

Effect of Salinity on Growth, Yield and Quality of Sweet Potato (*Ipomoea batatas*)

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Abstract

Agriculture faces three way problems in the Sundarban blocks of South 24 parganas district of West Bengal. These are soil salinity, late release of land for *rabi* crop due to poor drainage system along with low percolation rate, and poor irrigation facility as the ground water is saline. In this perspective, it was imperative to find out a crop which can tolerate salinity to some extent and can grow without irrigation. Sweet potato being a crop which can grow without irrigation, the present investigation was made to find out the threshold salinity level for growing sweet potato in the saline rice fallow of Sundarbans. It was observed that this crop could be grown successfully at a salinity level upto EC 2.37 dS/m. With gradual increase in salinity level, the initial herb growth was well but root development became poor. Although a satisfactory yield and a profitable return was obtained upto a medium soil salinity level.

Key words : Salinity, Sweet potato, Sundarban, Yield, Growth.

In the southern parts of South 24 Parganas district of West Bengal especially in Sundarbans, the agriculture faces three way hindrances. These are soil salinity, late release of land for *rabi* crop due to poor drainage system along with low percolation rate, and poor irrigation facility as the ground water is saline. The farmers of this region have less mobility in crop selection for the *rabi* season after *aman* paddy. In this crop selection process, one should keep in mind that the crop should bear the following characters i.e. it should survive in water stressed condition, can tolerate soil salinity to some extent and can protect the soil from direct sun by covering the soil surface, thus minimizing soil salinization process. Keeping these in mind, sweet potato was selected to observe its potential performance in this area. Ahn (1) reported that the sweet potato is sensitive to drought at the tuber initiation stage i.e. 50—60 days after planting. But, unlike other crops, sweet potato can grow well in any type of problematic soil with or without irrigation facility as sweet potato is a drought tolerant crop (2). In sundarban soil, sweet potato has enough scope because sundarban has its own peculiarity with respect to its salinity development. It is observed that just after harvesting of paddy particularly in the month of December, there is very little or

no salinity in the soil. But with time when the upper surface of the soil starts drying, some of the plots become saline due to the upward movement of saline ground water. In this situation, planting of sweet potato vines immediately after harvest of *aman* paddy, can save both the soil and the crop as well. Sweet potato is a good economic crop in this situation, as it provides some monetary return at that time when no other crop was possible. It is also used as a green fodder during March to May, when scarcity of green fodder is acute in this region. In Sundarbans situation, sweet potato was tried sporadically, particularly by the farmers, for the last five to seven years and huge tuber production was recorded in the less sa-

Table 1. Soil nutrient status of eight treatments.

Treatments	pH	EC (dS/m)	OC (%)	N ₂ (kg/ha)	P ₂ O ₅ (kg/ha)	K ₂ O (kg/ha)
T ₁	7.04	1.63	0.86	563.6	89.7	443.5
T ₂	6.86	1.85	0.78	542.9	79.6	451.6
T ₃	6.98	2.06	0.81	556.1	83.4	411.8
T ₄	6.82	2.26	0.80	510.7	80.5	403.2
T ₅	6.88	2.37	0.84	537.4	78.8	436.2
T ₆	7.01	2.49	0.80	513.5	81.3	468.8
T ₇	6.92	2.58	0.76	532.2	78.2	423.6
T ₈	7.02	2.70	0.85	560.6	85.9	431.7

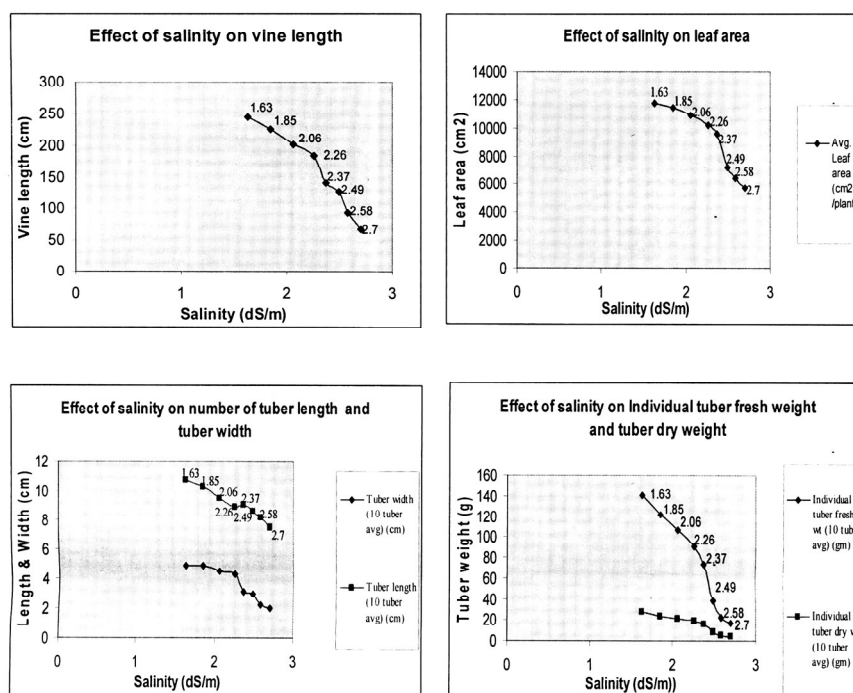


Figure 1. Effect of salinity on vine length, leaf area, number of tuber, tuber width, tuber weight of sweet potato.

line plots ($EC < 2.37$ dS/m). In quite higher saline plots ($EC > 2.37$ dS/m) the herb growth was good, but tuber production was not satisfactory. In this condition, a systematic study was essential to find out the threshold level of salinity tolerance of sweet potato as no systematic study in this respect has been carried out till date. In the present investigation, the salinity tolerance potential of sweet potato has been observed for better and greater advocacy for the farming communities of Sundarbans and other salinity affected areas.

Methods

Present investigation was carried out at the Instructional farm of Ramkrishna Ashram Krishi Vigyan Kendra, Nimpith. Eight different plots having eight different salinity levels were selected for conducting this experiment. All the eight plots had more or less similar nutritional and pH level (Table 1). Each of the eight plots was again sub-divided into three parts and each part was treated as one replication. The variety of sweet potato used in this experiment was cv Shree Vardhini, which was collected from AICRP, Tu-

ber crops, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. Thus, in each treatment (salinity level) three number of plots were developed and totally twenty four number of plots were prepared.

Each plot was of 8 m in width and 10 m in length. In each plot, vine cutting of 45 cm length was planted at 45 cm \times 60 cm spacing. Thus in each plot approximately 300 numbers of cutting were planted. Planting of vine was done on 5 February, 2010. In

Table 2. Weather data during the investigation period (2009-2010). Source : KVK meteorological observatory, RAKVK, Nimpith.

Months	Temperature (C)		Rain-fall (mm)	Relative humidity (%)	
	Maximum	Minimum		Maximum	Minimum
Dec 2009	228.8	10.0	—	94.5	29.5
Jan 2010	27.5	10.2	—	93	26
Feb 2010	32.5	11.9	—	98	26
Mar 2010	38.5	21.5	—	98	23
Apr 2010	39.5	22.6	4.0	99	30
May 2010	38.6	23.0	180.5	99	31
Jun 2010 (1st week)	37.4	22.7	96.4	99	51

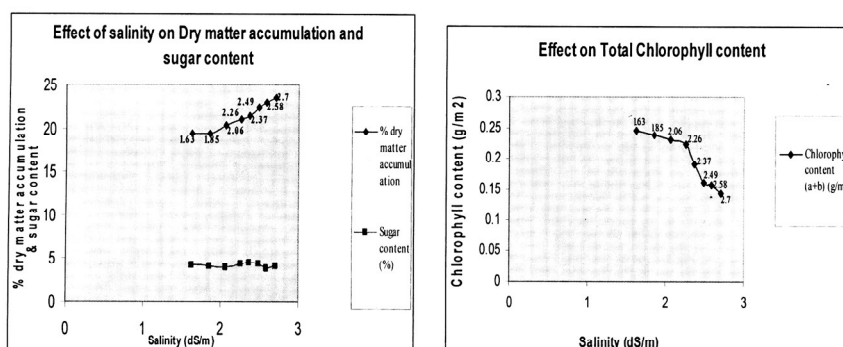


Figure 2. Effect of salinity on dry matter accumulation, sugar content and total chlorophyll content of seet potato.

each plot only 160 kg well rotten organic manure (FYM at 20 t/ha) was applied. No chemical fertilizers were applied in the experimental plots. The crop was grown as rainfed and no irrigation was applied. There was very little rain during the crop period. The meteorological data is given below (Table 2).

Observations were recorded from ten representative plants selected randomly from each replication on the different characters viz. vine length (cm), number of primary branches, leaf area (cm²) per plant, number of tuber per plant, tuber length (10 tuber av in cm), tuber width (10 tuber av in cm), individual tuber fresh weight (10 tuber av in g), Individual tuber dry wt (10 tuber av in g), percent dry matter, yield per plant (g), yield/ha, total chlorophyll (g/m²) of leaf and total sugar (%) of tuber.

Leaf area was calculated by multiplying number

of leaf in the plant and average individual leaf size. Total chlorophyll was calculated by addition of the amount of chlorophyll *a* and chlorophyll *b*. Sample leaf was extracted in 80% acetone and absorption was read at 663 nm and 645 nm in a spectrophotometer for chlorophyll *a* and chlorophyll *b* respectively. Using the absorption coefficients, the amount of chlorophyll was calculated (3). Reducing sugar was calculated as per Nelson-Somogyi method. All the data were analyzed by standard ANOVA procedure for randomized block design.

Results and Discussion

Effect of Salinity on Vine Length and Leaf Area

The vine length of sweet potato was significantly influenced by the EC level of the soil. The vine

Table 3. Effect of different salinity levels on yield and yield attributing characters.

Treatments	Vine length (cm)	No. of primary branches	Av leaf area (cm ²)/plant	No. of tuber per plant	Tuber width (10 tuber av) (cm)	Tuber length (10 tuber av) (cm)	Yield per plant (g)	Yield per hectare (t/ha)
T ₁	244.4	5.8	11740	5.1	4.87	10.75	716.12	26.50
T ₂	226.3	5.1	11460	4.9	4.92	10.32	594.86	22.01
T ₃	201.9	4.9	10930	5.0	4.53	9.46	534.00	19.76
T ₄	184.3	4.8	10210	4.8	4.26	8.88	435.98	16.13
T ₅	140.5	5.7	9600	5.7	3.11	9.01	419.98	15.54
T ₆	127.0	6.6	7210	6.7	2.94	8.57	254.40	9.41
T ₇	93.4	7.1	6410	6.9	2.19	8.14	155.46	5.75
T ₈	68.1	5.7	5730	7.3	1.98	7.49	127.17	4.71
SE (±)	3.64	0.8	81.9	0.12	0.17	0.19	15.21	1.21
LSD (P = 0.05)	11.5	2.6	248.6	0.4	0.58	0.62	48.25	3.94

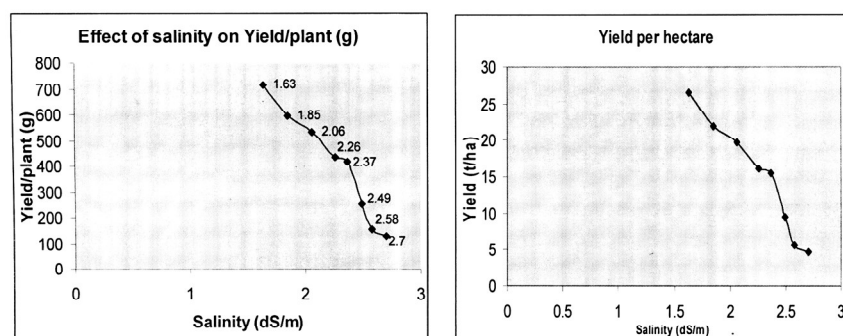


Figure 3. Effect of salinity on yield per plant (g) and yield per hectare (t/ha).

length of the plant decreased significantly with the increase in EC level of the soil. In the present experiment, minimum vine length was recorded 68.1 cm where EC level was the highest (2.70 dS/m) and the maximum (244.4 cm) with lowest EC level (EC 1.63 dS/m). Here, pH, organic carbon, available nitrogen, phosphate and potash had insignificant variation in different treatment levels. Therefore, it can be concluded that only the EC was limiting factor on the growth of the vine (Fig. 1).

Leaf area significantly reduced with the increasing EC level from 1.63 to 2.70 dS/m and the lowest leaf area (5730 cm²) was observed in treatment 8 (EC 2.70 dS/m, Table 3). Both vine length and leaf area/plant were negatively correlated with the salinity present in soil.

Thus the growth of vine, number of leaf per plant and individual leaf size of sweet potato were highly influenced by EC status of the soil. Higher EC level caused hindrance for the growth and development of sweet potato which confirmed the importance of low to medium salinity for better growth and development of the plant.

Effect on Number of Primary Branches per Plant

Table 3 shows that number of primary branches was not significantly influenced by the level of salinity of the soil (Fig. 1).

Effect on Number of Tubers per Plant and Tuber Width

Number of tubers per plant and tuber width showed typical response to salinity (Fig. 1). There

was no significant difference in number of tubers per plant upto the salinity level EC 2.26 dS/m (T₄, Table 1), after that it increased gradually with the increase of salinity level. It might be due to a physiological pressure which imparted upon the plant due to high salinity inducing the plant to bear more number of tubers, as individual tuber size was becoming low with increase in salinity.

Tuber width also showed no significant differences upto the salinity level EC 2.26 dS/m (T₄, Table 1), after that it decreased with the increase in soil salinity level. These traits had direct correlation with marketable yield. Slender tuber not only reduced the total yield but, it had lower market price also.

Table 4. Effect of different salinity levels on quality characters of sweet potato tubers.

Treatments	Individual tuber fresh wt (10 tuber av) (g)	Individual tuber dry wt (10 tuber av) (g)	Percent dry matter accumulation	Chlorophyll content (a+b)/ (g)	Sugar content (%)
T ₁	140.5	27.31	19.44	0.245	4.28
T ₂	121.4	23.62	19.46	0.239	4.11
T ₃	106.8	21.68	20.29	0.231	3.95
T ₄	90.83	19.05	20.97	0.223	4.42
T ₅	73.68	16.01	21.45	0.191	4.53
T ₆	37.97	8.52	22.44	0.162	4.36
T ₇	22.53	5.16	22.90	0.157	3.89
T ₈	17.42	4.09	23.48	0.145	4.07
SE (±)	3.64	0.91	0.28	0.02	0.23
LSD (P=0.05)	10.56	2.85	0.89	0.06	0.72

Effect on Tuber Length

The tuber length of the plant decreased significantly with the increase in EC level of the soil. In the present experiment, minimum tuber length was recorded (7.49 cm) where EC level was the highest (2.70 dS/m), and the maximum tuber length (10.75 cm) was recorded with lowest EC level (EC 1.63 dS/m). The experimental results clearly indicate that the tuber length of the sweet potato significantly influenced by the EC status of the soil. With increase of EC level of soil, the tuber length reduced sharply. The quality of tubers, therefore, severely hampered when the crop was cultivated in soils having high salinity (Fig. 1).

Effect on Individual Tuber Fresh Weight, Tuber Dry Weight and Percent Dry Matter Accumulation

Table 4 shows that individual tuber fresh weight and tuber dry weight was significantly influenced by the salinity status of the soil. Individual tuber fresh weight and tuber dry weight had significantly reduced with the increasing EC level from 1.63 to 2.70 dS/m. The highest individual tuber fresh weight (140.5 g) was observed at the lowest EC level (1.63 dS/m) and the lowest individual tuber fresh weight (17.42 g) was observed at the highest soil salinity level (EC 2.70 dS/m). In the salinity (EC) level beyond 2.37 dS/m, the tuber yield per plant reduced drastically, which implied that the level of salinity might have the threshold limit for tuber yield of the sweet potato. High EC level of the soil (> 2.4 dS/m) severely hampered the tuber growth and yield of the sweet potato confirming the range of EC for successful cultivation of the crop (Fig. 1).

In high EC level (>2.4dS/m) of the soil the tuber yield of the crop decreased but surprisingly the dry matter accumulation increased. In high saline soil the dry matter accumulation of the tuber becomes significantly higher than low saline soil (EC level <2.4dS/m). The results show that the high salinity level may minimize the capability of the plants to store the moisture in the tuber or limiting the function of different enzymes involved in storage of moisture to the tubers (Fig. 1).

Effect on Total Chlorophyll and Sugar Content of Tuber

The results indicate that the total chlorophyll content (a + b) (g/m^2) of sweet potato was highly influenced by the EC level of the soil (Fig. 2). The level of chlorophyll content decreased with the increase in EC level of the soil. The maximum total chlorophyll content (0.245 g/m^2) was observed at lowest salinity level of the soil (EC 1.63 dS/m) and lowest total chlorophyll content (0.145 g/m^2) was observed at the highest salinity level (EC 2.70 dS/m) of the soil. The chlorophyll content of the leaf have significant correlation with the tuber fresh weight, tuber dry weight and tuber yield of the crop indicating that, by influencing the chlorophyll synthesis, the salinity of the soils influenced the tuber yield of the sweet potato. The result also indicated total sugar content of the tuber of the sweet potato has not influenced by the salinity of the soil.

Effect of Salinity on Tuber Yield

The results showed that salinity plays a key role on the tuber yield of sweet potato (Fig. 3). The tuber yield of the crop is increasing with the lower salinity level of the soil. The tuber yield of the crop is significantly reduced in the soil where EC level > 2.37 dS/m and the best soil for the cultivation of sweet potato was observed where the EC level of the soil was around 1.85 dS/m. This finding is in close proximity with the findings of Greig and Smith (4) who concluded that the threshold level of soil salinity for successful sweet potato cultivation is 1.5 dS/m. The results also indicate that tuber yield of sweet potato is directly correlated with the vine length, leaf area per plant, amount of chlorophyll synthesis on leaf per unit area.

Conclusion

It may be inferred that the salinity of the soil has significant influence on tuber yield of sweet potato and the sweet potato is a crop which can tolerate medium soil salinity. The salinity of the soil significantly influences macro and micro-nutrient uptake and transportation and by that way it may control photosynthesis, source-sink transportation, pho-

tosynthates accumulation in different storage organs (tuber) and other physiological activities which are directly related to tuber yield of the plants. Further, the sweet potato can be grown profitably in coastal and saline belts of Sundarbans as a rainfed crop without irrigation where the EC level of the soil do not exceed 2.37 dS/m and availability of soil nitrogen, phosphate, potash and organic carbon is medium to high. But the crop cannot be recommended for profitable cultivation in the areas where the salinity level (EC) of the soil goes beyond 2.40 dS/m.

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