The Agriculturists 11(1): 95-102 (2013) ISSN 2304-7321 (Online), ISSN 1729-5211 (Print)
A Scientific Journal of Krishi Foundation ***Indexed Journal***

Screening of Salt Tolerant CIP Potato Germplasm for Saline Areas

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Received: 8 February 2013 Accepted: 18 May 2013

Abstract

Fifteen salt tolerant CIP (International Potato Centre) Potato genotypes along with BARI (Bangladesh Agricultural Research Institute) Alu 7 (Diamant) and one local variety viz., Dohazari Sada were evaluated at Bashkhali, Chittagong during 2011-12 to screen the suitable genotypes for cultivation in saline areas of Bangladesh. Diamant and Dohazari Sada and all of the CIP genotypes were found to grow well up to 60 DAP (Days After Planting) at saline areas having healthy plants and no senescence was noticed but after that 61-100% plants died due to high level of soil salinity (6.41dS/m) depending on genotypes. Genotype CIP 112 gave the highest yield (21.07 t/ha) and CIP 102 was comparatively less affected by soil salinity than the other genotypes. However, all the salt tolerant CIP genotypes were found to be promising in the saline soil.

Keywords: **Potato, salt tolerant, yield contributing characters, germplasm**

1. Introduction

Potato (*Solanum tuberosum* L.) belongs to the family Solanaceae. The genus Solanum contains more than 1,000 species, of which almost 230 are tuberiferous. *Solanum tuberosum* is the only world wide distributed species (Hawkes, 1992). The potato originated and was first domesticated in the Andes Mountains of South America 7,000-10,000 years ago. Although it is an old crop, it did not spread much beyond South America until the late 16th century when the Spaniards brought potato to Europe. From Europe, it gradually expanded to Asia, Africa, North America and all other parts of the world in the next 200 years. In the last 50 years, it has become an indispensable crop in the developing world because of its short life cycle and high return. Potato is a unique crop for its high yield, good nutritional value and versatile uses such as French fries, Chips and other pre-fried potato products.

At present, Bangladesh is producing 8 to 10 million tones of potatoes per year. In the year 2009-10, potato ranked 2nd among the best 20 commodities in terms of international price from the produce (FAOSTAT, 2010), which indicated that potato is the 2nd most important commodity in Bangladesh in terms of output. Bangladesh is holding 8th position in world ranking and 3rd position in Asia in respect of potato production. Potato is the 3rd most important food crop next to rice and wheat. In the recent years, the production of potato has increased tremendously (Table 4). There is a wide scope of increasing acreage including coastal area and production of potato in the country with improved production techniques and improvement of seed quality.

The coastal area covers about 30% of the country and it extends inside up to 150 km from the coast. Out of 2.85 million hectares of the coastal and offshore areas about 0.83 millions hectares

are arable lands, which cover over 30% of the total cultivable lands of Bangladesh (Anon, 2011-12). The cultivable areas in coastal districts (south and south western part of Chittagong, Barisal and Khulna divisions) are affected with varying degrees of soil salinity due to climate changes. In many of these areas the climatic conditions for potato growing is decreasing due to the rising of salinity. Hence, there is an ample scope to introduce salinity tolerant variety of potato in those areas. Therefore, the present investigation was undertaken to screen salt tolerant potato clones with the help of CIP, USAID Horticulture Project and Tuber Crop Research Centre, BARI for salt tolerant variety development.

2. Materials and Method

Fifteen salt tolerant CIP genotypes viz., CIP-101, CIP-102, CIP-104, CIP-108, CIP-111, CIP-112, CIP-117, CIP-120, CIP-124, CIP-126, CIP-129, CIP-130, CIP-134, CIP-137, CIP-139 along with BARI Alu 7 (Diamant) and one local variety (Dohazari sada) having salt tolerant potentials were evaluated at Bashkhali, Chittagong during December to March, 2011-12. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 3.0 m x 1.8 m. Fertilizers were applied as per recommendation (Mandal *et al*., 2011) @ 250-150-250-120 kg/ha of urea, TSP, MoP and Gypsum, respectively. Full amount of TSP, MoP and Gypsum and 50% of urea were applied as basal and the remaining amount of urea was side dressed 35 DAP. Tubers were planted on 11 December, 2011 with a spacing of 60 cm x 25 cm. Weeding, irrigation, earthing up and other intercultural operations were done as per recommendation developed by TCRC, BARI, Gazipur.

All data on yield and yield contributing characters were recorded. Data on sprouting percentage, plant vigour, number of compound leaves, plant height (cm), number of stem per plant, foliage coverage percent, senescence, tuber number per plot, tuber weight per plot (kg), tuber number per plant, tuber weight per plant (g), yield (t/ha) and dry matter content were collected. Plant vigour and senescence data were also recorded on 1-5 scale where, for vigour; 1= very poor, 2= poor, 3= good, 4= very good and 5= excellent plant vigour and for senescence; 1= 0-20%; 2= 21-40%, 3= 41-60%, 4= 61-80% and 5= 81-100% plant foliage dry (Anon, 2011-12). Tubers were also graded as marketable (>20 g) and non marketable (<20 g) by weight basis. In case of local variety Dohazari Sada; very small tuber (<5 g) was considered as non marketable tuber. Soil (within 1 inch depth from surface) salinity level of experimental plots was determined at planting time, germination stage, seedling stage, vegetative stage, tuber formation stage and harvesting stage with the help of a Digital EC meter (Model HI 98304 by HANNA, made in Mauritius) in the laboratory at Agricultural Research Station, Pahartali, Chittagong. Data were analyzed statistically and the means were separated by LSD following MSTATC software.

3. Results and Discussion

Tubers were harvested on 14 March, 2012. All the information and data of the experiment are presented in Tables 1, 2 and 3 and Figures 1 and 2. The yield and yield contributing characters of the studied variety and genotypes varied significantly. All the genotypes showed more than 85% emergence except CIP 104 & CIP 130. Considering plant vigour, CIP 102, CIP 134 and CIP 137 were the excellent, while CIP 117 & CIP 124 showed poor vigour. All the CIP genotypes had good number of compound leaves per plants ranging from 18 to 44.87 at 45 DAP and 24.53 to 61.20 at 60 DAP. The local variety Dohazari Sada had the highest number of compound leaves per plant (44.87 at 45 DAP and 61.20 at 60 DAP). Plant heights at 45 DAP varied significantly ranging from 16.80 to 36.53 cm. These results are closely related with Wikipedia (2012), where the reported potato plants are herbaceous perennials that grow upto 60 cm (24 inches) height, depending on variety.

Table 1. Sprouting, plant vigour, number of compound leaves, plant height, no. of stem per plant and foliage coverage percent of salt tolerant potato genotypes

Genotypes	Sprouting % at 45 DAP	Plant vigour at		No. of compound leaves at		Plant height at (cm)		No. of stem/plant at 60 DAP	Foliage coverage (%) at	
		45 DAP	60 DAP	45 DAP	60 DAP	45 DAP	60 DAP		45 DAP	60 DAP
CIP 101	86.10	3.00	4.33	19.90	24.60	25.40	41.40	2.33	33.33	63.33
CIP 102	97.22	4.00	5.00	18.00	36.04	25.80	49.20	2.80	63.33	90.00
CIP 104	74.07	2.67	4.00	19.93	28.26	16.80	43.07	2.87	33.33	63.33
CIP 108	88.88	3.00	4.00	24.60	38.67	25.87	43.87	4.00	40.00	71.67
CIP 111	99.07	3.67	4.67	38.00	50.20	26.87	49.33	4.87	53.33	81.67
CIP 112	98.14	4.33	4.67	50.33	61.20	21.00	39.13	8.13	50.00	80.00
CIP 117	98.14	3.33	3.67	27.60	30.13	22.07	34.00	4.47	35.00	60.00
CIP 120	94.36	4.00	4.00	22.40	25.47	20.80	33.00	2.73	45.00	63.33
CIP 124	84.25	2.67	3.67	26.60	35.80	23.07	43.40	4.20	40.00	70.00
CIP 126	98.14	4.33	4.33	41.13	47.07	30.87	45.60	5.00	60.00	76.67
CIP 129	91.66	3.00	4.00	26.40	29.20	23.47	38.13	4.07	41.67	71.67
CIP 130	25.92	4.00	4.00	24.57	27.46	33.20	43.37	2.67	43.33	70.00
CIP 134	88.88	3.67	5.00	34.80	35.93	36.53	44.87	4.20	53.33	85.00
CIP 137	98.14	4.33	5.00	40.47	38.07	29.67	42.93	5.47	56.67	80.00
CIP 139	99.25	4.33	4.67	21.13	24.53	24.67	39.00	3.27	58.33	80.00
Diamant	97.22	4.00	4.67	42.60	46.80	35.93	45.93	5.20	60.00	80.00
Dohazari sada	98.14	3.33	4.00	44.87	51.40	22.87	38.33	6.87	45.00	75.00
CV (%)	5.19	19.37	14.27	25.27	16.51	11.23	15.42	6.27	28.02	14.76
Level of significance	**	*	NS	**	**	**	NS	**	NS	NS
$LSD_{0.05}$	7.70	1.17	1.02	12.93	10.19	4.88	10.78	0.44	22.26	18.22

* and ** significant at 5% and 1%, respectively. DAP= Days after planting

Table 2. Senescence, number of tuber per plot and tuber weight per plot of salt tolerant potato genotypes

Genotypes	Senescence at		Tuber no./plot			Tuber wt. (kg) /plot		
	70 DAP	77 DAP	Marketable	Non Marketable	Total	Marketable	Non Marketable	Total
CIP 101	3.66	4.00	136.67	43.00	179.67	6.07	0.35	6.42
CIP 102	2.33	2.33	178.33	92.33	237.33	8.73	0.74	9.48
CIP 104	3.67	3.67	110.00	56.67	166.67	5.06	0.56	5.62
CIP 108	3.67	4.00	166.67	72.67	239.33	7.38	0.62	8.01
CIP 111	3.67	4.33	195.00	136.67	331.67	8.91	1.20	10.11
CIP 112	4.67	4.67	340.00	168.33	508.33	10.30	1.15	11.38
CIP 117	3.33	4.67	151.00	52.33	203.33	7.00	0.52	7.51
CIP 120	4.00	4.67	163.33	37.33	200.67	7.90	0.32	8.19
CIP 124	3.00	4.00	129.00	60.33	189.33	6.33	0.62	6.96
CIP 126	3.00	5.00	180.00	85.33	265.33	8.00	0.90	8.90
CIP 129	3.33	4.00	124.67	52.67	180.67	5.65	0.56	6.21
CIP 130	3.67	4.00	59.67	21.00	80.67	4.28	0.21	4.50
CIP 134	3.33	3.33	190.00	119.33	309.33	7.80	1.15	8.96
CIP 137	3.33	4.67	176.67	143.33	320.00	6.43	1.51	7.96
CIP 139	4.33	4.33	123.67	46.33	170.00	8.00	0.47	8.47
Diamant	3.67	5.00	164.67	74.33	239.00	7.65	0.87	8.52
Dohazari sada	3.67	4.00	256.67	420.67	677.33	2.72	1.34	4.13
CV (%)	16.93	12.60	31.48	26.80	25.84	37.29	37.48	36.22
Level of significance	*	**	**	**	**	NS	**	NS
$LSD_{0.05}$	0.96	0.87	87.66	44.12	113.7	4.31	0.48	4.65

* and ** significant at 5% and 1%, respectively. DAP= Days after planting

Table 3. Tuber number per plant, tuber weight per plant, yield and dry matter of salt tolerant potato genotypes

Genotypes	Tuber no. /plant	Tuber wt. (g)/plant	Yield (t/ha)			DM %
			Marketable	Non Marketable	Total	
CIP 101	5.82	208.50	11.25	0.65	11.95	22.37
CIP 102	6.75	270.78	16.17	1.37	17.55	25.00
CIP 104	6.17	207.01	9.38	1.03	10.41	26.51
CIP 108	7.49	251.24	13.67	1.16	14.82	22.82
CIP 111	9.32	284.44	16.51	2.21	18.72	22.69
CIP 112	14.37	322.39	18.94	2.13	21.07	22.66
CIP 117	5.76	212.86	12.95	0.96	13.91	23.64
CIP 120	5.90	241.08	14.62	0.59	15.17	24.00
CIP 124	6.52	241.00	11.73	1.16	12.89	20.13
CIP 126	7.49	252.24	14.80	1.68	16.48	22.38
CIP 129	5.41	185.72	10.47	1.04	11.50	21.79
CIP 130	8.72	486.70	7.93	0.40	8.33	26.06
CIP 134	9.67	276.48	14.45	2.14	16.58	24.51
CIP 137	9.05	225.90	11.92	2.81	14.72	25.33
CIP 139	4.75	237.32	14.82	0.87	15.87	26.00
Diamant	6.80	242.79	14.17	1.61	15.78	18.08
Dohazari sada	19.13	116.33	5.04	2.48	7.64	32.67
CV (%)	24.51	33.06	37.29	37.49	36.15	1.20
Level of significance	**	*	NS	**	NS	**
$LSD_{0.05}$	3.33	139.9	7.9	0.89	23.05	0.47

* and ** significant at 5% and 1%, respectively.

Table 4. Area, production and yield of potato in Bangladesh in last 23 years

Year	Area (million hectares)	Production (million tons)	Yield (t/ha)	Year	Area (million hectares)	Productio n (million tones)	Yield (t/ha)
1989-90	0.117	1.07	9.16	2001-2002	0.237	2.99	12.62
1990-91	0.124	1.24	10	2002-2003	0.318	4.35	13.68
1991-92	0.128	1.38	10.78	2003-2004	0.367	5.31	14.47
1992-93	0.13	1.39	10.89	2004-2005	0.403	5.95	14.76
1993-94	0.131	1.44	10.99	2005-2006	0.373	5.38	14.42
1994-95	0.132	1.47	11.14	2006-2007	0.377	5.4	14.32
1995-96	0.131	1.5	11.45	2007-2008	0.396	5.27	16.31
1996-97	0.134	1.5	11.19	2008-2009	0.435	7.93	18.25
1997-98	0.137	1.56	11.39	2009-2010	0.435	7.93	18.25
1998-99	0.245	2.77	11.31	2010-2011	0.46	8.33	18.09
1999-2000	0.243	2.93	12.06	2011-2012	0.43	8.21	19.07
2000-2001	0.248	3.21	12.94	-	-	-	-

Source: BBS, 1990-2012

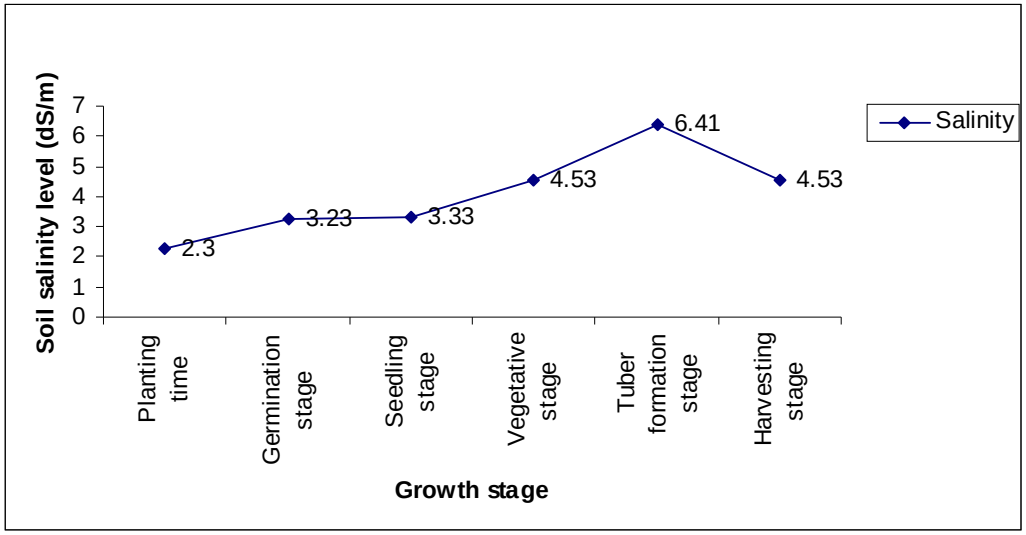

Fig. 1. Soil salinity level at different growth stages at the experimental plot in Bashkhali, Chittagong

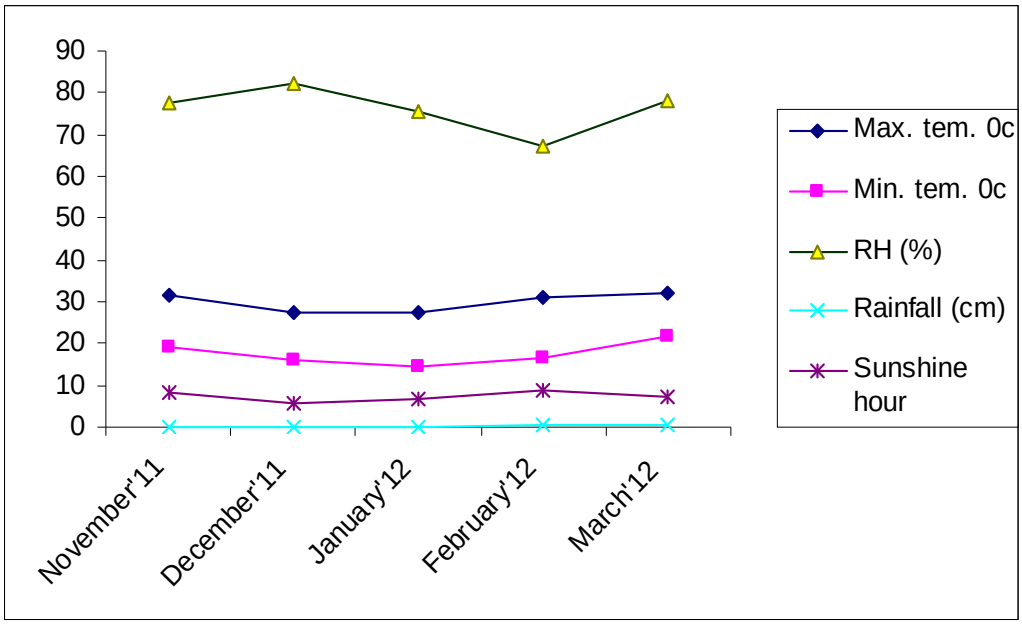

Fig. 2. Average weather data at different times of the crop season

Number of stems per plant was significant among the genotypes. The highest number of stem was found in the genotype CIP 112 (8.13). Percent ground foliage coverage showed significant variations among the genotypes (Table 1). Number and weight of tubers per plot also varied significantly among the genotypes. The highest number of tubers per plant as well as per plot was recorded in the local variety Dohazari sada. The lowest number of tubers per plant was recorded from CIP 139 (4.75). The highest weight per plot was obtained from CIP 112 (11.38 kg) while the lowest was recorded in CIP 130 (4.50 kg). Tuber weight per plant varied significantly among the genotypes and the highest weight was obtained from CIP 130 (486.7g), while the lowest was recorded from Dohazari sada (116.33g).

Among all the genotypes, CIP 112 was the best yielder (21.07 t/ha) while Dohazari sada contributed lowest yield (7.64 t/ha). CIP 112 (21.07 t/ha), CIP 111 (18.72 t/ha), CIP 102 (17.55 t/ha), CIP 134 (16.58 t/ha), CIP 126 (16.48 t/ha) and CIP 139 (15.87 t/ha) were also found to be promising and produced comparatively better yield than the popular variety Diamant (15.78 t/ha, Table 3). The potential yield of Diamant is 30 t/ha in Bangladesh situation (Mandal *et al*., 2011). These results are comparable to those reported in Wikipedia (2012) where it was reported that the average world farm yield for potato was 17.4 t/ha. Sekmen *et al*. (2007) reported that high concentrations of salt in soil causes large decreases in yields for a wide variety of crops all over the world. The level of soil salinity in the studied area during different stages of plant growth raised from electrical conductivity (EC) of 2.3 to 6.41 dS/m (Fig. 1), because soil salinity fluctuated with climatic variations viz., temperature, rainfall, relative humidity and sunshine hour etc. (Fig. 2) and soil moisture. These results are supported by Maas *et al*. (1977)

who described that cultivated potatoes are sensitive to soil salinity, with damage thresholds ranging from electrical conductivity of 1.5 to 3.0 dS m^{-1}). Salt tolerance of potato plants depends on light intensity and air humidity. Concentration of NaCl above 50mM was sufficient to cause growth restrictions and decrease tuber yield in various field-grown potato cultivars (Backhausen *et al.*, 2005). Tuber weight i.e. yield is the most important parameter of potato. Though the lowest yield was given by Dohazari sada but highest dry matter (32.67 %) was accumulated from the variety. Here, yield was comparatively lower in all the genotypes which might be due to salinity of the soil.

4. Conclusions

From the result, it is evident that in the coastal area of Bangladesh, soil salt decreases the tuber yield of potato. Considering the yield, CIP 112 (21.07 t/ha), CIP 102 (17.55 t/ha), CIP 111 (18.72 t/ha), CIP 126 (16.48 t/ha), CIP 134 (16.58 t/ha) and CIP 139 (15.87 t/ha)) were found promising against soil salinity of up to 6.41 dS/m EC.

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