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Performance of Sweet Potato Genotypes under Island Ecosystem of Andaman

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Abstract

Field experiments were conducted for two consecutive rabi seasons during 2013 - 15 in natural saline soils at farmers' fields in South Andaman district, Andaman & Nicobar Islands. The experimental soils are acidic, saline and moderate in fertility status. Four white fleshed genotypes (Samrat, Kishan, Sree Bhadra and Pusa Safed) and 2 orange fleshed genotypes (ST-14 and CIP-440127) of sweet potato were evaluated under Island ecosystem of Andaman. Among the genotypes, Samrat has recorded significantly highest mean tuber yield in both the locations at Chouldari Gram Panchayat of South Andaman (15.18 & 16.12 t ha^{-1}, respectively) followed by CIP-440127 (13.45 & 14.43 t ha^{-1}, respectively). Significantly highest vine yield was recorded by Samrat at both the locations (16.69 & 16.62 t ha^{-1}, respectively). The harvest index was also found to be highest in the genotype Samrat at both the locations (47.6 and 49.2%, respectively) followed by CIP-440127 (45.7 and 48.9%, respectively). Significantly highest dry matter (27.35 and 26.63%) and starch content (17.67 and 18.38%) were observed in Kishan, while the total sugars ranged from 2.93 - 3.53 % and 2.86 - 3.28% in respect of both the locations of Andaman. Significantly higher uptake of N (151 & 180 kg ha^{-1}) and P (19.43 and 22.06 kg ha^{-1}) was recorded in Samrat at both the locations. Highest K uptake was observed in the genotype CIP-440127 (198 kg ha^{-1}) followed by Samrat (184 kg ha^{-1}) at location-1, while it was highest in Samrat (194 kg ha^{-1}) at location-2 followed by CIP-44017 (185 kg ha^{-1}). The pH of the soil showed no significant variation at the time of harvest of the crop, whereas the soil salinity (ECe) rose up to 14.2 and 12.1 dS m^{-1} at location 1 and 2 from the initial level of 5.15 and 4.53 dS m^{-1} respectively. A decreasing trend of mean organic C and available N at location-1 and no variation in location-2; however, an increasing trend of available P & K from the initial status were observed at both the locations. The DTPA extractable Zn was found to decrease after the second cropping season over the initial status of 1.48 and 2.72 mg kg^{-1} at both the locations. Thus, the results indicated that the performance of Samrat and CIP-440127 were superior to other genotypes under Island ecosystem of Andaman.

Key words: Island ecosystem, sweet potato, yield, proximate composition, soil quality.

Introduction

Agriculture is the first human activity and represents the major use of land across the world (Galvani, 2007). Some emerging strategies to enhance food production involves increasing yield and cropping intensities, genetic modification which may involve converging strategies of seed and germplasm preservation and improvement, and/or developing strategies for use of degraded and wastelands for arable lands (Bruce, 2012). Salinity is one of the most widespread soil degradation processes on the earth. Soil salinisation is regarded as a major cause of desertification and therefore is a serious form of soil degradation being salinisation and sodification among the major degradation processes endangering the potential use of cultivable soils. Salinity stress negatively impacts agricultural yield throughout the world affecting the production of agricultural crops. The plant response to salinity stress consists of numerous processes that must function in coordination to alleviate both cellular hyperosmolarity and ion disequilibrium (Yokoi et al., 2002).

It has been estimated that about one billion ha of land is affected by salinity, 60% of which is cultivated (Goyal *et al*., 2003). Andaman & Nicobar Islands is a conglomeration of 570 islands, situated at a longitude of 92° - 94°E, 6° - 14°N latitude, having a coastal line stretch of 1,962 km with a total geographical area of 8249 sq. km, out of which only 6% area is meant for agriculture. The soils of Andaman & Nicobar Islands have developed under the dominant influence of vegetation and climate over diverse parent materials. The soils adjacent to coastal areas are subjected to inundation with tidal saline water and developed on peaty sulphidic mud clays and sands which are subject to tidal flooding (Mongia et al., 1993). The saline soils of Andaman & Nicobar Islands occupy an area of 77,000 ha constituting 9.3 per cent of the total geographical area (Mandal et al., 2010). The territory consists of two distinctive group of islands namely, Andaman in an area of 6,34,000 ha and Nicobar in an area of 1,95,100 ha (Murthy, 2007).

Soluble salts most commonly present in the saline soils are the chlorides and sulphates of sodium, calcium and magnesium. Nitrates may be present rarely in appreciable quantities. Sodium and chloride are by far the most dominantions, particularly in highly saline soils, although calcium and magnesium are usually present in sufficient quantities to meet the nutritional needs of crops. Many saline soils contain appreciable quantities of gypsum ($CaSO_4$, $2H_2O$) in the profile. Soluble carbonates are always absent. Salt content of these soils is generally low i.e. 2 - 3 dS m^{-1} during rainy season due to dilution effect of heavy rains and rose upto 10 - 40 dS m^{-1} during summer (Abrol et al., 1980). pH of these soils varies from 5.0 - 8.0 and exchangeable Na dominated by 18 - 27 % followed by Mg and Ca. Excess salts interfere with plant nutrition by affecting nutrient availability, uptake, or their physiological role within the plant. Intensive use of chemical fertilizers is being practiced for enhanced crop production, which has become cost intensive and beyond the reach of resource poor farmers. It is inevitable to reduce the doses of inorganic nutrients and to use various organic sources especially in this era of organic agriculture that can sustain the crop productivity and to reduce the negative impact of excessive use of chemical fertilizers. The soil salinity is one of the major factors that limits the spread of plants in their natural habitats. It is an ever-increasing problem in arid and semi arid regions (Shanon, 1986).

The property of salinity tolerance is not a simple attribute, but it is an outcome of various features that depend on different physiological interactions, which are difficult to determine. The morphological appearance presented by the plant in response to salinity, may not be enough to determine its effect, so it is important to recognize other physiological and biochemical factors, including toxic ions, osmotic potential, lack of elements and other physiological and chemical disorders, as well as the interactions between these various stresses. The increase in fresh weight of the shoot system may be due to the ability of the plant to increase the size of its sap vacuoles, which allows for the collection of a lot of water, and this in turn dissolves salt ions that have accumulated and leads to the subsequent increase in fresh weight (Munns, 2002).

Sweet potato is a high energy containing but low input crop. Screening of sweet potato germplasm against salinity is one of the acceptable methods to select better varieties / lines for saline soil. Root growth of sweet potato is much more sensitive to salinity stress than vine growth resulting in low crop productivity (Greig and Smith, 1962). It is very difficult to maintain a desirable level of salinity under field conditions. As salinity level in field is sporadic, it differs greatly in the same field (Philip and Bradley, 2001). So, screening of salt tolerant genotypes under the field condition is very difficult. The studies in coastal saline soils representing Odisha, West Bengal and Andhra Pradesh revealed that some of the genotypes, Pusa Safed, Samrat, CIP-440127 and Kishan were tolerant to moderate salinity under natural habitat (Laxminarayana, 2012; Laxminarayana et al., 2012; Laxminarayana and Burman, 2014). In the present investigation, promising genotypes of sweet potato were evaluated for their yield, and proximate composition as well as to enhance the total farm productivity in natural saline soils under Island ecosystem of Andaman.

Materials and Methods

Field experiments were conducted for two consecutive rabi seasons during 2013-15 in natural saline soils at farmers' fields of Shri. Biswanath Majumdar from Lalpahar village (Location-1) and Shri. D. Madhu of Chouldari

Village (Location-2), Chouldari Gram Panchayat of South Andaman district, Andaman & Nicobar Islands in collaboration with ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman. Initial composite soil samples were collected from both the locations, processed and analyzed for physico-chemical properties. The experimental soil at location-1 is acidic (pH 5.29), saline (ECe 5.15 dS m^{-1}), and having 1.95 % organic C, 326, 54.0, and 139 kg N, P_2O_5, and K_2O ha^{-1}. The experimental soil from location-2 is acidic (pH 4.77), saline (ECe 4.53 dS m^{-1}), and having 0.90% organic C, 215, 84.0, and 147 kg N, P_2O_5, and K_2O ha^{-1}. The trials were laid out with 4 white-fleshed genotypes (Samrat, Kishan, Sree Bhadra and Pusa Safed) and 2 orange-fleshed genotypes (ST-14 and CIP-440127) of sweet potato replicated thrice in a randomized block design. Well rotten farmyard manure (containing 0.64, 0.26, and 0.48% N, P, and K, respectively) was applied @ 5.0 Mg ha^{-1} well in advance of planting. The vine cuttings were treated with chloropyriphos 20% EC before planting. An uniform dose of N @ 50 kg ha^{-1} in the form of urea in three equal splits at 0, 30 and 45 days after planting (DAP), P_2O_5 @ 25 kg ha^{-1} as single super phosphate at basal and K_2O @ 50 kg ha^{-1} as muriate of potash in two equal splits at 0 and 45 DAP were applied. Vine cuttings of different genotypes were planted at a spacing of 60 x 20 cm. All the cultural practices were followed as per schedule. The crop was harvested at 120 DAP and yield parameters like vine length, tubers per plant, average tuber weight, tuber yield and vine yield were recorded. Soil samples were collected after harvest of the crop, shade dried, pounded and analyzed for physico-chemical properties (Page et al., 1982). It was observed that the soil sanity (ECe) rose up to 14.2 and 12.1 dS m^{-1} in respect of both the locations of Andaman. The salinity shoot up at the time of harvest is due to capillary movement of salts along with water molecules in the process of evapotranspiration and the salts gets entrapped in the surface soil lead to rise in the salinity levels. However, the pH showed an increasing trend with the crop growth period.

Tubers were washed thoroughly with distilled water, sliced, oven dried, and dry weights were recorded. Total sugars in the tuber samples were estimated in the alcohol filtrate and the starch was determined in the residue as per the procedure outlined by Moorthy and Padmaja (2002). The oven dried tuber and vine samples were ground, digested in conc. H_2SO_4 and analysed for N content by steam distillation (Humphries, 1956). Plant samples were digested in diacid mixture (HNO_3 & $HClO_4$, 7:3) and total P and K were estimated. Uptake of N, P and K was computed by multiplying nutrient content with respect to tuber and vine yields (dry weight), computed the uptake of nutrients. The data was analyzed statistically and computed critical difference values for comparison and interpretation of data.

Results and Discussion

Tuber and vine yield

Among the genotypes, Samrat has recorded significantly highest mean tuber yield (Table 1) in both the locations of Andaman (15.18 & 16.12 t ha^{-1}, respectively) followed by CIP-440127 (13.45 & 14.43 t ha^{-1}, respectively) and Sree Bhadra (12.80 & 13.38 t ha^{-1}, respectively). Significantly highest mean vine yield was recorded in Samrat at both the locations (16.69 & 16.62 t ha^{-1}, respectively) and was at par with Sree Bhadra (16.48 & 15.66 t ha^{-1}, respectively). The harvest index was also found to be highest in the genotype Samrat at both the locations (47.6 and 49.2 %, respectively) followed by CIP-440127 (45.7 and 48.9%, respectively). Thus, the results indicated that Samrat, CIP-440127 and Sree Bhadra were found tolerant to salinity stress under Island ecosystem of Andaman & Nicobar Islands as revealed from the previous studies in coastal saline soils of West Bengal (Laxminarayana and Burman, 2014). Though the initial salinity did not affect the crop growth and establishment, the increase of salinity levels during formation of tuberous roots and tuber bulking stages severely affected by salinity stress during summer months resulted in poor performance of the crops. Some of the genotypes are able to produce higher root biomass which could be able to absorb soil moisture and nutrients from surface as well as deeper layers and withstand for shoot up of salinity levels due to the mechanisms like minimizing evapotranspiration, balancing the osmotic potential, stomatal conductance and expanded leaf area.

Proximate composition

Significantly highest mean dry matter (27.35 and 26.63%) was observed in Kishan at both the locations of Andaman (Table 1) and was at par with Samrat (26.51 and 25.63%) and Pusa Safed (25.67 and 25.45%, respectively). Significantly highest mean starch content (17.67 and 18.38 %) was recorded by Kishan (Table 1) in both the locations

Table 1. Performance of sweet potato genotypes under Island ecosystem of Andaman (mean of 2 years)

Genotype	Tubers $plant^{-1}$	Tuber wt. (g)	Tuber yield ($t\ ha^{-1}$)			Vine yield ($t\ ha^{-1}$)			Harvest Index (%)	Starch (%)	Sugars (%)	Dry matter (%)
			2013-14	2014-15	Mean	2013-14	2014-15	Mean				
Location-1												
1. ST-14	1.73	153.60	10.39	7.74	9.07	15.18	11.22	13.20	40.70	16.67	2.99	25.20
2. Kishan	2.50	165.33	13.54	10.03	11.78	17.50	13.16	15.33	43.50	17.67	3.53	27.35
3. Samrat	2.62	195.40	18.32	12.05	15.18	19.11	14.28	16.69	47.60	16.77	3.18	26.51
4. Pusa Safed	2.14	159.35	15.01	9.60	12.31	17.72	12.56	15.14	44.80	16.81	3.00	25.67
5. Sree Bhadra	2.19	145.52	15.83	9.77	12.8	18.13	14.84	16.48	43.70	16.81	3.18	24.87
6. CIP-440127	2.43	185.45	16.23	10.66	13.45	19.22	12.79	16.00	45.70	17.19	2.93	25.82
CD ($P=0.05$)	0.34	34.39	0.83	0.86	0.64	1.54	0.93	1.16	-	1.27	0.40	1.36
Location-2												
1. ST-14	1.75	147.98	11.99	8.81	10.40	14.90	8.99	11.94	46.60	17.36	2.86	25.24
2. Kishan	1.89	179.92	14.17	11.57	12.87	16.73	11.87	14.30	47.40	18.38	3.28	26.63
3. Samrat	2.18	173.78	19.04	13.20	16.12	20.30	12.93	16.62	49.20	16.86	3.02	25.63
4. Pusa Safed	1.74	155.10	15.09	11.65	13.37	17.79	10.79	14.29	48.30	16.71	2.91	25.45
5. Sree Bhadra	1.84	137.48	16.08	10.68	13.38	18.33	12.99	15.66	46.10	15.94	2.87	25.02
6. CIP-440127	2.09	173.6	16.46	12.41	14.43	18.91	11.30	15.10	48.90	16.69	2.91	25.05
CD ($P=0.05$)	0.30	23.26	1.15	0.91	1.15	1.19	1.38	1.11	-	1.12	0.31	1.55

of Andaman. Total sugars ranged from 2.93 - 3.53 % and 2.86 - 3.28 % in respect of Location-1 and Location-2.

Significantly higher amount of total sugars (3.53 & 3.28 %) and dry matter (27.35 & 26.63 %) were observed in Kishan at both the locations of Andaman. Relatively lower amount of dry matter contents was observed in Sree Bhadra under salinity stress at both the locations of Andaman.

Nutrient uptake

Significantly highest total uptake of N was recorded in Samrat at both the locations of Andaman (151 & 180 kg ha^{-1}) (Table 2) and was at par with CIP-440127 (143 kg ha^{-1}) at location-1 and Pusa Safed (170 kg ha^{-1}) at location-2. Significantly highest P uptake was observed with Samrat (19.43 and 22.06 kg ha^{-1}) at both the locations followed by CIP-440127 (18.54 and 18.39 kg ha^{-1}) and Kishan (16.40 and 18.25 kg ha^{-1}). The variety CIP-440127 recorded highest total uptake of K (198 kg ha^{-1}) at Location-1 followed by Samrat (184 kg ha^{-1}) and Kishan (172 kg ha^{-1}). However, the genotype Samrat has recorded highest total uptake of K (194 kg ha^{-1}) at Location-2 followed by CIP-44017 (185 kg ha^{-1}) and Kishan (168 kg ha^{-1}). The results indicated that CIP-440127 and Samrat has the ability to absorb more K nutrition which helps in the genotypes to tolerate salt stress against the deleterious effects of Na. Under salinity stress condition, maintenance of K^+ level is essential for plant survival, as most of the physiological activity is going on in the shoot (Farida Begum et al., 2015). Sweet potato plantlet try to survive by transporting more K^+ to maintain the K^+ level in the shoot and less Na^+ to the shoot as Na^+ was toxic.

Physico-chemical properties

The pH of the soil increased to 5.34 from the initial level of 5.29 at location-1, whereas it increased to 5.17 from the initial level of 4.77 at location-2 after the second cropping season (Table 3). The mean soil salinity (ECe) at location 1 & 2 rose up to 14.2 and 12.1 dS m^{-1} at the time of harvest of the crop from the initial level of 5.15 and 4.53 dS m^{-1}, respectively. It was noticed that

Table 2. Nutrient uptake of sweet potato genotypes under Island ecosystem of Andaman (mean of 2 years)

Genotype	Uptake in tubers (kg ha^{-1})			Uptake in vines (kg ha^{-1})			Total nutrient uptake (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K
Location-1									
1. ST-14	32.65	5.21	45.92	77.73	8.24	96.41	110.40	13.44	142.40
2. Kishan	42.81	7.38	56.79	78.38	9.01	115.51	121.20	16.40	172.30
3. Samrat	50.04	9.24	68.44	101.09	10.19	115.12	151.20	19.43	183.60
4. Pusa Safed	38.91	6.56	50.40	87.21	9.50	109.74	126.10	16.06	160.10
5. Sree Bhadra	42.23	7.30	55.90	85.15	8.50	107.41	127.40	15.80	163.30
6. CIP-440127	50.02	9.27	74.56	92.79	9.27	123.21	142.80	18.54	197.70
CD (P=0.05)	9.00	1.70	9.65	13.74	1.46	15.66	11.04	2.53	22.06
Location-2									
1. ST-14	39.42	6.31	42.58	96.11	8.83	97.59	135.50	15.14	140.20
2. Kishan	50.68	8.20	56.20	109.65	10.05	111.72	160.30	18.25	167.90
3. Samrat	55.36	10.29	71.24	124.26	11.76	123.18	179.60	22.06	194.40
4. Pusa Safed	44.68	8.07	58.67	124.93	9.40	105.56	169.60	17.47	164.20
5. Sree Bhadra	48.07	7.87	56.78	109.91	10.31	105.94	158.00	18.18	162.70
6. CIP-440127	52.53	9.47	77.47	103.41	8.92	107.44	155.90	18.39	184.90
CD (P=0.05)	8.29	1.54	8.93	12.90	1.26	10.40	14.23	2.17	16.52

Table 3. Soil physico-chemical properties as influenced by sweet potato genotypes under Island ecosystem of Andaman (After harvest of 2nd crop)

Genotype	pH	EC (dS m^{-1})	Org. C (%)	Available nutrient (kg ha^{-1})			Available micro nutrient (mg kg^{-1})			
				N	P_2O_5	K_2O	Fe	Cu	Mn	Zn
Location-1										
Initial	5.29	2.06	1.95	326.10	54.00	139.60	28.46	0.89	28.76	1.48
1. ST-14	5.34	5.70	1.74	289.90	136.40	154.90	35.03	0.81	40.47	1.15
2. Kishan	5.26	5.77	1.79	273.70	138.10	163.60	31.24	0.73	40.51	1.12
3. Samrat	5.30	5.60	1.68	284.70	155.40	165.10	36.72	0.87	35.75	1.21
4. Pusa Safed	5.24	5.65	1.49	269.90	146.30	168.50	38.37	0.86	39.48	1.09
5. Sree Bhadra	5.24	5.77	1.83	265.00	146.60	164.30	37.63	0.89	38.79	0.99
6. CIP-440127	5.19	5.51	1.65	272.40	145.40	168.00	38.93	0.90	41.14	1.07
Mean	5.26	5.67	1.70	275.90	144.70	164.10	36.32	0.84	39.36	1.11
CD (P=0.05)	0.16	0.67	0.32	23.43	14.81	14.85	8.78	0.32	5.10	0.24
Location-2										
Initial	4.77	1.81	0.90	215.40	84.00	146.70	30.45	1.76	45.32	2.72
1. ST-14	5.15	4.79	0.88	190.30	154.00	174.10	48.30	1.70	62.61	1.89
2. Kishan	5.13	4.89	0.92	192.10	156.00	181.50	45.51	1.84	63.13	1.90
3. Samrat	5.12	4.88	0.89	194.40	155.60	180.50	43.11	1.93	66.91	1.83
4. Pusa Safed	5.12	4.80	0.97	194.10	163.40	177.60	43.73	1.71	61.09	1.89
5. Sree Bhadra	5.10	4.77	0.82	184.50	154.10	176.50	47.97	1.97	57.80	1.88
6. CIP-440127	5.17	4.85	0.93	216.80	157.50	176.40	45.32	1.98	65.79	1.84
Mean	5.13	4.83	0.90	195.40	156.80	177.80	45.66	1.86	62.89	1.87
CD (P=0.05)	0.07	0.54	0.22	23.90	10.92	10.71	5.85	0.24	8.99	0.33

the mean organic C at location-1 decreased to 1.70%, however, no change in the mean organic C was observed at location-2. The mean available N significantly decreased to 276 kg ha^{-1} from the initial level of 326 kg ha^{-1} at location-1 and whereas at location 2, it decreased to 195 kg ha^{-1} from the initial status of 215 kg ha^{-1}. The available P content in both the locations significantly improved over the initial status of the soils as the applied P fertilizers get accumulated in these acid soils. A significant improvement in available K status was observed in the soils of both the locations over that of initial status. It seems that the crop requirements were partly met from the released K and both the applied K and released K brought out available K build up in the soil.

The mean available Fe content (Table 3) was found to increase significantly to 36.32 and 45.66 mg kg^{-1} from the initial status of 28.46 and 30.45 mg kg^{-1} at location-1 and 2, respectively. Similarly the mean available Mn content was increased to 39.36 and 62.89 mg kg^{-1} from the initial status of 28.76 and 45.32 mg kg^{-1} at location-1 and 2, respectively. Higher levels of both Fe & Mn contents in the soils were observed which may be due to the nature of parent materials on which the soils formed and the influence of soil forming factors. The available Cu content in the soils at both the locations was also found higher than the critical limit of 0.2 mg kg^{-1}. The DTPA extractable Zn was found to decrease after the second cropping season over the initial status of 1.48 and 2.72 mg kg^{-1} at both the locations. The available Zn content in all the plots was found to be higher than the critical limit of 0.60 mg kg^{-1}, which might be due to residual accumulation of Zn that was applied @ 10 kg ha^{-1} in the preceding crops.

Conclusion

In conclusion the genotypes of sweet potato i.e. Samrat and CIP -440127 were found tolerant to salinity stress under Island ecosystem of Andaman considering their yield performance, proximate composition and nutrient uptake especially the uptake of K in tubers and vines. These genotypes can be exploited in the saline lands of Andaman for sustainable production of sweet potato for food and nutritional security.

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