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SOIL SALINITY MANAGEMENT FOR INCREASING POTATO YIELD IN THE COASTAL AREA OF SOUTHERN BANGLADESH

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Abstract

The study was conducted at farmers' field of Charfashion upazila in Bhola district under AEZ-18 during the *Rabi* season of 2015-2016 and 2016-2017 to find out suitable soil salinity management practice(s) for maximizing potato yield as well as farmers' income. Two planting systems viz. raised bed and flat land, and four management systems with fertilizers and mulching were considered in a factorial experiment. The rate of increase in soil salinity in raised beds was significantly lower than that of flat land. On an average, raised bed planting produced 13.04% higher tuber yield than flat land planting. The combination of raised bed + recommended fertilizer (RF) with cowdung @ 5 t ha^{-1} as IPNS+ straw mulch (@ 3.5 t ha^{-1}) produced the highest tuber yield in both the years (average 21.66 t ha^{-1}) and it was 75.10% higher than flat planting system with no mulch. This treatment combination also provided the highest average gross margin (Tk. 115945 ha^{-1}) and BCR (2.26). Besides, combination of raised bed + RF+25% K+ straw mulch provided average tuber yield (20.91 t ha^{-1}), gross margin (Tk. 110969 ha^{-1}) and BCR (2.25), which were very close to above treatment combination. The lowest average potato yield (12.51 t ha^{-1}), gross margin (Tk. 39835 ha^{-1}) and BCR (1.50) were obtained from combination of flat land planting + RF +no mulching. So, combination of raised bed + mulching+ RF along with IPNS basis cowdung @ 5 tha^{-1} or 25% extra K can help minimize soil salinity and produce significantly higher potato yield in the coastal areas.

Keywords: Coastal area, soil salinity, raised bed, flat land, mulching, potato

Introduction

Soil salinity is one of the major environmental hazards to global agriculture (Zhang *et al*., 2007).The saline area in Bangladesh is about 0.83 million hectares and presently estimated that it has increased up to 1.2 m ha (Islam *et al*., 2008).The coastal area of the country constitutes about 20% of the country of which about 53% are affected by different degrees of salinity (Haque, 2006). Soil salinity in Bangladesh is a seasonal problem that affects crop production severely in the saline belt during *rabi* season whereas in *Kharif-II* season soil salinity reaches about neutral and does not affect crop production (Khan *et al*.,

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2008). Soil salinity affects crop growth, yield and quality (Razzouk and Whittington, 1991; Dong *et al*., 2008). The salinity causes unfavorable environment and hydrological situation restricting the normal crop production throughout the year (Amin *et al*., 2008) and very few crops/cultivars could survive or produce economic yield in severe soil salinity environment (Shrivastava and Kumar, 2015). The severity of soil salinity problem in the coastal areas of Bangladesh increases with the desiccation of the soil (Haque, 2006). It affects crops depending on degree of salinity at the critical stages of growth, which reduces yield and in severe cases total yield loss (Rasel *et al*., 2013). The dominant crop grown in the saline areas is local T.Aman rice (Var. Sadamota, Rajashail, Kajalshail, Lalmota, etc.) and yield is comparatively lower than high yielding modern varieties. The main cropping pattern practiced in coastal areas is Fallow-Fallow-T.Aman rice. Late harvest of T.Aman rice (up to the first week of January) and delay receding of tidal flood water are the main causes of fallow land in this region. That is why about 40-45% and 30-35% of lands remain fallow in *rabi* and *kharif-1* seasons, respectively in southern region (Rafiquzzaman *et al*., 2010). The increasing pressure of growing population in the country demand more food. That is why it has become imperative to explore the possibilities of increasing productivity in saline areas through proper management practices.

Raised bed planting for row-spaced crops in many parts of the world is gaining importance (Sayre, 2007). It can save 25–30% irrigation water, increasing water use efficiency (Hassan *et al*., 2005; Malik *et al*., 2005; Choudhary *et al*., 2008; Ahmad *et al*., 2009) and providing better opportunities to leach salts from the furrows (Bakker *et al*., 2010). Under saline conditions, increased salt accumulation on top of the bed has also been reported by Choudhary *et al*. (2008) due to the upward movement of salts through capillary rise in response to evaporation gradients. Mulching is one the effective and promising management practices to reduce dry season salinity and conserve moisture in plant root zone, as it can decrease soil water evaporation, increase infiltration and regulate soil water and salt movement (Huang *et al*., 2001; Deng *et al*., 2003; Qiao *et al*., 2006; Devkota *et al*., 2015).It can reduce up to 30% salinity increase as compared to normal flat system with no mulch (BARI, 2008). Besides, potash fertilizer has an added advantage for controlling the soil salinity. It reduces sodium uptake by plants and of course increases potassium uptake. Thus potassium fertilization protects crops from harmful effects of sodium (Haque, 2006). Potato is mainly used as a vegetable in Bangladesh and grown all over the country. Bhola district is an important area for potato production among the coastal areas of Bangladesh. About 5660 ha land in Bhola district was under potato cultivation in 2014-2015, of which a major portion was under saline environment (DAE, 2014). As potato is cultivated in *Rabi* season, it provides very poor yields in saline coastal areas compared to its potential as soil salinity reaches to maximum during *rabi* season. Cultivation of potato in *Rabi* season

with improved management practices including mulching could increase tuber yield significantly compared to traditional method under saline ecosystem. Thus the experiment was undertaken to find out improved management practices to reduce the adverse effect of soil salinity for maximizing yield of potato as well as farmers' income in coastal areas of Bhola district.

Materials and Methods

The experiment was conducted at farmers' field of Charfashion upazila under Bhola district under AEZ-18 in the *rabi* season of 2015-2016 and 2016-2017. The land type was medium highland with soil salinity 2.43 and 2.16 dSm^{-1} at the time of planting in 2015-2016 and 2016-2017, respectively. The treatments comprise of planting method P_1: Raised bed and P_2: Flat land and four management practices, viz., M_1: recommended fertilizer (RF) for potato production, M_2: RF + straw mulch (3.5 t ha^{-1}), M_3: RF + 25% K + straw mulch (3.5 t ha^{-1}) and M_4: RF with cowdung @ 5 t ha^{-1}in IPNS + straw mulch (3.5 t ha^{-1}). Potato variety was BARI Alu-7 (Diamant) and sowing date was 30 November 2015 and 05 December 2016, respectively. The experiment was laid out in factorial randomized complete block (RCB) design with six replications. Unit plot size was 4 m × 5 m. Recommended fertilizers (RF) for potato was 115-30-125-19-3.5-1.7 N-P-K-S-Zn-B $kgha^{-1}$ (FRG, 2012). Raised beds were made at the time of potato planting and beds were covered with rice straw (3.5 t ha^{-1}) mulch just after planting. Whole tuber of 'A' grade was planted at a spacing of 60 cm × 25 cm. Hand weeding was done twice at 20 and 45 days after planting. Furadan (Carbofuran) 5G @ 20 kg ha^{-1} was applied at the time of final land preparation for controlling cut warm. Single light irrigation was done at 38 days after planting. Secure @ 2g Lit^{-1} water was sprayed twice at 52 and 63 days after planting as a preventive measure against late blight infestation due to foggy weather. Soil salinity of the experimental plots was recorded at 15 days interval from planting to harvest of potato. It started on 30 November and ended on 01 March both the years. Soil samples were also collected before planting and after harvest of potato to determine the nutrient status of the experimental plots' soil. Harvesting was done on 20 March 2016 and 23 March 2017. Yield and yield components data of potato and cost of all inputs and operations were recorded. Economic performance was also calculated. Data were analyzed following the computer program MSTAT-C (Freed, 1985).

Results and Discussion

Effect of planting systems

Tubers $plant^{-1}$ and tuber yield differed significantly due to different planting system in both the years (Table 1). Though all yield contributing characters did not differ significantly, their cumulative effect contributed higher tuber yield in raised bed system than normal flat system potato planting. The highest tuber

yield of 18.28 t ha^{-1} in 2015-2016 and 19.19 t ha^{-1} in 2016-2017 was found in raised bed planting system. Raised bed and at the same time mulching reduced soil salinity considerably (BARI, 2008; Bashar *et al*., 2014). Similar results were also reported by Muromota *et al*. (1991). The lowest tuber yield (15.98 t/ha and 17.16 t/ha, respectively in 2015-16 and 2016-17) was obtained from flat land planting because of lower number of tubers per plant and lower number of plants per sq. meter. Higher level of soil salinity in flat land system compared to raise bed system might have affected plant growth and yield of potato. On an average, raised bed increased potato yield by 13.04% compared to flat system.

Table 1. Tuber yield and yield attributes of potato under different planting systems in saline soil at Charfashion, Bhola during 2015-2016 and 2016-2017

Treatment	Plant height (cm)	Plants m^{-2} (No.)	Tubers $plant^{-1}$ (No.)	Individual tuber wt. (g)	Tuber yield (t ha^{-1})
2015-2016					
Raised bed (P_1)	40.95	6.91	5.92	45.15	18.28
Flat land (P_2)	39.9	6.72	5.31	46.37	15.98
T-test	NS	NS	3.86	NS	4.39
2016-2017					
Raised bed (P_1)	42.9	7.01	6.00	45.22	19.19
Flat land (P_2)	42.3	6.65	5.60	47.13	17.16
T-test	NS	NS	2.82	NS	5.14
Mean					
Raised bed (P_1)	41.9	6.96	5.96	45.19	18.73
Flat land (P_2)	41.1	6.69	5.46	46.75	16.57

P_1: Raised bed, P_2: Flat system, NS= non-significant

Effect of management practices

Management practices i.e. fertilizers and mulching influenced plant height, individual tuber weight and tuber yield significantly in both the years while number of tubers $plant^{-1}$ only in 2015-2016 (Table 2). The highest plant height (42.5 cm) in 2015-2016 was recorded in M_4 (recommended fertilizers + cowdung 5.0 t ha^{-1} in IPNS + straw mulch) and similar trend was recorded in 2016-2017 but M_4 and M_3 treatments at par in 2016-2017. Individual tuber weight was maximum in M_3 that was statistically identical to M_4 in 2015-2016 but insignificant in 2016-2017. Numerically higher number of plants m^{-2} was

observed in all treatments having mulch than that of non-mulched treatment (M_1). Mulching reduced increase in soil salinity (Table 6, Table 7 and Table 8) that might have facilitated better crop stands establishment. Thus mulching along with 25% extra K or cowdung @5 t ha^{-1} contributed to higher no. of tubers $plant^{-1}$ and individual tuber weight in treatment M_3 and M_4, respectively. Although all yield contributing characters did not differ significantly, their cumulative effect made difference in tuber yield in different management practices. The maximum tuber yield (19.92 and 21.22 t ha^{-1} in 2015-2016 and 2016-2017, respectively) was obtained from Recommended fertilizer + cowdung 5 t ha^{-1}in IPNS + straw mulch (M_4 treatment) which was statistically similar to M_3: Recommended fertilizer + 25% extra K + straw mulch practices (19.39 and 20.39 t ha^{-1} in 2015-2016 and 2016-2017, respectively). These results were obtained might be due to the cumulative effect of higher number of tubers $plant^{-1}$ and individual tuber wt. Moreover, reason might be such that cowdung retained moisture in the soil for longer period that reduced soil salinity and ultimately increased tuber yield. Bezborodov *et al*. (2010) reported an approximately 20% increase in surface soil salinity of the non-mulch treatments compared to a surface mulching with 1.5 t ha^{1} wheat residues under conventional tillage. Maintaining a higher K^+/Na^+ ratio by applying potassium in saline soils helps in plant growth and yield (Tanji and Kielen, 2002; Takahashi *et al*., 2007; Peter *et al*., 2010; Yue *et al*., 2012).

Table 2. Tuber yield and yield attributes of potato under different management practices in saline soil condition at Charfashion, Bhola in 2015-2016 and 2016-17

Treatment	Plant height (cm)	Plants m^{-2} (No.)	Tubers $plant^{-1}$ (No.)	Individual tuber wt. (g)	Tuber yield (t ha^{-1})
2015-2016					
M_1	37.7c	6.56	5.14c	40.96c	13.06c
M_2	40.5b	6.84	5.48b	44.20b	16.15b
M_3	41.3b	6.84	5.82a	49.28a	19.39a
M_4	45.2a	7.02	6.02a	48.62a	19.92a
CV (%)	7.44	6.19	7.69	10.12	11.03
$LSD_{0.05}$	3.6	NS	0.31	3.28	1.92
2016-2017					
M_1	38.2c	6.50	5.72	40.48c	14.09c
M_2	42.4b	6.94	5.57	45.06b	17.00b
M_3	43.3ab	6.83	5.85	49.56a	20.39a
M_4	46.5a	7.06	6.07	49.61a	21.22a

CV (%)	9.08	8.65	10.04	5.74	10.76
$LSD_{0.05}$	4.0	NS	NS	4.46	2.08
			Mean (Pooled)		
M_1	38.0c	6.53	5.43	40.72b	13.58c
M_2	41.4b	6.89	5.52	44.63b	16.58b
M_3	42.3ab	6.84	5.83	49.42a	19.89a
M_4	45.8a	7.04	6.05	49.12a	20.57a
CV (%)	8.20	7.54	11.36	6.53	11.52
$LSD_{0.05}$	4.19	NS	NS	4.38	2.13

M_1: Recommended Fertilizers (RF): @ 115-30-125-19-3.5-1.7 N-P-K-S-Zn-B kg ha^{-1}, M_2: RF + Straw mulch, M_3: RF + 25% extra K + Straw mulch, M_4: RF with cowdung @ 5t ha^{-1} in IPNS + Straw mulch

Interaction effect of planting systems and different management practices

Plant height, number of tubers $plant^{-1}$, individual tuber weight and tuber yield differed significantly due to the interaction effect of planting systems (raised bed and flat system) and different management practices (fertilizers and mulching) in both the years (Table 3, Table 4 and Table 5). The highest plant height was observed in P_2M_4 which was statistically identical with P_1M_4 in both the years (average 47.0 cm and 44.7 cm in P_2M_4 and P_1M_4, respectively). The highest number of tubers $plant^{-1}$ was observed in P_1M_4 in both the years (average 6.14) that was statistically identical to P_1M_3 and P_2M_4. The maximum individual tuber weight was found in P_1M_3 followed by P_1M_4, P_2M_3 and P_2M_4 in 2015-2016. In 2016-2017, the maximum individual tuber weight was found in P_1M_4 (50.17 g) and it was statistically identical to P_1M_3, P_2M_4, P_2M_3 and P_2M_2. Though all yield attributes did not differed significantly due to the interaction effect but their cumulative effect made difference in tuber yield in both the years. In 2015-2016, the highest tuber yield (21.13 t ha^{-1}) was obtained in P_1M_4 which was statistically identical with P_1M_3. But in 2016-2017, P_1M_4, P_1M_3 and P_2M_4 gave statistically identical tuber yield. In 2016-2017, tuber yield in all the treatments was slightly higher compared to 2015-16 due to lower soil salinity in 2016-2017. The highest average tuber yield was obtained in P_1M_4 (21.66 t ha^{-1}). Treatment combinations having raised bed with straw mulch + cowdung or extra K might have conserved soil moisture for longer period and thus reduced soil salinity to some extent that favoured better growth and yield. This finding is in agreement with Muromota *et. al*. (1991) and Mahmood *et al*. (2002). Application of potassium and different mulches had positive effect on growth characters and yield and economic analysis of potato (Pulok *et al*., 2016). In both the years all yield attributes and tuber yield (average 12.37 t ha^{-1}) was lowest in P_2M_1 (flat system planting and no mulch).

Table 3. Tuber yield and yield attributes of potato as influenced by interaction of planting systems and management practices in saline soil of Charfashion, Bhola in 2015-2016

Treatment		Plant height (cm)	Plants m^{-2} (No.)	Tubersplant^{-1} (No.)	Individual tuber wt. (g)	Tuber yield (t ha^{-1})
P_1	M_1	36.8d	6.65	5.74c	37.78e	14.04c
	M_2	40.8c	7.00	5.88b	42.98d	17.28b
	M_3	42.2bc	6.92	6.00a	49.95a	20.65a
	M_4	44.0ab	7.06	6.12a	49.90a	21.13a
P_2	M_1	32.6c	6.07	5.54c	42.13d	12.08d
	M_2	40.2c	6.68	5.16d	45.41bcd	15.01c
	M_3	40.4c	6.76	5.63c	48.61ab	18.12b
	M_4	46.4a	6.98	5.91ab	47.33abc	18.70b
CV (%)		9.3	7.16	8.32	11.54	9.58
$LSD_{0.05}$		3.1	NS	0.28	3.42	1.63

P_1: Raised bed, P_2: Flat bed, M_1: Recommended Fertilizers (RF): @ 115-30-125-19-3.5-1.7 N-P-K-S-Zn-B kg ha^{-1}, M_2: RF + Straw mulch, M_3: RF + 25% Extra K + Straw mulch, M_4: IPNS with cowdung @ 5 t ha^{-1} + Straw mulch

Table 4. Tuber yield and yield attributes of potato as influenced by interaction of planting systems and management practices in saline soil of Charfashion, Bhola in 2016-2017

Treatment		Plant height (cm)	Plants m^{-2} (No.)	Tubers plant^{-1} (No.)	Individual tuber wt. (g)	Tuber yield (t ha^{-1})
P_1	M_1	38.9cd	6.91	5.81bc	37.8d	15.53de
	M_2	42.9b	7.14	5.93ab	42.79c	17.87cd
	M_3	44.3bb	6.89	6.09a	50.13a	21.16ab
	M_4	45.4ab	7.11	6.16a	50.17a	22.19a
P_2	M_1	37.5d	6.09	5.62c	43.16bs	12.65f
	M_2	41.8c	6.74	5.20d	47.32ab	16.13de
	M_3	42.3bc	6.77	5.60c	48.98a	19.61bc
	M_4	47.5a	7.01	5.98ab	49.05a	20.24ab
CV (%)		7.9	8.12	6.65	8.67	10.08

$LSD_{0.05}$		3.6	NS	0.25	4.21	2.08

Table 5. Mean tuber yield and yield attributes of potato as influenced by interaction of planting systems and management practices in saline soil of Charfashion, Bhola in 2015-2016 and 2016-2017 (Pooled)

Treatment		Plant height (cm)	Plants m^{-2} (No.)	Tubers $plant^{-1}$ (No.)	Individual tuber wt. (g)	Tuber yield ($t\ ha^{-1}$)
P_1	M_1	37.9de	6.78	5.78bc	37.79c	14.79e
	M_2	41.9bc	7.07	5.91abc	42.89b	17.58cd
	M_3	43.3bc	6.91	6.05a	50.04a	20.91ab
	M_4	44.7ab	7.09	6.14a	50.04a	21.66a
P_2	M_1	35.1e	6.08	5.58c	42.65b	12.37f
	M_2	41.0cd	6.71	5.18d	46.37ab	15.57de
	M_3	41.4c	6.77	5.62bc	48.80a	18.87bc
	M_4	47.0a	7.00	5.95ab	48.19a	19.47abc
CV (%)		7.86	8.35	7.97	10.32	10.64
$LSD_{0.05}$		3.28	NS	0.32	4.09	2.20

Soil Salinity

There was no significant difference in soil salinity level of different treatments on 15 December in both the years (Table 6, Table 7 and Table 8).Increase in soil salinity started from 31 December (i.e. about one month after planting) in both the years and the rate of increase was significant. Significantly the highest salinity level was observed in flat system planting with no mulch (P_2M_1) (average salinity level was 4.15, 5.42, 6.64, 7.44 and 8.07 dSm^{-1} on 31 December, 15 January, 31 January, 15 February and 01 March, respectively). Soil salinity increase in raised bed with mulching was very close to flat system with mulching. It indicates that mulching in saline soils is more important than planting in raised bed. This might be due to capillary movement of soil water that was higher in open land than mulched land (Devkota *et al*., 2015). Raised bed also reduced soil salinity increase than plain or flat land (Choudhary *et al*., 2008). In raised bed capillary movement of water increases in the furrow than top of the bed. Rahman *et. al.* (2006) observed that salinity was higher in no mulch treatment than treatments with different mulch materials. So, potato could be cultivated in coastal saline area minimizing soil salinity through raised bed with mulching.

Table 6. Salinity levels (dSm^{-1}) at potato experimental plots under different management practices at Charfashion, Bhola during 2015-2016

Treatments		Soil salinity monitoring dates						
		30 Nov'15	15 Dec'15	31 Dec'15	15 Jan'16	31 Jan'16	15 Feb'16	01 Mar'16
P_1	M_1	2.43	2.91	3.33bc	3.96bc	4.32bc	5.06b	5.82b
	M_2	2.43	2.68	2.96c	3.46c	3.93c	4.15c	4.56c
	M_3	2.43	2.65	2.92c	3.41c	3.88c	4.07c	4.50c
	M_4	2.43	2.64	2.92c	3.40c	3.87c	4.00c	4.31c
P_2	M_1	2.43	3.06	4.55a	5.98a	6.83a	7.75a	8.24a
	M_2	2.43	3.12	3.98ab	4.56b	4.98b	5.13b	5.28bc
	M_3	2.43	2.76	3.10c	3.68c	4.12bc	4.69bc	5.12bc
	M_4	2.43	2.80	3.17c	3.65c	4.07c	4.68bc	5.03bc
CV(%)		-	4.23	8.51	6.37	7.12	8.00	6.17
$LSD_{0.05}$		-	NS	0.68	0.71	0.87	0.95	0.97

P_1: Raised bed, P_2: Flat bed, M_1: Recommended Fertilizers (RF): @ 115-30-125-19-3.5-1.7 N-P-K-S-Zn-B kg ha^{-1}, M_2: RF + Straw mulch, M_3: RF + 25% Extra K + Straw mulch, M_4: IPNS with cowdung @ 5 t ha^{-1} + Straw mulch

Table 7. Salinity levels (dSm^{-1}) at potato experimental plots under different management practices at Charfashion, Bhola duirng 2016-2017

Treatments		Soil salinity monitoring dates						
		30 Nov'16	15 Dec'16	31 Dec'16	15 Jan'17	31 Jan'17	15 Feb'17	01 Mar'17
P_1	M_1	2.16	2.88	3.23abc	3.76bc	4.22b	4.89b	5.40b
	M_2	2.16	2.51	2.96c	3.26bc	3.63b	4.10bc	4.37bc
	M_3	2.16	2.40	2.82c	3.20c	3.55b	4.01bc	4.26c
	M_4	2.16	2.41	2.78c	3.12c	3.42b	3.83c	4.15c
P_2	M_1	2.16	3.14	3.75a	4.86a	6.44a	7.12a	7.90a
	M_2	2.16	3.09	3.65ab	3.96b	4.00b	4.78b	5.07bc
	M_3	2.16	2.78	3.11abc	3.56bc	3.94b	4.62bc	4.93bc
	M_4	2.16	2.76	3.05bc	3.58bc	3.91b	4.47bc	4.82bc
CV(%)		-	3.88	7.12	5.43	7.84	6.92	8.31
$LSD_{0.05}$		-	NS	0.66	0.75	0.82	0.92	1.06

Table 8. Average salinity levels (dSm^{-1}) at potato experimental plots under different management practices at Charfashion, Bhola during 2015-2016 and 2016-17

Treatments		Soil salinity monitoring dates						
		30 Nov	15 Dec	31 Dec	15 Jan	31 Jan	15 Feb	01 Mar
P_1	M_1	2.30	2.90	3.28	3.55	4.27	4.98	5.61
	M_2	2.30	2.60	2.96	3.36	3.78	4.13	4.47
	M_3	2.30	2.53	2.87	3.31	3.72	4.04	4.38
	M_4	2.30	2.53	2.85	3.26	3.65	3.92	4.23
P_2	M_1	2.30	3.10	4.15	5.42	6.64	7.44	8.07
	M_2	2.30	3.11	3.82	4.26	4.49	4.96	5.18
	M_3	2.30	2.77	3.11	3.62	4.03	4.66	5.03
	M_4	2.30	2.78	3.11	3.62	3.99	4.58	4.93

Soil Nutrient Status

Analysis of soil samples (composite) taken across the experimental plots before planting and after harvest of the crop did not show significant variation in soil nutrient status (Table 9). However, slight increase in organic matter, total N (%) and K while slight decrease in soil pH, P, S and B was found in soils after harvest (Table 9). Increase of organic matter might be due to addition of mulch materials. Negative balance of K is common in Bangladesh soils (Hossain *et al.*, 2016). Proper dose of K and 25% extra K in two plots might have influenced this slightly positive K balance. Application of recommended fertilizer in proper method can help in soil nutrient status degradation.

Table 9. Initial and post-harvest soil nutrient status of the experimental plots (average of 2015-2016 and 2016-2017)

	pH	OM (%)	Total N (%)	K (meq/ 100 g soil)	P	S	Zn	B
					(µg/g soil)			
Initial status	7.94	1.25	0.072	0.17	5.84	34.15	0.65	0.47
Interpretation	SA	L	VL	L	VL	H	L	Opt
Post-harvest statu	7.95	1.26	0.073	0.18	5.81	34.08	0.65	0.45
Interpretation	SA	L	VL	L	VL	H	L	Opt
Increase (+)/ decrease (-)	(+)0.01	(+)0.01	(+)0.001	(+)0.01	(-)0.03	(-)0.07	-	(-)0.02

Cost and Return analysis

Cost and return of potato was influenced by planting systems and management practices in saline soil condition (Table 10). Gross return (GR) varied due to variation of tuber yield as farm gate price of potato from different treatments was same. On an average, the highest GR (Tk. 208288 ha^{-1}) was obtained from the treatment raised bed + RF with 5 t ha^{-1} cowdung in IPNS + mulching (P_1M_4). Total variable cost (TVC) varied due to different management practices and the lowest average TVC (Tk. 79010 ha^{-1}) was found in flat land with no mulch system (P_2M_1). TVC increased mainly due to mulch material and additional labour for preparing raised bed and spreading of rice straw (mulch). The highest average TVC (Tk. 92343 ha^{-1}) was recorded in the treatment P_1M_4 due to cost of cowdung and transport and application in the field. Although TVC was highest in P_1M_4, gross margin (GM) was also the highest (Tk. 115945 ha^{-1}) in the same treatment as it provided the highest tuber yield. GM produced by P_1M_3 (Tk. 110969 ha^{-1}) was very close to P_1M_4 whereas GM was the lowest in P_2M_1 (Tk. 39835 ha^{-1}) due to the lowest tuber yield. Benefit cost ratio (BCR) is an indicator of profitability of a production activity. BCR was the highest (2.26) in P_1M_4 and it was very close to P_1M_3 (2.25). Other treatments such as P_2M_3, P_2M_4 and P_1M_2 also produced a considerable BCR. Treatment P_2M_1 (Flat land and no mulch) provided the lowest BCR 1.50 which indicated that flat land with no mulch is not suitable for potato cultivation in saline area.

Table 10. Average cost and return of potato as influenced by planting systems and management practices at saline area of Charfashion, Bhola during 2015-2016 and 2016-2017

Treatment		Yield (t ha^{-1})	Gross return (Tkha^{-1})	Total variable cost (Tkha^{-1})	Gross margin (Tkha^{-1})	BCR
P_1	M_1	15.16	144020	84503	59518	1.70
	M_2	17.73	168388	87890	80498	1.92
	M_3	21.04	199833	88864	110969	2.25
	M_4	21.93	208288	92343	115945	2.26
P_2	M_1	12.51	118845	79010	39835	1.50
	M_2	15.85	150575	82635	67940	1.82
	M_3	19.24	182780	83626	99155	2.19
	M_4	19.47	184965	86935	98030	2.13

P_1: Raised bed, P_2: Flat bed, M_1: Recommended Fertilizers (RF): @ 115-30-125-19-3.5-1.7 N-P-K-S-Zn-B kg ha^{-1}, M_2: RF + Straw mulch, M_3: RF + 25% Extra K + Straw mulch, M_4: IPNS with cowdung @ 5 t ha^{-1} + Straw mulch

Conclusion

Crop production in the coastal saline areas particularly during *Rabi* season (dry season) is very limited due to rise in soil salinity. From this study it is revealed that, raised bed and mulching (with rice straw) both minimizes rise in soil salinity significantly. Besides, use of cowdung or extra amount of potassium (K) with recommended fertilizers along with raised bed and mulching helps to reduce soil salinity and increased crop yield. Thus treatment comprised of raised bed + mulching + recommended fertilizers with cowdung (5 tha^{-1} as IPNS) or 25% additional K produced higher yield of potato in coastal saline environment. Farmers of coastal saline areas of Bhola district can adopt the technology for higher yield and economic return from potato.

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