Physiology. 11: 3589-3598.

Taher, D., Solberg, S., Prohens, J., Chou, Y., Rakha, M. and Wu, T. (2017). World vegetable center eggplant collection: origin, composition, seed dissemination and utilization in breeding. Front Plant Sci. 8: 1484. doi: https://doi.org/10.3389/fpls.2017.01484.

United Nations, Food and Agriculture Organization, (2011). Agriculture, Food and Water: A Contribution to the World Water Development Report, Rome.

Williams, C.H. and Twine, V. (1960). Modern Methods of Plant Analysis. In: [Peach, K. and Tracey M.V. (eds.)], Springer Berlin, Heidelberg. 5: 3-5.

Yaghubi, M., Nematzadeh, G., Pirdashti, H., Modarresi, M. and Motaghian, A. (2014). The effects of salinity on antioxidant enzymes activity in the leaves of two contrast rice (*Oryza sativa* L.) cultivars. International Journal of Biosciences. 4: 116-125.

Yassin, M., Fara, S.A., Hossain, A. and Saneoka, H. (2019). Assessment of salinity tolerance bread wheat genotypes: using stress tolerance indices. Fresenius Environmental Bulletin. 28(5): 4199- 4217.

Yoshida, S., Fordo, D., Cork, J. and Gomez, K., (1972). Laboratory manual for physiological studies of rice. 3rd Edition, The International Rice Research Institute, Philippines. 11-23.