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EFFECT OF ORGANIC AMENDMENTS ON GERMINATION AND YIELD OF POTATO UNDER SALINE CONDITION

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Abstract

A pot experiment was conducted at the Research Farm of Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during 2013-14 to find out suitable organic amendment(s) for increasing germination and yield of potato tubers under saline condition. Three levels of salinity (S_2= 4 dS/m, S_3= 8 dS/m and S_4= 12 dS/m) along with control (S_1) were included in the trial. Tubers of the variety Diamant were planted after placing four different organic amendments viz. A_1= saw dust, A_2= rice straw, A_3= ashes and A_4= rice bran around the tuber. Results revealed that at 20 DAP, the lowest emergence (16.67%) was recorded in the treatments, where ashes and rice bran were used with high salinity level (12 dS/m). At 25 DAP, 100% emergence was recorded in the treatments, where no salinity was imposed. More than 65% plants were emerged when salinity levels were 4 dS/m or 8 dS/m with any of the amendments used. Whereas, high salinity level (12 dS/m) was maintained and rice bran was used as amendment, the emergence was very low till 25 DAP (16.67%). The highest per plant yield was obtained from the interaction effect of S_1A_2 (401.00 g) followed by that of S_2A_2 (365.33 g), S_2A_3 (353.50 g), S_2A_1 (350.67 g), S_1A_3 (347.50 g), and S_1A_1 (343.33 g), S_3A_1 (330.67 g) and S_3A_2 (325.50 g). Therefore, using organic amendments like saw dust and rice straw, potato can be grown at a condition where salinity level is upto 8 dS/m.

Keywords: Organic amendments, salinity, potato, emergence, yield.

Introduction

Potato *(Solanum tuberosum)* is the second largest food crop in Bangladesh, but the southern region of the country is vegetable deficit area as mainly rice and some selected vegetables are cultivated in this region. Although, potato is one of them but the yield is very low compared to that in other growing areas of the country. Soil salinity is one of the most important constraints to grow potato with satisfactory yield (Sarder *et al.,* 2010). The horticulture industry frequently uses a standard of 2 dS/m to define saline water. While, the U.S. Department of Agriculture defines water with an EC greater than 4.0 dS/m as saline. Area under salinity is increasing day by day in our country. At present, the coastal region covers almost 29,000 km or about 20% of the country. Again, the coastal areas of Bangladesh cover more than 30% of the cultivable lands of the country. About 53% of the coastal areas are affected by salinity (Alam *et al.,* 2012). The factors which contribute significantly to the development of saline soils are tidal flooding during the dry season (June-October), direct inundation by saline or brackish water and upward or lateral movement of saline ground water during dry season (November-May) (Karim *et al.,* 1990). Salinity appears as a major problem in drought condition i.e., in Rabi season when potato or other Rabi crop

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is grown in our country. Ultimately, salinity along with drought condition hinders proper germination as well as growth of potato plant that finally affects on yield. In Rabi season, lands of these areas remain vacant and there is an ample scope of growing potato in these areas. This will meet up vegetable deficit of the coastal region as well as will increase farmer's income. Preliminary research in saline soils with straw or water hyacinth mulch in potato cultivation has been found suitable (Zaman *et al.,* 2008 ; Hossain *et al.,* 2010; Sardar *et al.,* 2010; Akhter and Begum, 2011). On the other hand, different potato varieties showed varied performance in saline soil (Akhter and Begum, 2011). So, there is an urgent need to assess the germination and yield performance of potato under different organic amendments in saline soil. But before setting up of experiment in field condition in saline areas, it is better to find out the performance in pot culture. Hence, the present investigation was undertaken to find out the suitable organic amendment(s) on germination and yield of potato tubers under saline condition.

Materials and Methods

A pot experiment was set up at the field laboratory of the Department of Horticulture, BSMRAU. All the 48 pots were filled each with 12 kg mixtures of 75% sandy loam soils and 25% cowdung. Therefore, salt solution was added upto field capacity. Three levels of salinity (S_2= 4 dS/m, S_3= 8 dS/m and S_4= 12 dS/m) along with control (S_1= 0 dS/m) were included in the trial. The salinity was maintained by adding required amount of salt solution (NaCl) in the soil to make desired levels. In the control treatment, only water was added. After applying the salt solution or water, when the soil in pots were suitable for planting; then one tuber of variety Diamant were planted per pot after placing four different organic amendments viz., A_1= saw dust, A_2= rice straw, A_3= ashes, and A_4= rice bran around the tuber to keep high moisture level and to enhance germination by reducing moisture loss/stress. Sufficient amount of amendments were used so that they make a full cover around the tubers. Randomized Complete Block Design was followed with three replications. Each pot represented a single replication. Recommended doses of fertilizers (Anon., 2012) was used in the trial. Full dose of TSP, MoP, Gypsum, $ZnSO_4$ and Boric acid and half of urea was used before planting and mixed with soil. Rest half of urea was applied as side dressing at 30 days after planting of tubers. As the organic amendments were used outside the tubers, so, there were no chance of contact between tubers and fertilizers. The experiment was set on 30 November 2013 and harvesting was done on March 02, 2014. Weeding, earthing up and other intercultural operations were done as and when necessary. During earthing up, 1.5 kg of soil was used in each pot. Data were collected on emergence at 10, 15, 20, 25, and 30 days after planting, plant vigor (1-9 scale), foliage coverage (%), plant height (cm), stems/hill at 60 DAP, number of compound leaf/plant, tubers/plant (number), tuber yield (g/plant) and grades of tubers (by % weight). The collected data were analyzed with MSTATC-C program and means were separated with Duncan's Multiple Range Test (DMRT) at 1% or 5% level of significance.

Results and Discussion

Emergence (%)

Significant effect of different levels of salinity was observed in emergence of potato tubers. The treatment where no salinity imposed was emerged earlier than all other treatments up to 25 DAP. At 30 DAP, 100% emergence

were recorded in all treatments. However, it was generally found that rate of emergence decreased with the increase of salinity level (Fig. 1). Levy (1992) also reported to have retarded plant emergence in potato with increased salinity levels.

Like salinity, organic amendments had significant effect on emergence of potato. The highest emergence was observed in saw dust at all days after planting followed by rice straw, ash and rice bran. At 25 DAP, although, the emergence was near to 100% but in rice bran it was less than 70% (Fig. 2). On the other hand, at 30 DAP, the emergence reached 100% in all treatments. Practically, it was observed that the treatments where rice bran was applied around the tubers during planting had a slower emergence. This might be due to the cementing characteristics of rice bran when saline solution was added. However, when the plants were emerged although at late, it did not affect afterwards.

Data regarding interaction of different levels of salinity and organic amendments are presented in Table 1. It is revealed from the table that the highest emergence at 10 DAP (83.3%) was recorded from the treatment S_1A_1, where saw dust was used as amendment without salinity. At 15 DAP, all plants were observed to be emerged in the same treatment but no plants were still emerged in the treatments S_3A_3, S_3A_4 and S_4A_4. At 20 DAP, the lowest emergence (16.67%) was recorded from S_4A_3 and S_4A_4, where ashes and rice bran were used with high salinity level (12 dS/m). At 25 DAP, full emergence was recorded in the treatments, where no salinity was imposed. More than 65% plants were emerged when salinity levels were 4 dS/m or 8 dS/m with any of the amendments used (Table 1). But when high salinity level (12 dS/m) was maintained and rice bran was used as amendment (S_4A_4), the emergence was very low till 25 DAP (16.67%). This implies the negative effect of high salinity on emergence of potato tubers when planted with rice bran as organic amendment. Levy *et al*. (1993) also obtained a negative effect of high salinity on emergence of potato. They set an experiment in 500 cm^3 pots with a salinity level of 3.2-7.0 dS/m and found some seed tubers rotted. They reported that plant growth was severely inhibited, possibly because soil aeration was impeded. Similar negative effects of salinity on crop growth has also been reported by other authors in different crops including

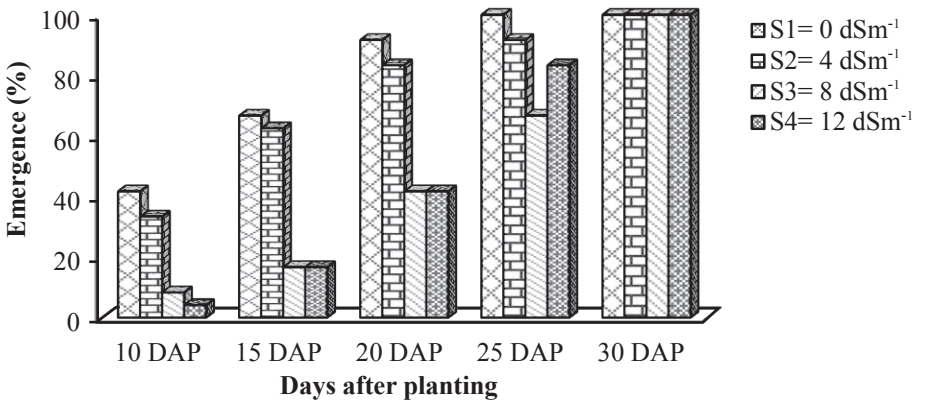

Fig. 1. Emergence of potato at different levels of salinity.

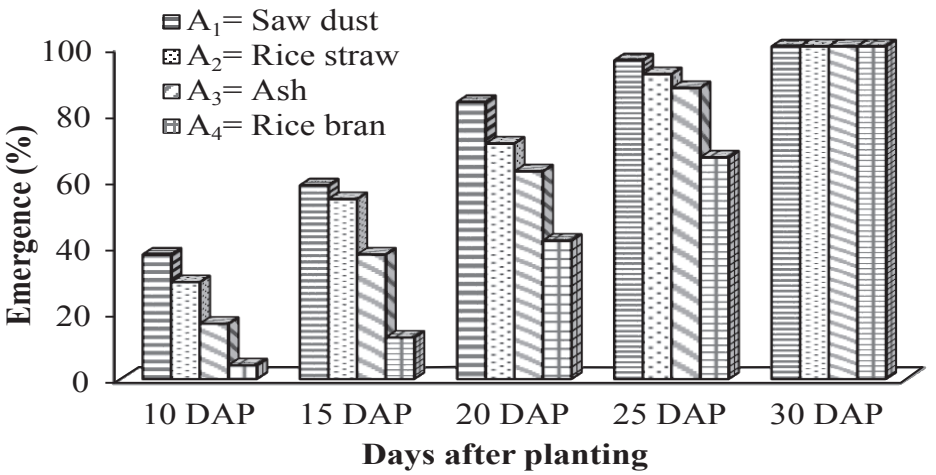

Fig. 2. Effect of organic amendments on emergence of potato at different days after planting.

Table 1. Interaction effect of salinity and organic amendments on emergence of potato at different days after planting

S × A	Emergence (%)				
	10 DAP	15 DAP	20 DAP	25 DAP	30 DAP
S_1A_1	83.33	100.00	100.00	100.00	100.00
S_1A_2	33.33	83.33	100.00	100.00	100.00
S_1A_3	33.33	66.67	100.00	100.00	100.00
S_1A_4	16.67	16.67	66.67	100.00	100.00
S_2A_1	66.67	66.67	100.00	100.00	100.00
S_2A_2	33.33	83.33	83.33	100.00	100.00
S_2A_3	33.33	66.67	83.33	83.33	100.00
S_2A_4	0.00	33.33	66.67	66.67	100.00
S_3A_1	0.00	33.33	66.67	83.33	100.00
S_3A_2	33.33	33.33	50.00	66.67	100.00
S_3A_3	0.00	0.00	33.33	100.00	100.00
S_3A_4	0.00	0.00	33.33	83.33	100.00
S_4A_1	0.00	33.33	66.67	100.00	100.00
S_4A_2	16.67	16.67	50.00	100.00	100.00
S_4A_3	0.00	16.67	16.67	66.67	100.00
S_4A_4	0.00	0.00	16.67	16.67	100.00
Mean	21.88	40.63	64.58	85.42	100.00
CV (%)	17.67	19.98	16.88	13.47	-
F-value	**	**	**	*	-

S= Salainity levels, A= Organic amendments, S_1= control, S_2= 4 dS/m, S_3= 8 dS/m and S_4= 12 dS/m; A_1= saw dust, A_2= rice straw, A_3= ashes and A_4= rice bran, **= Significant at 1% level and *= Significant at 5% level

potato (Levy, 1992; Zaman *et al.,* 2008 and Seyedbagheri and Neibling, 2013).

Yield contributing characters

Different yield contributing characters like plant vigor, foliage coverage, plant height, number of stems per hill and number of leaves per plant at 60 DAP of the studied potato varieties with different salinity levels and organic amendments are presented in Table 2, 3, and 4. At different salinity levels, plant vigour and other yield contributing parameters varied significantly. Plant vigor was found to be decreased with the increase of salinity. The highest foliage coverage was recorded from the control treatment (77.35%) followed by that in S_2, S_4 and S_3. Similar trend was also observed in other characters (Table 2). Chapin (1991) and Marschner (1995) reported that generally, plants are stressed in three ways in saline soils (a) low water potential of the root medium leads water deficit, (b) the toxic effects of the Na^+ and Cl^- and (c) nutrient imbalance by depression in uptake and/or shoot transport. On the other hand, Romero-Aranda and Syvertsen (1996) opined that toxic accumulation of Na^+ and Cl^- in the leaves has also been correlated with stomatal closure and reduction of total chlorophyll content in leaves both of which limit the amount of photosynthetic production. Regarding amendments, the highest plant vigour was recorded in rice straw (7.71) followed by saw dust (7.52), rice bran (6.69) and ash (6.62). The highest foliage coverage was recorded in saw dust (74.70%) and the lowest in ash (63.22%). Tallest plant was observed in rice bran (71.69 cm) and shortest from saw dust (62.38 cm). Number of stems per hill was found the highest in saw dust (6.54), which was statistically similar to rice straw but significantly differed with other two amendments. Number of leaf did not vary significantly (Table 3). Although, variation was found in case of single effect of the treatments but interaction effect of salinity × amendments on yield contributing parameters was found non-significant (Table 4).

Table 2. Effect of salinity on yield contributing characters of potato

Salinity Level (dSm^{-1})	Plant vigor (1-9 scale)	Foliage coverage (%)	Plant height (cm)	No. of stems/hill	No. of leaves/ plant
S_1= 0	7.42	77.35	67.99	6.00	17.04
S_2= 4	7.46	69.97	68.04	6.04	15.72
S_3= 8	6.87	65.79	62.74	4.62	14.39
S_4= 12	6.78	66.69	66.29	5.50	13.62
Mean	7.13	69.95	66.27	5.54	15.19
CV (%)	14.6	10.58	11.66	7.05	11.42
F-value	*	*	*	*	**

**= Significant at 1% level and *= Significant at 5% level

Table 3. Effect of organic amendments on yield contributing characters of potato

Amendments	Plant vigour (1-9 scale)	Foliage coverage (%)	Plant height (cm)	No. of stems/ hill	No. of leaves/ plant
A_1= Saw dust	7.52	74.70	62.38	6.54	15.73
A_2= Rice straw	7.71	73.12	68.57	6.17	16.25
A_3= Ash	6.62	63.22	62.43	4.58	13.91
A_4= Rice bran	6.69	68.76	71.69	4.87	14.87
Mean	7.13	69.95	66.27	5.54	15.19
CV (%)	14.6	10.58	11.66	7.05	11.42
Level of Significance	**	*	**	*	NS

**= Significant at 1% level, *= Significant at 5% level and NS= Non-significant

Table 4. Interaction effect of salinity and organic amendments on yield contributing characters of potato

S × A	Plant vigor (1-9 scale)	Foliage coverage (%)	Plant height (cm)	No. of stems/ hill	No. of leaves/ plant
S_1A_1	8.00	85.50	63.80	7.83	17.82
S_1A_2	8.25	76.50	71.87	6.50	17.88
S_1A_3	7.17	72.90	57.93	5.33	16.07
S_1A_4	7.75	74.52	61.97	4.33	16.38
S_2A_1	6.25	78.30	62.15	7.00	16.30
S_2A_2	8.17	77.40	72.23	6.83	18.98
S_2A_3	7.08	64.80	71.76	4.67	14.18
S_2A_4	6.67	59.40	66.04	5.67	13.42
S_3A_1	7.08	67.50	61.05	5.33	15.18
S_3A_2	7.17	74.70	64.90	5.33	15.55
S_3A_3	6.42	56.70	75.42	4.00	12.95
S_3A_4	6.47	64.26	63.80	3.83	13.87
S_4A_1	7.25	67.50	62.52	6.00	13.63
S_4A_2	7.25	63.90	65.27	6.00	12.58
S_4A_3	5.92	58.50	65.27	4.33	12.45
S_4A_4	7.25	76.86	74.32	5.67	15.80
Mean	7.13	69.95	66.27	5.54	15.19
CV (%)	14.6	10.58	11.66	7.05	11.42
F-value	NS	NS	NS	NS	NS

S= Salainity levels, A= Organic amendments, S_1= control, S_2= 4 dS/m, S_3= 8 dS/m and S_4= 12 ds/; A_1= saw dust, A_2= rice straw, A_3= ashes and A_4= rice bran, NS= Non-significant

Yield and grades of tubers

Although, salinity had no significant effect on number of tubers per hill but it had significant effect on tuber yield per plant and grades of tubers. In case of tuber yield per plant, the highest yield was recorded from the control treatment (371.21 g), where no salinity was imposed followed by 4dS/m (327.37 g), 8 dS/m (206.75 g) and 12 dS/m (182.46 g). Generally, yield was found to be decreased with the increase of salinity. Munira *et al.* (2015) and Maas (1986) also reported a negative correlation between yield and increasing salinity. Whereas, Rahman *et al.* (2008) opined that most of the crop plants including potato is intolerable to high salinity condition resulting decreased yield. These findings supported the result obtained from the present experiment. However, more than 300 g/plant yield was obtained from the treatments S_1 (371.21 g) and S_2 (327.37 g) (Table 5). This indicated that potato could be grown upto a salinity level of 4 dS/m without using any amendments. This differs with the findings of Katerji *et al*. (2003), who reported that salinity levels as low as 2.3 dS/m reduce both growth and tuber yield of potato. This difference of result might be attributed due to the difference of cultivars. Li *et al*. (2006) also stated similar opinion where they reported that the responses of potato cultivars and wild species to elevated levels of NaCl and Na_2SO_4 are variable.

Regarding grades of tubers, the maximum amount of (30.69%) small sized tubers (<28 mm) were produced when a salinity level of 8 dS/m was imposed and the minimum from the control treatment. The maximum amount of medium sized (28-55 mm) tubers were recorded from S_2, where a salinity of 4 dS/m was imposed (73.16%). Etehadnia (2009) reported that salinity affects adversely on tuber as well as total crop growth and development of many plants including potato, which might affect the proper growth of tubers resulting large quantity of small sized tubers. In case of organic amendment, although, no significant difference was found in number of tubers per hill, but significant differences were found in weight of tubers per hill, yield, and grades of tubers. However, the highest per plant yield was obtained from rice straw (311.87 g) followed by saw dust (287.79 g), ash (286.87 g) and rice bran (201.25 g) (Table 6). Statistically similar yield was obtained from rice straw, saw dust and ash amendments, impling the effectiveness of these amendments

Table 5. Effect of salinity on yield and grades of tubers of potato

Salinity Level (dSm^{-1})	No. of tuber/ plant	Tuber yield (g/plant)	Grades of tubers (by % wt.)		
			<28mm	28-55mm	>55mm
S_1= 0	12.33	371.21	10.15	72.81	17.04
S_2= 4	13.46	327.37	16.88	73.16	9.96
S_3= 8	11.71	206.75	30.69	68.04	1.27
S_4= 12	13.42	182.46	26.77	70.70	2.53
Mean	12.73	271.95	21.13	71.18	7.69
CV (%)	10.70	15.14	14.86	12.12	18.47
Level of Significance	NS	**	**	NS	**

**= Significant at 1% level and NS= Non-significant

Table 6. Effect of organic amendments on yield and grades of tubers of potato

Amendments	No. of tuber/ plant	Tuber yield (g/plant)	Grades of tubers (by % wt.)		
			<28mm	28-55mm	>55mm
A_1= Saw dust	12.62	287.79	13.96	82.05	3.99
A_2= Rice straw	13.79	311.87	19.34	72.60	8.06
A_3= Ash	13.29	286.87	19.52	67.10	13.38
A_4= Rice bran	11.21	201.25	31.68	62.97	5.35
Mean	12.73	271.95	21.13	71.18	7.69
CV (%)	10.70	15.14	14.86	12.12	18.47
F-value	NS	**	*	*	NS

**= Significant at 1% level, *= Significant at 5% level and NS= Non-significant

under saline condition. Regarding grades of tubers, higher amount of small sized tubers were obtained from rice bran (31.68%). The maximum amount of medium sized tubers were found in saw dust (82.05%) followed by that in rice straw (72.60%), ash (67.10%) and rice bran (62.97%). But the maximum amount of large sized (>55 mm) tubers were obtained from ash (13.38%). This might be due to supply of potassium by ash.

While considering the interaction between salinity and amendments, the highest per plant yield was obtained from the interaction effect of S_1A_2 (401.00 g) followed by that in S_2A_2 (365.33 g), S_2A_3 (353.50 g), S_2A_1 (350.67 g), S_1A_3 (347.50 g) and S_1A_1 (343.33 g), S_3A_1 (330.67 g), and S_3A_2 (325.50 g). These treatments yielded more than 300 g/ plant which suggesed that using organic amendments like saw dust and rice straw, potato can be grown at a condition where salinity level is up to 8 dS/m. This result was in consistence with the findings of Oustani *et al.* (2015) where they obtained the highest tuber yield (44.55 t/ha) at a salinity level of 5.9 dS/m by using 60 t/ha poultry manures as organic amendment. Regarding grades of tubers, highest amount of small sized tubers were obtained from S_3A_4 (41.04%) and the lowest from the combination of S_1A_2 (4.24%). The highest amount of medium sized tubers were obtained from S_3A_1 (84.58%) (Table 7). More than 80% medium sized tubers were obtained from the combinations of S_2A_1 (81.91%), S_2A_2 (82.65%), and S_4A_1 (83.04%). Medium sized tubers are important as these

Table 7. Interaction effect of salinity and organic amendments on yield and grades of tubers of potato

S × A	No. of tubers/ plant	Tuber yield (g/plant)	Grades of tubers (by % wt)		
			<28mm	28-55mm	>55mm
S_1A_1	14.00	343.33	11.09	78.65	10.26
S_1A_2	11.50	401.00	4.24	71.80	23.96
S_1A_3	12.00	347.50	7.48	76.00	16.52
S_1A_4	11.83	223.00	17.80	64.79	17.41
S_2A_1	12.00	350.67	12.36	81.91	5.73
S_2A_2	14.67	365.33	14.18	82.65	3.17
S_2A_3	12.00	353.50	12.18	60.87	26.95
S_2A_4	15.17	220.00	28.81	67.22	3.97
S_3A_1	9.17	330.67	15.42	84.58	0.00
S_3A_2	13.33	325.50	26.38	73.62	0.00
S_3A_3	14.83	221.83	39.92	55.01	5.07
S_3A_4	9.50	139.00	41.04	58.96	0.00
S_4A_1	15.33	196.50	16.96	83.04	0.00
S_4A_2	15.67	205.67	32.56	62.32	5.12
S_4A_3	14.33	194.67	18.48	76.54	4.98
S_4A_4	8.33	133.00	39.10	60.90	0.00
Mean	12.73	271.95	21.13	71.18	7.69
CV (%)	10.70	15.14	14.86	12.12	18.47
F-value	NS	NS	NS	NS	NS

S= Salainity levels, A= Organic amendments, S_1= control, S_2= 4 dS/m, S_3= 8 dS/m and S_4= 12 dS/m; A_1= saw dust, A_2= rice straw, A_3= ashes and A_4= rice bran, NS= Non-significant

all are the marketable sized.

Conclusion

From the above results and discussion, it can be concluded that the yield of potato decreases with the increase of salinity level. Potato could be grown up to a salinity level of 4 dS/m without using any organic amendments. Whereas, using organic amendments like saw dust and rice straw, potato can be grown at a condition where salinity level is up to 8 dS/m.

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References

Akhter, S. and F. Begum. 2011. Screening of potato varieties against NaCl salinity. Annual Report 2010-11. Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. Pp. 131-134.

Alam, M. S., S. M. A. Islam and M. S. Osman. 2012. Soil salinity removal from agricultural land by using gypsum. Proceedings of the first seminar on Climate change impact and adaptation. Organized by Centre for Climate Change and Sustainability Research (3CSR), DUET, Gazipur on 12-13 June 2012. Pp. 139-146.

Anonymous. 2012. Annual report of TCRC 2011-

12. Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Gazipur 1701. 263 P.

Chapin, E. S. 1991. Integrated responses of plants to stress. A centralized system of physiological responses. *Biosci*. 40: 29-31.

Etehadnia, M. 2009. Salt stress tolerance in potato genotypes. An unpublished Ph.D. Thesis. Department of Plant Sciences, College of Graduate Studies and Research, University of Saskatchewan, Saskatchewan S7N 5A8.

Hossain, M. I., N. Jahan, B. C. Kundu, M. H. Ullah, S. R. Zaman, M. Shahidullah and M. S. I. Khan. 2010. Yield and yield attributes of potato as affected by planting technique and mulching materials in the southern region of Bangladesh. Annual Report 2009-10. Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. Pp. 114-117.

Karim, Z., S. G. Hussain and M. Ahmed. 1990. Salinity problems and crop intensification in the coastal regions of Bangladesh. Soils Publication No. 33. Bangladesh Agricultural Research Council, Farmgate, Dhaka. 17 P.

Katerji, N., J. W. van Hoorn, A. Hamdy, and M. Mastrorilli. 2003. Salinity effect on crop development and yield, analysis of salt tolerance according to several classification methods. *Agric. Water Manag*. 62: 37-66.

Levy, D. 1992. The response of potatoes (*Solanum tuberosum* L.) to salinity: plant growth and tuber yields in the arid desert of Israel. *Annals Appl. Biol.* 120: 547–555.

Levy, D., E. Fogelman and Y. Ytzhak. 1993. Influence of water and soil salinity on emergence and early development of potato (*Solanum tubersum* L.) cultivars and effect of physiological age of seed tubers. *Potato Res*. 36: 335-340.

Li, X. G., F. M. Li, Q. F. Ma and Z. J. Cui. 2006. Interactions of NaCl and Na_2SO_4 on soil organic C mineralization after addition of maize straws. *Soil Biol. Biochem*. 38: 2328-2335.

Maas, E. V. 1986. Physiological response of plants to chloride**.** *In:* Jackson, T. L. (ed.) Chloride and Crop Production. Proceedings of ASA Symposium Special Bulletin. 2. ASA, Madison, WI. Pp. 4-20.

Marschner, H. 1995. Mineral Nutrition of higher plants. Academic Press, New York. Pp. 657-680.

Munira, S., M. M. Hossain, M. Zakaria, J. U. Ahmed and M. M. Islam. 2015. Evaluation of potato varieties against salinity stress in Bangladesh. *Int. J. Plant Soil Sci.* 6: 73-81.

Oustani, M., M. T. Halilat and H. Chenchouni. 2015. Effect of poultry manure on the yield and nutrients uptake of potato under saline conditions of arid regions. *Emir. J. Food Agric*. 27: 106-120.

Rahman, M. H., R. Islam, M. Hossain and S. A. Haider. 2008. Differential response of potato under sodium chloride stress conditions *in vitro*. *J. Bio-Sci*. 16: 79-83.

Romero-Aranda, R. and J. P. Syvertsen. 1996. The influence of foliar applied urea nitrogen and saline solutions on net gas exchange of Citrus leaves. *J. Amer. Soc. Hor. Sci.* 121: 501-506.

Sardar, P. K., M. M. Hossain and B. C. Kundu. 2010. Effect of planting method and mulching on the yield of potato in coastal area of Satkhira. Annual Report 2009-10. Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. Pp. 111-113.

Seyedbagheri, M. M. and H. Neibling. 2013. Influence of soil amendments on soil health and crop production [Cited from browsing website http://www.sugarproducer. com/2013/05/influence-of-soil-amendments-on accessed on 12-1-2015].

Zaman, S. M., B. C. Kundu and M. M. Hossain. 2008. Effect of planting method and mulching on the yield of potato in coastal area. Annual Report 2007-08. Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. Pp. 62-63.

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Elin, R. J. 2010. Assessment of magnesium status for diagnosis and therapy. *Magnes. Res.* 23: 194-98.

Hill, D. S. 1787. Agricultural Insect Pests of the Tropics and Their Control 2nd ed. Cambridge Univ. Press, New York, USA. 746 P.

Troughton, J. H. 1975. Phytoshynthetic Mechanisms in Higher Plants, Pp. 357-91. In Cooper J.P. (ed.) Photosynthesis and Productivity in Different Environments. Cambridge Univ. Press, Cambridge, UK.

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