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ASSESSING THE IMPACTS OF SALINITY ON YIELD AND MINERAL STATUS OF RADISH IN THE SOUTH-CENTRAL COASTAL REGION OF BANGLADESH

A. K. M. Faruk-E-Azam, M. N. S. Khan, M. Maniruzzaman, Abdullah-Al-Zabir* and S. U. Ahmed[1]
Department of Agricultural Chemistry, Patuakhali Science and Technology University
Patuakhali-8602, Bangladesh
[1]Care Bangladesh, Nilganj road, Kishoreganj-2300, Bangladesh
*Corresponding author's mail: zabir@pstu.ac.bd

ABSTRACT

A study was conducted during July 2020 to June 2021to explore the impacts of salinity on the yield and mineral composition of radish in the challenging as well as salinity prone south-central coastal region of Bangladesh. The study encompassed multiple locations, including PSTU farm, Dumki; south Muradia, Dumki; Nauvanga, Kalapara; Pakhimara, Kalapara of Patuakhali district and Sawdagarpara, Taltoli of Barguna district having EC level 0.87, 0.97, 4.4, 4.8 and 6.4 dSm^{-1}, respectively. The yield of radish was increased with the increasing of soil EC level. Mineral analysis encompassed the examination of phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), sodium (Na), zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) content in Radish. The results unveiled a decreasing trend in P, Ca, S, Zn, Fe, Cu, and Mn levels as soil EC levels rose. In contrast, K, Mg, and Na exhibited an ascending trend with higher soil EC levels. Results indicated that radish displayed a moderate tolerance to salinity, up to a soil EC 6.4 dSm^{-1}. Consequently, it can be recommended for commercial cultivation in the study areas.

Key words: Radish, yield, minerals, salinity, coastal area.

Introduction

Vegetables offer a wide array of health benefits, being inherently low in fat and calories while boasting a rich content of essential vitamins, protein, and dietary fiber. They additionally serve as valuable sources of critical mineral nutrients, including P, K, Ca, Mg, Fe, Cu, Mn,Se and Zn (Savage and Deo, 1989; Demir and Mavi, 2008). However, in numerous regions of the world, especially arid and semi-arid areas, excessive levels of soluble salts in the soil pose a significant challenge to crop production, including that of vegetables (FAO, 2002). Salt stress represents a formidable environmental factor that severely curtails the productivity of vegetable crops, primarily due to the fact that most vegetables are classified as glycophytes. The significance of salt tolerance in vegetables is amplified by their economic value, and salt-induced stressors disrupt crucial plant metabolic processes, leading to diminished growth and yields. The deleterious impact of excess soil salt manifests through two main mechanisms: osmotic hindrance, which impedes root water uptake, and specific ion effects, which can induce direct toxicity. Moreover, the insolubility of ions and their competitive absorption may disrupt the nutrient balance in plants (Greenway and Munns, 1980; Yoon *et al*., 2004; Yang *et al*., 2009). Additionally, salinity has been noted to enhance sodium (Na+) uptake while potentially reducing potassium (K^+) and calcium (Ca^{2+}) absorption (Neel *et al*., 2002). Radish holds a significant position in the agricultural landscape of Bangladesh, both in terms of cultivation area and production volume. However, radish yields in saline soils markedly lag behind those in salt-free soil environments. The cultivation of any vegetable, including radish, entails intricate procedures, and saline conditions further compound the complexity of this process (Sivritepe *et al*., 2003). Radish is typically categorized as a moderately salt-sensitive crop (Maas and Hoffman, 1977), although there are instances where it demonstrates low sensitivity (Sonneveld, 1988). Paradoxically, elevated salinity levels in the root zone have been employed as a method to enhance the quality of certain vegetables, including radish (Mizrahi and Pasternak, 1985). Looking ahead, projections suggest that by 2050, nearly half of the world's cultivated land will become salinized, posing a substantial threat to sustainable agricultural development and the secure production of crops (Butcher *et al*., 2016). Soil salinization, coupled with secondary salinization, resulting from salt stress, has the potential to profoundly impact both the yield and quality of radish taproots. Therefore, the analysis of genes associated with salt tolerance in radish offer a solid theoretical foundation for a deeper understanding of the mechanisms governing the radish's response to salt stress and the development of salt-tolerant germplasms (Zhang *et al*., 2021).

Materials and Methods

Vegetable and soils were collected during July 2020 to June 2021 from five different areas of Patuakhali and Barguna districts. Edible portions of Radish (*Raphanus sativus*) and soil from each area were collected. The samples were brought to the laboratory, processed and preserved accordingly. The areas were Patuakhali Science and Technology University (PSTU) farm, south Muradia,Nauvanga, Pakhimara of Patuakhali and Sawdagarpara of Barguna. The analyses including soil physicochemical properties and mineral status of soil and radish were done in the Laboratory of Agricultural Chemistry, PSTU. Soil pH was done by glass electrode pH meter followed by the methodology of Jackson (1973). The electrical conductivity (EC) of collected soil samples was determined electrometrically (1:5, soil: water ratio) by a conductivity as stated by Ghosh *et al*. (1983). Chemical analyses of the vegetable sample were done for different mineral constituents: Exactly 1 g of finely ground vegetable was taken into a 150 mL conical flask and 12-15 mL di-acid mixture (HNO_3:$HClO_4$=2:1) was added. The flask was placed on the electric hot plate for heating at around 180 to 200 degrees Celsius until the white fumes were evolved from the flask (Jackson, 1962). It was cooled at room temperature, washed with distilled water repeatedly and filtered into 100 mL volumetric flask through Whatman No. 42 filter paper and the volume was made up to the mark with distilled water. The plant extracts were preserved separately in plastic bottles for analyses of different nutrient elements. The samples were analyzed for P, K, Ca and Mg (Page *et al*., 1982; APHA, 2005), S (Tandon, 1995) following the standard methods generally practiced in the laboratory. The statistical analysis of data obtained from chemical analyses of vegetables was performed following the statistical package for agricultural research as described by Gomez and Gomez (1984).

Results and Discussion

Soil pH and EC level: Soil pH of the study area was 7.1, 7.2, 7.7, 5.5 and 6.3 in PSTU farm, South Muradia, Nauvanga, Kalapara, Pakhimara and Sawdagarpara, respectively. Soil pH was negatively related with soil electrical conductivity in the form of power function and not in linear relationship because there are several other factors such as soil mineral, porosity, soil texture, soil moisture and soil temperature which also affect soil electrical conductivity in the soil (USDA, 2011). The EC level of soil in PSTU farm, South Muradia, Nauvanga, Kalapara, Pakhimara and Sawdagarpara was 0.84, 0.97, 4.4, 4.8 and 6.4 dSm^{-1}, respectively. The raising of EC level happened because of salinity. The closer we get to the coastal area, the higher the soil salinity (Fig. 1). This result strongly agrees with that of Azam *et al.*, (2018), Polara *et al.* (2006) and Kumar *et al.,* (2018). The high pH in Sonakata soils might be due to presence of sodium carbonate and bi-carbonates, which precipitated as calcium and magnesium carbonates during evaporation, Bhaskar and Nagaraju, (1998).

Yield of radish: The yield of radish in PSTU farm, South Muradia, Nauvanga, Pakhimara and Sawdagarpara was 3.90, 7.60, 8.41, 8.95 and 6.67 tha^{-1}, respectively. The yield was getting higher from PSTU farm to Pakhimara because of high organic matter, nitrogen, phosphorus, potassium, sulphur, zinc and boron content of soil. Except in Sawdagarpara, Taltoli, Barguna, there were comparatively low organic matter content of soil (Fig. 2).

Phosphorus and Potassium accumulation in radish: Phosphorus accumulation in radish in PSTU farm Dumki, Patuakhali; south Muradia, Dumki, Patuakhali; Nauvanga, Kalapara, Patuakhali; Pakhimara, Kalapara, Patuakhali and Sawdagarpara, Taltoli, Barguna was 6078.2, 4022.8, 3098.2, 2966.4 and 2844.1 $mgkg^{-1}$, respectively. On the other hand, potassium content was estimated as13540,13728, 19812, 20053 and 19800 $mgkg^{-1}$,respectively. Phosphorus accumulation was highest in PSTU farm at EC level 0.84 dSm^{-1} and potassium accumulation was highest in Pakhimara at EC level 4.8dSm^{-1} (Fig. 3).

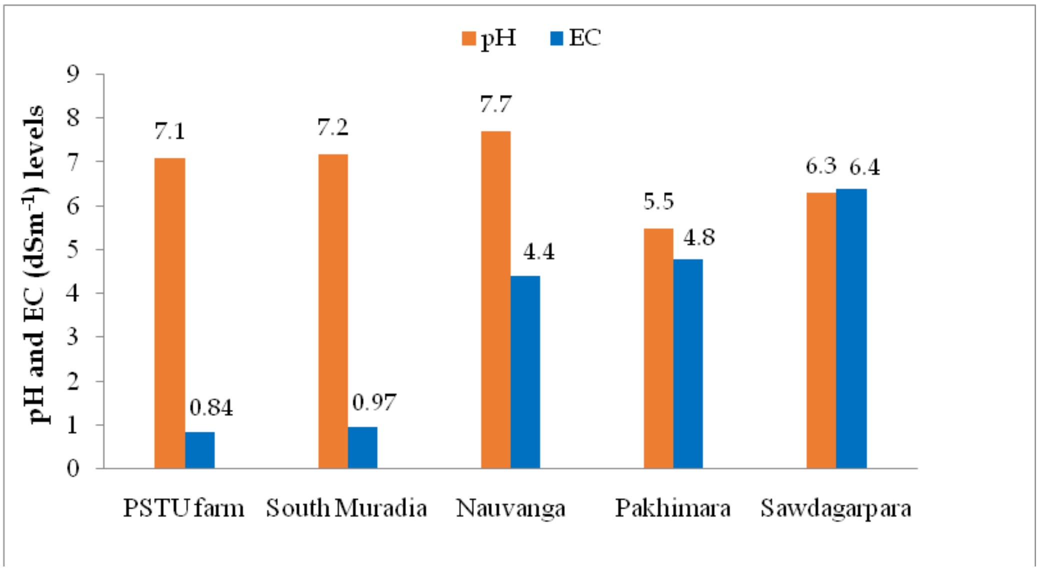

Fig. 1. Soil pH and EC level at different study areas

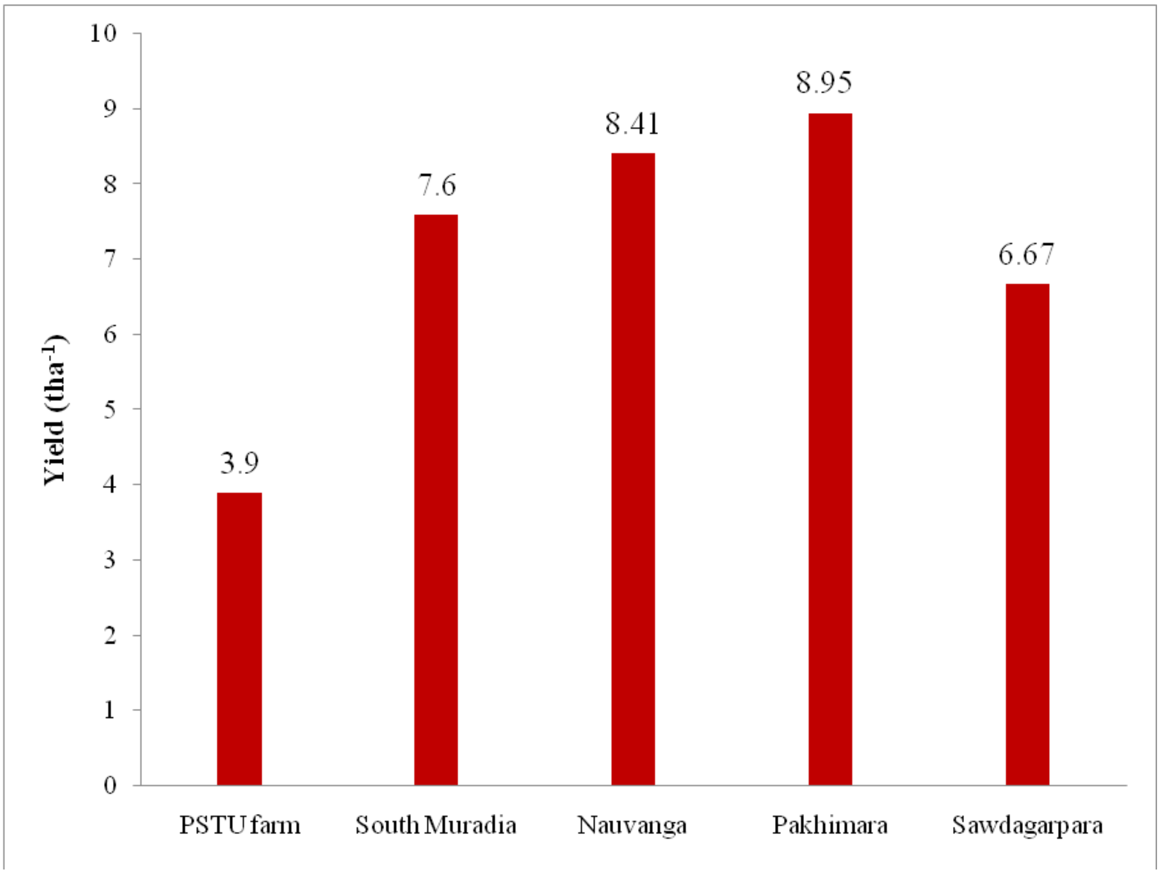

Fig. 2. Yield of radish at different study areas

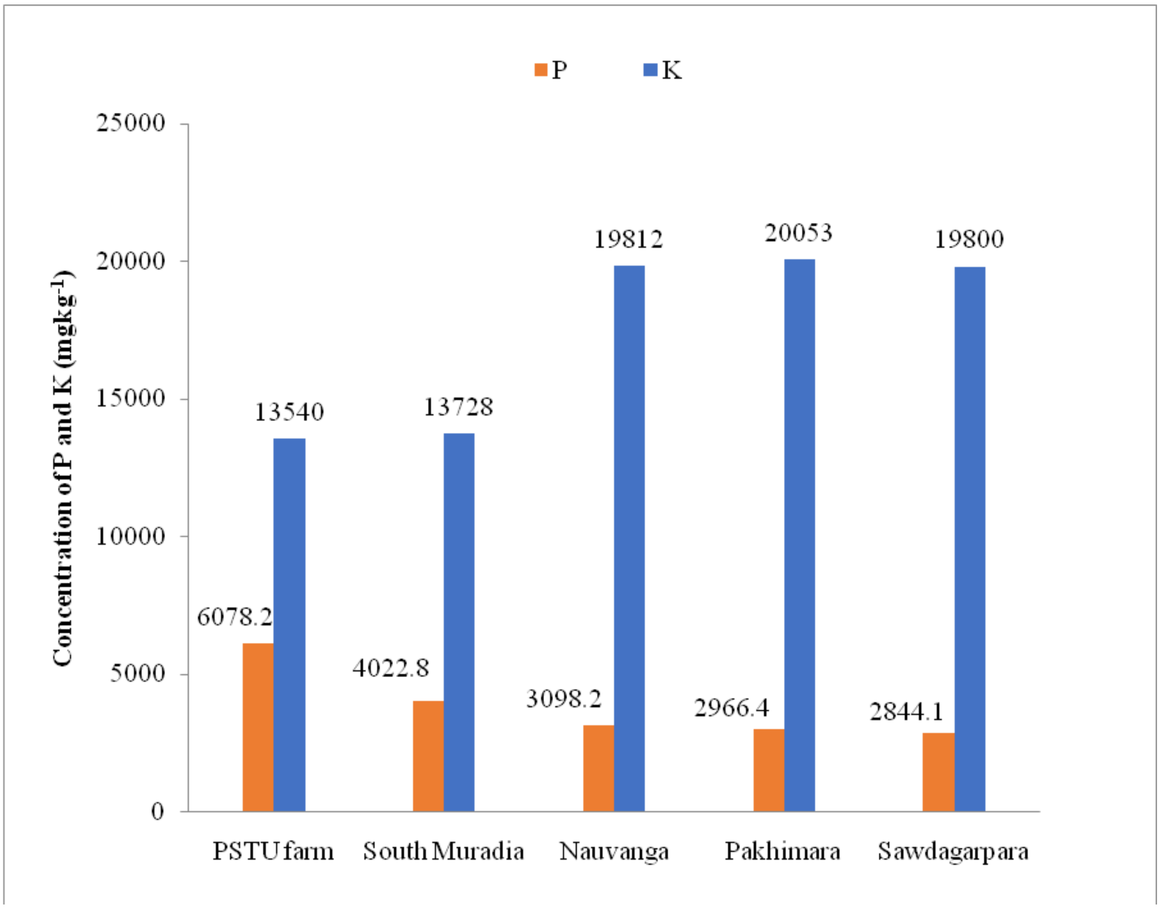

Fig. 3. Accumulation of P and K in radish at different study areas

Calcium and Magnesium accumulation in radish: Calcium accumulation in radish in PSTU farm Dumki, Patuakhali; south Muradia, Dumki, Patuakhali; Nauvanga, Kalapara, Patuakhali; Pakhimara, Kalapara, Patuakhali and Sawdagarpara, Taltoli, Barguna was 3520, 2720, 2280, 2300 and 2230 $mgkg^{-1}$ whereasmagnesium content was determined as2060, 2264, 2208,2221 and 2290 $mgkg^{-1}$,respectively. Calcium accumulation was highest in PSTU farm at EC level 0.84dSm^{-1} and magnesium accumulation was highest in South Muradia at EC level 0.97dSm^{-1} (Fig. 4).

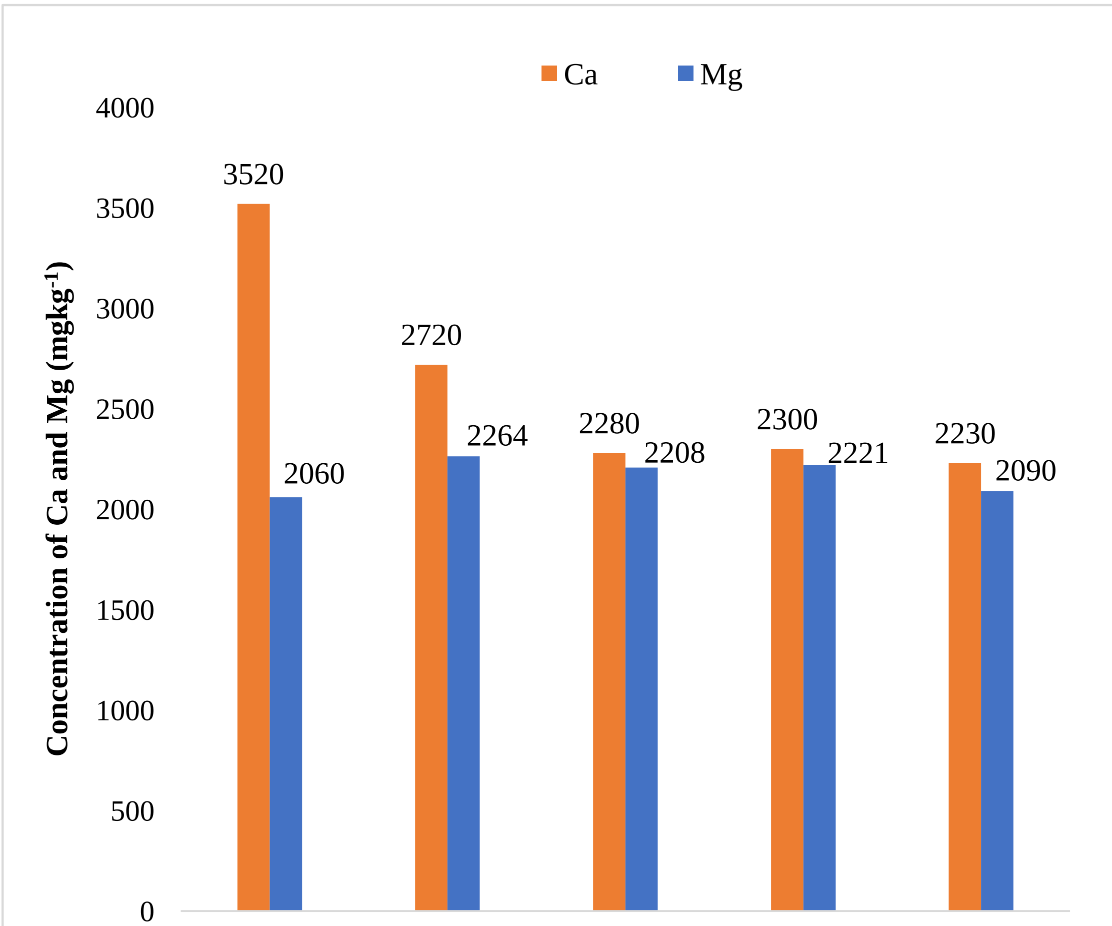

Fig. 4. Accumulation of Ca and Mg in radish at different study areas

Sulphur and Sodium accumulation in radish: Sulphur accumulation in raddish in PSTU farm Dumki, Patuakhali; south Muradia, Dumki, Patuakhali; Nauvanga, Kalapara, Patuakhali; Pakhimara, Kalapara, Patuakhali and Sawdagarpara, Taltoli, Barguna was 4376, 3488, 2880, 2700 and 2700 $mgkg^{-1}$, respectively. On the other side, sodium concentration was 10240,10620, 11960,12000 and 11300 $mgkg^{-1}$,respectively. Sulphur accumulation was highest in PSTU farm at EC level 0.84 dSm^{-1} and sodium accumulation was highest in Pakhimara at EC level 4.8 dSm^{-1} (Fig. 5).

Zinc and Iron accumulation in radish: Zinc accumulation in radish in PSTU farm Dumki, Patuakhali; south Muradia, Dumki, Patuakhali; Nauvanga, Kalapara, Patuakhali; Pakhimara, Kalapara, Patuakhali and Sawdagarpara, Taltoli, Barguna was 43.6, 33.6, 29.9, 27.5 and 25.4 $mgkg^{-1}$, respectively. Moreover, iron was recorded as 257.6, 238, 132.8, 124.9 and 12.6 $mgkg^{-1}$, respectively. Both zinc and iron accumulation were highest in PSTU farm Dumki at EC level 0.84 dSm^{-1} (Fig. 6).

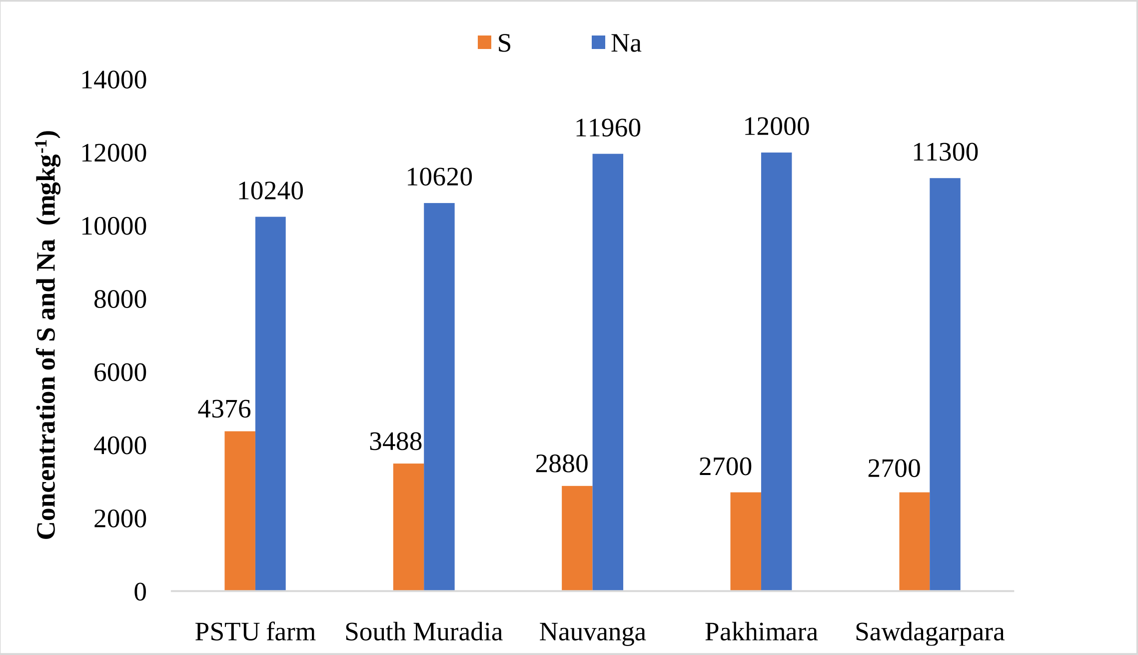

Fig. 5. Accumulation of S and Na in radish at different study areas

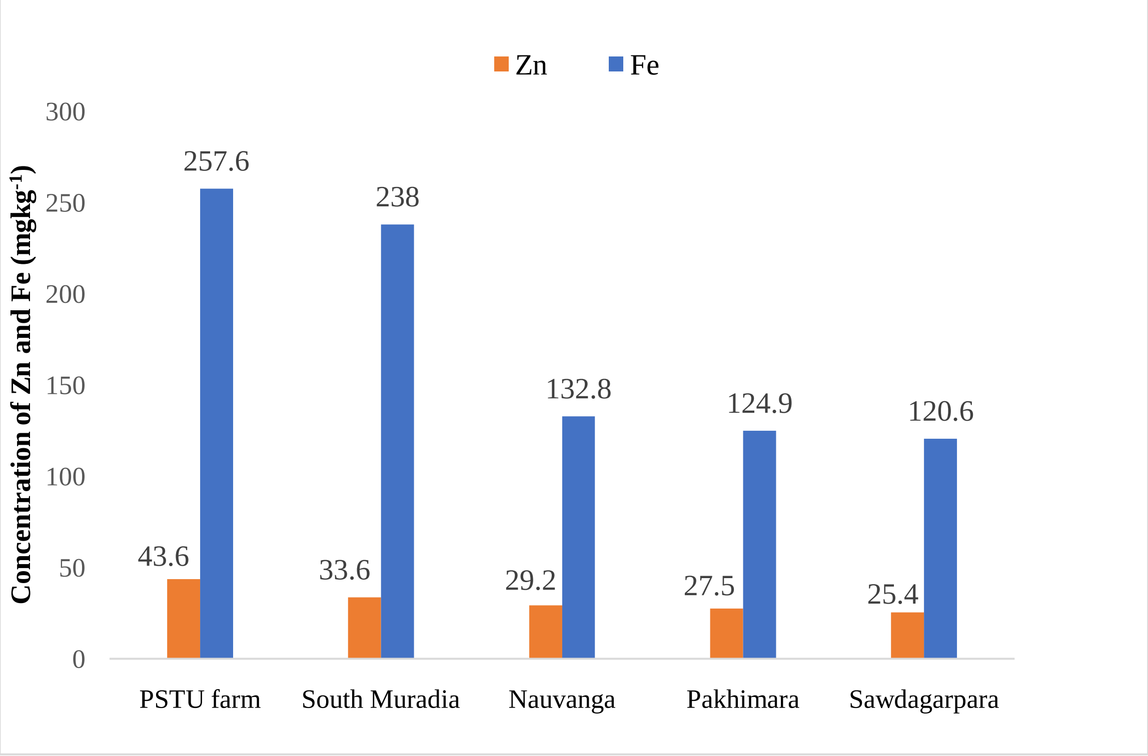

Fig. 6. Accumulation of Zn and Fe in radish at different study areas

Copper and Manganese accumulation in radish: Copper accumulation in radish in PSTU farm Dumki, Patuakhali; south Muradia, Dumki, Patuakhali; Nauvanga, Kalapara, Patuakhali; Pakhimara, Kalapara, Patuakhali and Sawdagarpara, Taltoli, Barguna was 7.2, 7.2, 4.8, 4.1 and 4.0 mgkg^{-1} whereas manganese was recorded as 21.6, 17.4, 15.2,14.5 and 13.8 mgkg^{-1},respectively. Copper accumulation was highest in both PSTU farm Dumki, Patuakhali and south Muradia at EC level 0.97 dSm^{-1} and manganese accumulation was highest in PSTU farm at EC level 0.84 dSm^{-1} (Fig. 7).

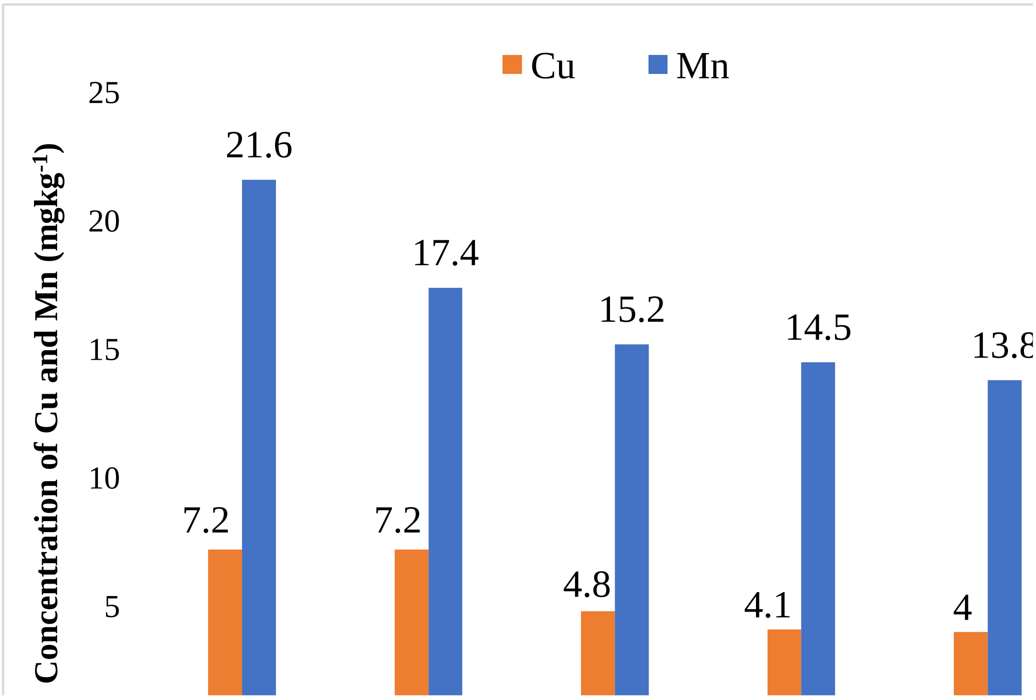

Fig. 7. Accumulation of Cu and Mn in radish at different study areas

Conclusion

Our study revealed a positive correlation between radish yield and soil EC, with the most favorable results observed up to an EC level of 6.4 dSm^{-1}. Notably, the mineral composition of radish exhibited distinct trends in response to varying soil EC levels. Phosphorus, Ca, S, Zn, Fe, Cu and Mn displayed a declining trend while K, Mg and Na exhibited an ascending trend as soil EC levels increased. These findings highlighted the radish's capacity to accumulate minerals more efficiently at higher EC levels, likely attributable to its inherent salt tolerance. Therefore, radish can be recommended as moderately saline tolerant vegetable offering its potential to be cultivated in the south-central coastal saline region of Bangladesh for nutritional security.

References

APHA (American Public Health Association). 2005. Standard Methods for the Examination of Water and Wastewater. 21th edi, AWWA and WEF. Washington, USA. pp. 30-40.

Azam, A. K. M. F., Rahman, M. T., Maniruzzaman, M., Zabir A. A. and Uddin, M. N. 2018. Nutrients Content in Some Vegetables Grown in South-Central Coastal Regions of Bangladesh. *The Agriculturists*, 16(2): 43-57.

Bhaskar, B. P. and Nagaraju, M. S. 1998. Characterization of some salt affected soils occurring in the Chitravathi river basin of Andhra Pradesh. *J. Indian Soc. Soil Sci*., 46(3): 416-121.

Butcher, K., Wick, A. F., Desutter, T., Chatterjee, A. and Harmon, J. 2016. Soil salinity: A threat to global food security. *Agron. J.*, 108: 2189-2200.

Demir, I. and Mavi, K. 2008. Effect of salt and osmotic stresses on the germination of pepper seeds of different maturation stages. *Brazilian Arch. Biol. Technol*, 51: 897-902.

FAO. 2002. Working with Local Institutions to Support Sustainable Livelihoods. Food and Agriculture Organization, Rome, Italy.

Ghosh, A. B., Bajaj, J. C., Hasan, R. and Singh, D. 1983. Soil and Water Testing Methods. A Laboratory Manual, Division of Soil Science and Agricultural Chemistry, IARI, New Delhi-110012. pp. 1-45.

Gomez, K.A. and Gomez, A. A. 1984. Statistical Procedures for Agricultural Research. 2nd ed^n, A Wiley Inter-Science Publication, New York. pp. 28-443.

Greenway, H., and Munns, R. 1980. Mechanisms of salt tolerance in non-halophytes. *Annual Review of Plant Physiol*., 31:149-190.

Jackon, M. L. 1962. Soil Chemical analysis. Constable and Co. Ltd. London, First Print.

Kumar, S. S., Salimath, S. B., Channagouda, R. F., and Gurumurthy, K. T. 2018. Physical and chemical properties of salt affected soils of Vani Vilas command area of Hiriyur taluk, Chitradurga district. *J. Pharmacognosy Phytochem.*, 7(1): 1379-1383.

Maas, E.V. and Hoffman, G. J. 1977. Crop salt tolerance- Current assessment. *Netherland J. Irrigation Drainage*, 103(2): 115-134.

Mizrahi, Y. and Pasternak, D. 1985. Effect of salinity on quality of various agricultural crops. Plant and Soil Science. *Asian J. Plant Sci*., 89: 301-307.

Neel, J. P. S., Alloush, G. A., Belesky, D. P. and Clapham, W. M. 2002. Influence of rhizosphere ionic strength on mineral composition, dry matter yield, and nutritive value of forage chicory. *J. Agron. Crop Sci*., 188: 398-407.

Polara, K. B., Patel, M. S. and Kalyansundram, N. K. 2006. Salt affected soils of north-west agro-climatic zone of Gujarat: Their characterization and categorization. *J. Indian Soc. Coastal Agric. Res.,* 24(1): 52-55.

Savage, G. P. and Deo, S. 1989. The nutritional value of peas (Pisum sativum L.): a literature review. Nutr. Abst. Rev. 59: 66–83.

Sivritepe, N., Sivritepe, H. O. and Eris, A. 2003. The effects of NaCl priming on salt tolerance in melon seedlings grown under saline conditions. *Sci. Hort.*, 97: 229-237.

Sonneveld C. 1988. Salt tolerance of greenhouse crops. *Netherlands J. Agric.. Sci.*, 6(3): 3-73.

Tandon, H. L. S. 1995. Methods of analysis of soils, plants, water and fertilizer. Methods of Analysis of Soils, Plants, Waters, Fertilizers and Organic Manures. Fertilizer Development and Consultation Organisation, New Delhi-110 048, India.

United State Department of Agriculture (USDA). 2011.Soil Quality Indicator: Soil Electrical Conductivity; Natural Resources Conservation Services: United State.

Yang, J. E., Lee, W. Y., Ok, Y. S. and Skousen, J. 2009. Soil nutrient bioavailability and nutrient content of pine trees (Pinus thunbergii) in areas impacted by acid deposition in Korea. *Environ. Monitor. Assess.*, 157: 43-50.

Yoon, Y., Ok, Y. S., Kim, D. Y. and Kim, J. G. 2004. Agricultural recycling of the by-product concentrate of livestock wastewater treatment plant processed with VSEP RO and bio-ceramic SBR. *Water Sci. Technol*., 49: 405-412.

Zhang, W., Li, J., Dong, J., Wang, Y., Xu, L., Li, K., Yi, X., Zhu, Y. and Liu, L. 2021. Rssos1 responding to salt stress might be involved in regulating salt tolerance by maintaining na+ homeostasis in radish (*Raphanus sativus* l.). *Horticulturae, 7*(11). https://doi.org/10.3390/horticulturae7110458.