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Salt Tolerance of Papaya (*Carica papaya*), Indian Spinach (*Basella alba* L.) and Okra (*Abelmoschus esculentus*) in the South Central Coastal Region of Bangladesh

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Abstract: A study was conducted on saline tolerant vegetables with their mineral constituents for nutritional security during July 2020 to June 2021. Edible portions of the three summer vegetables, such as papaya, Indian spinach and okra were collected from Barguna and Patuakhali districts. The locations were Sawdagarpara, Taltoli, Barguna district, Pakhimara of Khepupara upazila and Dumki of Patuakhali district. Sawdagarpara (saline soil, EC=6.2 dSm^{-1}), Taltoli, Barguna district and Pakhimara (saline soil, EC=3.8 dSm^{-1}), Khepupara, Patuakhali district were selected as the saline areas and Dumki (non-saline soil, EC=0.9 dSm^{-1}), Patuakhali was a non-saline area on the basis of soil EC levels. The vegetables were analyzed for P, K, Ca, Mg and S. In saline areas, comparatively lower accumulations of P and higher accumulations of K, Ca, Mg and S were found in non-saline areas. Considering the achieved findings, studied vegetables can tolerate moderate salinity (soil EC value up to 6.2dSm^{-1}) and they can be recommended to grow commercially in the study area for nutritional security. The accumulation trend in the vegetables was Ca>Mg>P>K>S. On the basis of total mineral ingredients, the trend of vegetables was found to be Indian spinach> papaya> okra. Therefore, the study recommended that *Carica papaya*, *Basella alba* L. and *Abelmoschus esculentus* are the moderately saline tolerant vegetable crops.

Key words: Soil salinity; Coastal area; Summer vegetables; Mineral ingredients.

INTRODUCTION

Bangladesh is a small deltaic country with a population of 132.9 million having an area of 1, 47,570 square kilometers (BBS, 2005). Landless and marginal farmers are the most disadvantaged and vulnerable group suffering from insecurity of food and nutrition. The main cause of malnutrition is low availability and consumption of vegetables. In Bangladesh per capita vegetable consumption is only 28 gm as against the daily requirement of 200g (Chadha *et al.*, 1994). Including potato and sweet potato is only about 70 g. More than 30,000 infants become blind every year due to vitamin A deficiency. This situation aggravates when any natural disaster occurs in any area. Plant species vary in how well they tolerate salt-affected soils. Some plants will tolerate high levels of salinity, while others can tolerate little or no salinity. The relative growth of plants in the presence of salinity is termed their salt tolerance. Electrical conductivity is the ability of a solution to transmit an electrical current. Although quantitative information on crop salt tolerance exists for over 130 crop species. The salt tolerance of vegetable species is important because the cash value of vegetable is usually high compared to field crops (Shannon and Grieve, 1999).

There is acute scarcity of vegetables in the south-central coast of Bangladesh. Vegetables are to bring from other parts of the country to meet up the daily requirement in the southern coastal region. The salt tolerance of vegetable species is important because the cash value of vegetables is usually high compared to field crops (Shannon and Grieve, 2013). The southern coastal area is facing disaster frequently. One and half million hectares are taken out of production each year as a result of high salinity levels in the soil (Munns and Tester, 2008). Efforts should be made to grow saline tolerant vegetable cultivars suitable for this region. The salt-laden soils alone have significant global dimension as almost one billion hectares spread in more than 100 countries are suffering from this abiotic stress

(Banyal *et al.*, 2019). The coastal area covers about 20% of the country and over thirty percent of the net cultivable area and is affected with varying degrees of soil salinity (SRDI, 2003). In Bangladesh, the average per capita daily vegetable intake is 56g, whereas the recommended intake is 250g per day (FAO, 2015).

Papaya may help reduce the risk of alzheimer's disease, protect against certain types of cancer, boosts the immune system, potentially protects the heart, aid in lowering blood sugar, plays a role in fighting inflammation, may help to protect the eyes and improves digestion (Higuera, 2019). Indian spinach leaves are very common kitchen garden vegetable grown in mostly coastal regions of India. They are having a fleshy and slimy texture. Indian spinach helps to boost up digestion, strong bone & teeth, keeps heart healthy, aids immunity, delays ageing, treats urinary infections, bright eyes, cures bowels and mouth ulcers, good for skin, beneficial for pregnancy and lactating mothers. The mucilaginous and fiber rich leaves along with stems help in proper digestion. It is alkaline and neutralizes any acidity problems. Pui shaak is rich in Vitamin B12, Vitamin B6, Folic acids and calcium. Leafy vegetables such as Indian spinach is rich source of dietary fiber has demonstrated benefit for health maintenance, disease prevention and as a component of medical nutrition therapy (Islam *et al.*, 2004). The main physiological effects of dietary fiber are improved bowel function (Spiller *et al.*, 1980). Okra is rich in vitamin A and C as well as antioxidants that help reduce the risk of serious health conditions like cancer, diabetes, stroke, and heart disease. Okra is also a good source of Magnesium (Brennan, 2020). The nutritional security of the study area will more or less depend upon the sustainable saline tolerant vegetable cultivation. The present study was conducted to examine the salt tolerance and mineral ingredients of the studied vegetable.

MATERIALS AND METHODS

Vegetable and soils were collected during July 2020 to June 2021 from three areas of Barguna and Patuakhali district. Edible portions of papaya, Indian spinach and okra and soil from each area were collected. The samples were brought to the laboratory, processed and preserved accordingly. The areas were Sawdagarpara, Taltoli, Barguna, Pakhimara, Khepupara, Patuakhali and Dumki, Patuakhali

The soil pH was determined in the Laboratory of Agricultural Chemistry, PSTU by the glass electrode pH meter. Ten gram of processed air dried soil was taken in a plastic container and 25 mL of distilled water was added to it. The suspension was stirred well several times and allowed to stand for about an hour. Then the electrode was immersed in the soil suspension and pH was measured (Jackson (1973).

The electrical conductivity (EC) of collected soil samples was determined electrometrically (1:5, soil: water ratio) by a conductivity meter. Ten gram of air dried soil was taken in a plastic container and 50 mL of distilled water was added to it. The suspension was stirred for 30 minutes intermittently and then allowed to stand for an hour. Then the electrical conductivity (EC) was determined (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. This was done in the Departmental Laboratory of Agricultural Chemistry and Central Laboratory, PSTU, Dumki, Patuakhali. 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 DISCUSSIONS

Papaya: Accumulations of P, Ca and Mg in papaya at different areas of Barguna and Patuakhali districts

The accumulations of P, Ca and Mg in papaya were ranged from 6418.3-7571.7 $MgKg^{-1}$, 19847.7-24042.0 $MgKg^{-1}$ and 12830.4-16332.3 $MgKg^{-1}$, respectively.

The maximum accumulations of both Ca and Mg in papaya were found at the highest EC level (EC 6.2 dSm^{-1} at Sawdagarpara) and the lowest was observed at Dumki. The uptake of P was found highest at the lowest soil EC level (EC 0.9 dSm^{-1} at Dumki) and the lowest was observed at Sawdagarpara (Figure 1).

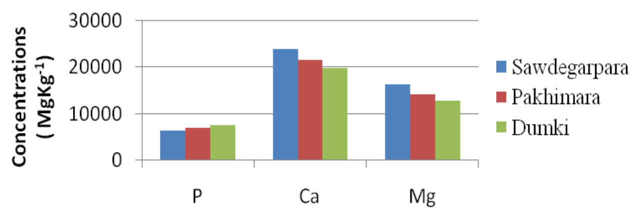

Figure 1. The accumulation of mineral ingredients in papaya in study areas

Potassium and S accumulations in papaya at different areas of Barguna and Patuakhali districts

The accumulations of both K and S in papaya were ranged from 56.0-68.0 $MgKg^{-1}$ and 645.0-810.0 $MgKg^{-1}$. The maximum accumulation of both K and S was found at the highest EC level (EC 6.2 dSm^{-1}) at Sawdagarpara and the lowest was observed at the lowest EC level (EC 0.9 dSm^{-1}) at Dumki (Figure. 2). In papaya the trend of mineral

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accumulation was Ca> Mg>P>S>K. Papaya is moderately tolerant to soil salinity. The effect of salinity on plants may vary among species and even among genotypes of the same species (Sa *et al*., 2013). Water used for irrigation in semiarid regions of the world is not always of good quality, and may contain higher salt levels that inhibit plants from growing. This study was conducted to evaluate the growth of papaya (*Carica papaya* L.)

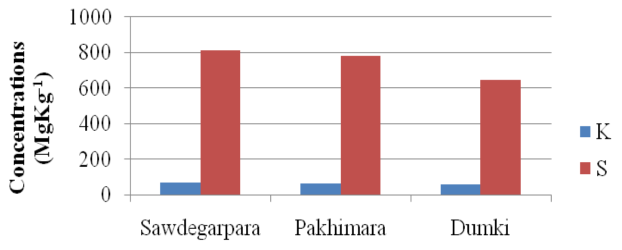

Figure 2. Minerals in papaya in study areas

Indian spinach: Accumulations of P, Ca and Mg in Indian spinach in different areas of Barguna and Patuakhali districts

The accumulations of P, Ca and Mg in Indian spinach were ranged from 4807.9-5053.4 MgKg^{-1}, 39842.2-41082.4 MgKg^{-1} and 38124.0-39123.4 MgKg^{-1}, respectively.

The highest accumulations of both Ca and Mg in Indian spinach were found at the highest EC level (EC 6.2 dSm^{-1} at Sawdagarpara) and the lowest was at Dumki. The uptake of P was found highest at the lowest soil EC level (EC 0.9 dSm^{-1} at Dumki) and the lowest was observed at Sawdagarpara (Figure. 3).

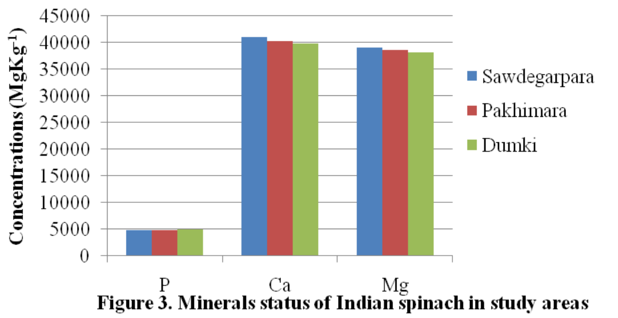

Figure 3. Minerals status of Indian spinach in study areas

Potassium and S accumulations in Indian spinach in different areas of Barguna and Patuakhali districts

The accumulations of both K and S in Indian spinach were ranged from 126.8-148.3MgKg^{-1} and 1042.4-1168.6 MgKg^{-1}. The maximum accumulation of both K and S was found at the highest EC level (EC 6.2 dSm^{-1} at Sawdagarpara) and the lowest was observed at the lowest EC level (EC 0.9 dSm^{-1} at Dumki) (Figure. 4). In Indian spinach, the trend of mineral accumulation was Ca>Mg>P>S>K.

The threshold level for spinach between 7 to 10 dSm-1 for water salinity, and from 5.6 to 8.9 dS m^{-1} for soil salinity (https://researcherslinks.com › current-issues › html). As per consumption pattern of Indian spinach, leaf and stem were mixed together. All the growth parameters of the crop were significantly improved for treated water except for the plant height. Carbohydrate, protein, fat, total dietary fiber (TDF) and energy increased (1.06, 2.76, 0.15, 3.21 g/100 g and 23.09 Kcal/100 g) with treated water than control and saline water while ash content (2.04 g/100 g) decreased than saline water. The pH, EC, Na, K, S, Fe and Mg of the soil decreased markedly by applying treated water and other nutrients present in the soil also varied (Farzana *et al*., 2019).

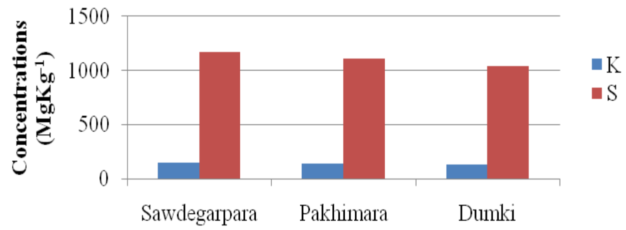

Figure 4. Minerals in Indian spinach in study areas

Okra: Accumulations of K, Ca and Mg in okra at different areas of Barguna and Patuakhali districts

Okra:

The accumulations of K, Ca and Mg in okra were ranged from 198.8-282.5 MgKg^{-1}, 123.4-192.3 MgKg^{-1} and 178.6-230.1 MgKg^{-1}, respectively. The highest accumulations of K, Ca and Mg all in okra were found at the highest EC level (EC 6.2 dSm^{-1} at Sawdagarpara) and the lowest was observed at Dumki (Figure. 5). Okra accumulated a higher amount of K than other elements and this might be due to its salinity tolerance at moderate level.

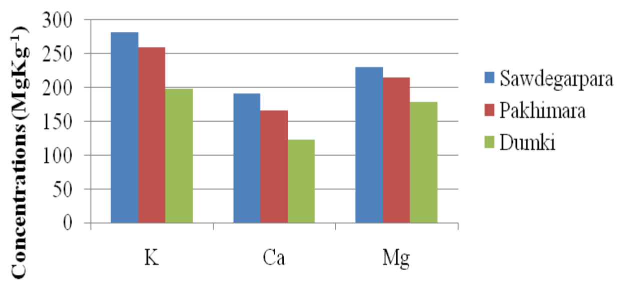

Figure 5. Minerals status of okra in study area

Accumulations of P and S in okra at different areas of Barguna and Patuakhali districts

The accumulations of P and S in okra were ranged from 54.2-84.5MgKg^{-1} and 41.3-57.6 MgKg^{-1}. The maximum accumulation of P was found at the lowest EC level (EC 0.9 dSm^{-1} at Dumki) and the lowest was observed at the highest EC level (EC 6.2 dSm^{-1} at Sawdagarpara). The highest accumulation of S was observed at the highest EC level (EC 6.2 dSm^{-1} at Sawdagarpara) and the lowest was observed at the lowest EC level (EC 0.9 dSm^{-1} at Dumki) (Figure. 6). In okra the trend of mineral accumulation was K>Mg>Ca>P>S.

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Little information is available in the literature on how far different physiological and biochemical attributes in okra are regulated by salt stress. Some key biochemical and physiological parameters were studied in two okra cultivars, which may provide an insight into the mechanism of salt tolerance in okra under varying levels of NaCl stress. Okra is one of the potential vegetable crops and is widely grown in all parts of the tropics, including temperate regions. It is classified as a moderately salt tolerant vegetable crop (Saleem *et al*., 2011).

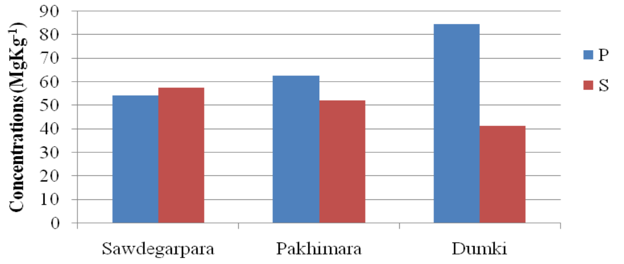

Figure 6. Minerals status of okra in study area

Accumulations of total mineral ingredients in vegetable at different areas of Barguna and Patuakhali districts.

Total mineral ingredients were accumulated highest in Indian spinach in both the conditions and the lowest was in okra. On the basis of total accumulation, the descending trend was found as Indian spinach>papaya>okra (Figure. 7).

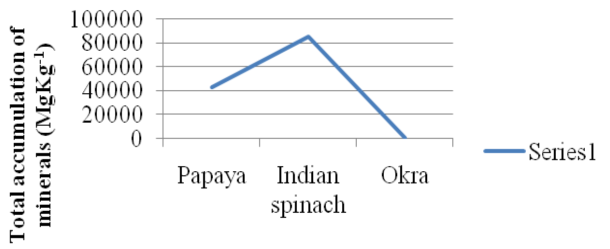

Figure 7. A comparison of vegetables on the basis of accumulation of total minerals

CONCLUSION

Edible portions of papaya, Indian spinach and okra were collected from Sawdagarpara (saline soil, EC 6.2 dsm^{-1}), Taltoli, Barguna district, Pakhimara (saline soil, EC 3.8 dsm^{-1}) of Khepupara upazila and Dumki (non-saline soil, EC 0.9 dsm^{-1}) of Patuakhali district. Higher accumulations of K, Ca, Mg and S were obtained in saline areas, whereas P accumulation was increased with the decrease of soil salinity for each vegetable. In both papaya and Indian spinach, the trend of mineral accumulation was Ca>Mg>P>S>K. Mineral ingredients were accumulated higher at the highest EC level in every vegetable, which might be due to their salt tolerance capability. Okra accumulated remarkably high amount of K than other elements might be due to its salinity tolerance and physiology. In okra, the trend of mineral accumulation was K>Mg>Ca>P>S. The trend of vegetables was found to be Indian spinach > papaya > okra in terms of total mineral content. Therefore, papaya, Indian spinach and okra may be recommended as moderately saline tolerant vegetable crops and may be cultivated in the south central coastal region of Bangladesh.

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