Project ID: 570

Competitive Research Grant (CRG)

Sub-Project Completion Report

on

Improving crop yield by using polythene mulch and potassium fertilization in saline soils

Project Duration

May 2017 to September 2018

Department of Soil Science

Patuakhali Science and Technology University

Dumki, Patuakhali

Submitted to

Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Acronyms

BARC- Bangladesh Agricultural Research Council
BRRI-Bangladesh Rice Research Institute
CO_3^- - Carbonate ion
Co-PI- Co Principal Investigator
CRG- Competitive Research Grant
CV- Coefficient of Variation
DAT- Days After Transplanting
Dr.- Doctor
EC- Electrical Conductivity
FRG- Fertilizer Recommendation Guide
GPS- Geographic Positioning System
HCO_3^- - Bicarbonate ion
K- Potassium
LoA- Letter of Agreement
LSD- Least Significant Difference
MoP- Muriate of Potash
Na-Sodium
NATP-National Agricultural Technology Program
P- Phosphorus
PCR- Project Completion Report
PI- Principal Investigator
Prof.- Professor
RCBD- Randomized Complete Block Design
S- Sulfur
SE-Standard Error
T. Aman- Transplanted Aman
Tk- Taka
TSP- Triple Super Phosphate

Table of Contents

Executive Summary

Severe soil and water salinity seriously restricts the expansion of Rabi/Kharif I crop growing in the saline soils of Bangladesh. Uncertain rainfall in September-November due to climate change effect also make difficult to grow T. Aman rice. Despite salinity exerts lethal effect, to feed ever increasing population we will have to increase quality food production (like high value vine crops eg. bitter gourd, snake gourd, sweet gourd, water melon, melon etc.). Appropriate technology is therefore needed to compensate the crop losses occurred by salinity.

Polythene mulches reduce evaporation losses from the soil surface, accelerate crop development in cool climates by increasing soil temperature, reduce erosion and assist in weed control. Polythene mulch could also be used to manage saline soil, which however, very poorly investigated.

In saline soils excess Na in soil solution hamper K uptake. Application of K in over dose may facilitate to maintain higher K^+:Na^+ ratio which increase tolerance capacity of crops to salinity. The project is therefore directed towards the introduction of high value vine crops in the cropping system through reduction of salinity effect by judicious use of polythene mulch and optimum rate of K fertilizer application in coastal saline soils of Bangladesh.

During the study period three experiments were done. In first experiment temporal and spatial variability of soil salinity in the coastal region of Bangladesh were determined. In experiment II an attempt was undertaken to improve vine crops yield using polythene mulch and potassium fertilizer management in coastal saline soils of Bangladesh, and finally in experiment III T. Aman rice yield was improved through potassium fertilizer management.

Under experiment I soil samples were collected on 27 March 2018 from Amtalil and Taltali upazila of Barguna district, and Kalapara upazila of Patuakhali district. From each upazilla 30 locations were selected randomly. From each location soil sample was collected from two soil depths: 0-5cm and 5-10 cm. Thus total 180 soil samples (3 upazilla × 30 location × 2 soil depths) were collected and chemical analysis were performed. Among the three upazilas Kalapara was most affected by salinity. The top soil is mostly affected by salinity and subsurface soil is relatively comfortable for plant tolerance. The soil was found strongly acidic in nature. Along with the salinity severe acidity could be another problem of coastal soil.

The second experiment was conducted following two factor RCB design where first factor was different kinds of mulch materials including no-mulch control, rice straw mulch and polythene mulch; the second factor had three levels of potassium fertilizer including no-K fertilizer, 100 and 150 % recommended K fertilizer dose having total nine treatment combinations. The treatments were applied in five vine crops including bitter gourd, snake gourd, sweet gourd, water melon and melon. All these experiments were conducted in three upazila: Amtali and Taltali of Barguna district, and Kalapara of Patuakhali district. The results revealed that over the locations and crops polythene mulch had outstanding performance and in most cases polythene mulch had several folds higher fruit yield over no-mulch control treatment. Potassium application have inconsistent result, in some locations and crops 100% recommended K was the best where as in some cases 150% recommended K was the best. Interestingly in few cases K application did not significantly improve fruit yield. Based on the interaction effect polythene mulch along with 100% recommended K was the best treatment combination to get maximum yield of the crops.

In third experiment different doses of K was applied in T. Aman rice to find out the optimum rate of K. The results showed that 100% K is sufficient to get optimum yield over the locations. However, split application was found somewhat better than the sole basal application of K.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project: Improving crop yield by using polythene mulch and potassium fertilization in saline soils
2. Implementing organization: Patuakhali Science and Technology University
3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

Principal Investigator:

Prof. Dr. Mohammad Asadul Haque
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4. Sub-project budget (Tk):
   4.1 Total: Tk 2485000/-
   4.2 Revised (if any): Tk 2485000/-
5. Duration of the sub-project:
   5.1 Start date (based on LoA signed): 08 May 2017
   5.2 End date: 30 September 2018

6. Justification of undertaking the sub-project:

Severe soil and water salinity seriously restricts the expansion of Rabi/Kharif I crop growing areas in the saline soils of Bangladesh. Uncertain rainfall in September-November due to climate change effect also make difficult to grow T. Aman rice. Despite salinity exerts lethal effect, to feed ever increasing population we will have to increase quality food production (like high value vine crops eg. sweet gourd, snake gourd, bitter gourd, water melon, melon etc.). Appropriate technology is therefore needed to compensate the crop losses occurred by salinity.

Polythene mulches reduce evaporation losses from the soil surface, accelerate crop development in cool climates by increasing soil temperature, reduce erosion and

assist in weed control. Polythene mulch could also be used to manage saline soil, which however, very poorly investigated.

In saline soils excess Na in soil solution hamper K uptake. Application of K in over dose may facilitate to maintain higher K^+:Na^+ ratio which increase tolerance capacity of crops to salinity. The proposed project is therefore directed towards the introduction of high value vine crops in the cropping system through reduction of salinity effect by judicious use of polythene mulch and optimum rate of K fertilizer in coastal saline soils of Bangladesh.

7. Sub-project goal: Generation of salinity escaping technology for improvement of crop yield in saline soils
8. Sub-project objective (s):
   - To determine temporal and special variability in soil salinity in the coastal region of Bangladesh
   - To improve crop yield through reduction of salt effect by using polythene mulch and application of K fertilizer in coastal saline soils of Bangladesh.
   - To determine the effects of salinity on the nutritional quality of crops
9. Implementing location (s): Amtali and Taltali upazila of Barguna district and Kalapara upazila of Patuakhali district
10. Methodology in brief:

Expt 1. Temporal and spatial variability of soil salinity in the coastal region of Bangladesh

To determine temporal variability two locations from each upazila of Amtalil and Taltali, Barguna district; and Kalapara of Patuakhali district were selected for periodic soil sample collection. Soil sample collection has been started from January 2018 and was continued up to June 2018. After completion of soil collection chemical analysis was performed. Soil samples were being collected from the selected locations at 15 days intervals. The collected soil samples were analysed for EC and pH value, CO_3^-, HCO_3^-, Cl^-, P, K, S and Na contents.

To determine the spatial variability, soil samples were collected on 27 March 2018 from Amtalil and Taltali upazila of Barguna district, and Kalapara upazila of Patuakhali district. From each upazilla 30 locations were selected randomly. The GPS reading was recorded using SAMSUNG Galaxy Mobile phone. From each location soil sample was collected from two soil depths: 0-5cm and 5-10 cm. Thus total 180 soil samples (3 upzilla × 30 location × 2 soil depths) were collected. Soil samples were analysed for determination of pH and EC value. Soil pH was determined in 1:2.5 soil water suspension. The EC was determined in 1:5 soil water suspensions. Analysis of other chemical parameters was done following standard methodologies.

Expt 2. Improving vine crops yield using polythene mulch and potassium fertilizer management in coastal saline soils of Bangladesh

Experimental location

The experiment was carried out in the farmers' field of the salt affected areas of Patuakhali (Kalapara upazila) and Barguna (Amtali and Taltali upazila) district.

Crops

The bitter gourd, snake gourd, sweet gourd, water melon and melon were grown in rabi and Kharif-I season. Separate field trials were conducted for each crop. Thus there were fifteen field trials (total 5×3=15 trials) were conducted using same treatment under this experiment.

Crop variety:

Bitter gourd- Lalteer hybrid Tiya
Snake gourd- Lalteer hybrid Chichinga Padma
Sweet gourd- Lalteer hybrid
Water melon- Takii seed Big Family
Melon- Chinal Bangi

Experimental design

The experiments were laid out in a two factor randomized complete block design with three replications. The first factor was different types of mulch material and second factor was different rates of K fertilizer.

Treatments

The treatment combinations were as follows

Factor A: Types of mulch material
- M_1 No mulching
- M_2 Rice straw mulching
- M_3 Polythene mulching

Factor B: Rate of K
- M_1 No K fertilizer
- M_2 100% recommended K fertilizer
- M_3 150% recommended K fertilizer

Seed sowing

The seeds/seedlings were sown / transplanted in pits maintaining a spacing of 2m ×2m spacing. In polythene mulch system the pit soils were covered with a one and half meter diameter polythene sheet. The seeds/seedlings were sown/transplanted in soil within the 5 cm diameter round-cut portion in the central point of the polythene sheet. For rice straw treatment pit soil was covered with rice straw. For non mulch treatment seeds also sown in pits maintaining above mentioned spacing.

Irrigation

Same amount of irrigation water was given once a week in each plant so that all the plants enjoy similar environment.

Fertilization

Every plant received recommended rate of fertilizers as soil test basis (FRG 2012) except K fertilizer. In all the experimental plant triple super phosphate (TSP), gypsum, boron, zinc and treatment wise K fertilizer (MoP) were applied during final land preparation. Urea was applied in three equal splits at final land preparation, 30 and 60 days after sowing. Regarding polythene mulch treatments urea was applied in the root rhizosphere zone using round cut hole of the polythene sheet.

Data collection

i) Growth yield and yield contributing characters.
ii) Mineral nutrient content of plant.
ii) Nutritional quality (Leaf chlorophyll, total sugar, reducing sugar, proline content etc.).
iii) Soils samples analysis

Expt 3. Improving T. Aman rice yield through potassium fertilizer management in coastal saline soils of Bangladesh

Experimental location

This experiment was also conducted in three locations at Patuakhali (Kalapara upazila) and Barguna (Amtali and Taltali upazila) district.

Season

This experiment was conducted in Kharif II (T. Aman) season.

Crops and Varieties

Bangladesh Rice Research Institute released one high yielding T. Aman rice variety (BRRI dhan73) was used in the experiment.

Experimental design and layout

The experiment was laid out in a single factor randomized complete block design with three replications, each plot measuring 5m $\times$ 3m. The treatment was randomly distributed to the plots in each block. The plots were surrounded by 30 cm wide and 10 cm high earthen bunds. One meter wide path was made in-between two blocks.

Treatments

T_1 Control (No K fertilizer)
T_2 75 % recommended K fertilizer dose (RKFD) at final land preparation
T_3 100 % RKFD at final land preparation
T_4 125 % RKFD at final land preparation
T_5 150 % RKFD at final land preparation
T_6 75 % RKFD half at final land preparation and half at 30 DAT

T_7 100 % RKFD half at final land preparation and half at 30 DAT
T_8 125 % RKFD half at final land preparation and half at 30 DAT
T_9 150 % RKFD half at final land preparation and half at 30 DAT

Seedling transplanting

Thirty five days old rice seedlings were transplanted maintaining the spacing 20cm × 20cm. Two to three seedlings was transplanted in each hill.

Fertilizer application

Every plot received recommended rate of fertilizers as soil test basis using fertilizer recommendation guide (FRG 2012). In all the experimental plots triple super phosphate (TSP), gypsum and zinc was applied during final land preparation. Muriate of potash (MoP) was applied according to the treatments and layout. Urea was applied in three equal splits at final land preparation, 25 and 40 days after transplanting.

Data collection:

i) Growth, yield and yield contributing characters
ii) Initial soil physico-chemical parameters
iii) Post harvest grain and straw K and Na content.

11. Results and discussion:

Expt. I: Temporal and spatial variability of soil salinity in the coastal region of Bangladesh

Spatial variability

Table 1.1.1 to 1.1.3 displayed the soil pH and EC values of the collected soils. At Amtali upazila the pH value in 0-5 cm soil depth ranged from 3.93 to 4.94 with an average of 4.30. At 5-10 cm soil depth the pH value ranged from 4.21 to 5.90, the average being 4.75 (Table 1.1.1). The results clearly indicate that the soil is strongly acidic in nature. The EC value in 0-5 cm soil depth varies from 0.45 to 10.65 dS m^{-1}, the mean value being 3.06 dS m^{-1}. Regarding 5-10 cm soil depth this range was 0.21 to 2.21 with average of 1.13 dS m^{-1}. The results indicated that the top soil is mostly affected by salinity and subsurface soil is relatively better for plant tolerance

At Taltali upazila the range of pH value in 0-5 and 5-10 cm soil depth was 3.73 to 5.72 and 4.01 to 5.88, and the average of 4.19 and 4.62, respectively (Table 1.1.2). The results clearly evidenced that top soil is relatively acidic than sub surface soil. The EC value in this upazila ranged from 1.63 to 4.44 and 0.44 to 3.15 dS m^{-1} in 0-5 and 5-10 cm soil depth, respectively. The average EC values were 4.71 and 1.58, respectively. The soil of Taltali upzila was found more saline than Amtali Upzila.

At Kalapara upazila the pH value in 0-5 and 5-10 cm soil depth ranged from 3.53 to 5.56 (mean 4.18), and 3.80 to 6.36 (mean 4.95), respectively (Table 1.1.3). The results clearly showed that the top soil acidity is higher than the sub soil. The mean EC value in 0-5 soil depth was 5.74 dS m^{-1} and the value was only 1.74 dS m^{-1} in 5-10 cm soil depth. The EC value varied from 0.56 to 17.85 dS m^{-1} and 0.27 to 5.05 dS m^{-1}. Thus the results indicated that among the three upazilas Kalapara was most affected by salinity. Along with the salinity severe acidity could be another problem of coastal soil.

Table 1.1.1. Spatial variability of pH and $EC_{1:5}$ value in different soil depths at Amtali upazila of Barguna district

Location of village	GPS. Reading	pH		$EC_{1:5}$ (dS/m)	
		0-5cm	5-10cm	0-5cm	5-10cm
Satdhara(1)	Latitude-22.10322,Longitude-90.2199	4.87	5.68	0.45	0.33
Dakkhin pocchim Amtali(1)	Latitude-22.1008,Longitude-90.20903	4.62	4.67	0.48	0.35
Dakkhin pocchim Amtali(2)	Latitude-22.09751,Longitude-90.207347	4.94	5.14	0.48	0.21
Orpangasia(1)	Latitude-22.09116,Longitude-90.20404	4.37	4.70	1.16	0.41
Moddho Tarikata(1)	Latitude-22.08831,Longitude-90.20288	4.82	4.78	2.13	0.86
Moddho Tarikata(2)	Latitude-22.08689,Longitude-90.20526	4.16	4.59	1.55	0.86
Moddho Tarikata(3)	Latitude-22.08389,Longitude-90.20583	4.04	4.21	1.76	0.62
Moddho Tarikata(4)	Latitude-22.08336,Longitude-90.20489	4.15	4.50	4.03	2.21
Moddho Tarikata(5)	Latitude-22.07576,Longitude-90.20746	4.25	4.46	2.80	1.05
Chakmoia Darogartobok(1)	Latitude-22.06559,Longitude-90.20094	4.17	4.69	6.63	0.95
Chakmoia Darogartobok(2)	Latitude-22.06483,Longitude-90.20093	4.03	4.30	3.47	1.05
Chakmoia Darogartobok(3)	Latitude-22.06372,Longitude-90.19411	4.69	4.96	5.28	1.82
Chakmoia Darogartobok(4)	Latitude-22.06377,Longitude-90.22511	4.11	4.57	3.43	0.96
Pocchim Chakmoia Darogartobok(1)	Latitude-22.06268,Longitude-90.18833	3.96	4.44	5.05	2.07
PocchimChakmoia Darogartobok(2)	Latitude-22.06327,Longitude-90.18822	4.24	4.70	3.49	1.35
Manikjhuri(1)	Latitude-22.09817,Longitude-90.22835	4.17	4.56	1.58	0.49
Manikjhuri(2)	Latitude-22.09836,Longitude-90.2236	4.20	4.55	2.95	0.81
Manikjhuri(3)	Latitude-22.09055,Longitude-90.22991	4.32	4.54	0.94	0.57
Manikjhuri(4)	Latitude-22.09042,Longitude-90.22954	4.70	4.87	0.81	0.36
Tiakhali(1)	Latitude-22.07459,Longitude-90.23528	4.35	5.90	0.82	0.28
Tiakhali(2)	Latitude-22.06412,Longitude-90.23738	4.04	4.63	3.57	0.68
Tiakhali(3)	Latitude-22.06019,Longitude-90.23807	3.93	4.59	2.55	1.02
Tiakhali(4)	Latitude-22.0599,Longitude-90.23804	4.02	4.23	1.77	0.71
Tiakhali(5)	Latitude-22.05288,Longitude-90.23862	4.23	5.23	3.13	1.1
Tiakhali(6)	Latitude-22.053,Longitude-90.23855	4.20	4.78	2.20	0.81
Charghat(1)	Latitude-22.04093,Longitude-90.2419	4.22	4.98	6.35	1.4
Charghat(2)	Latitude-22.04063,Longitude-90.24204	3.96	4.88	10.65	6.1
Charghat(3)	Latitude-22.04063,Longitude-90.242041	4.20	4.79	3.46	1.0
Charghat(4)	Latitude-22.03965,Longitude-90.2426	4.76	5.25	3.27	1.62
Charghat(5)	Latitude-22.03943,Longitude-90.24203	4.30	4.41	5.58	1.9
	Average	**4.30**	**4.75**	**3.06**	**1.13**

Table 1.1.2. Spatial variability of pH and EC value in different soil depths at Taltali upazila of Patuakhali district

Location	GPS. Reading	pH		$EC_{1:5}$ (dS m^{-1})	
		0-5cm	5-10cm	0-5cm	5-10cm
Kochupatra(1)	Latitude-22.0587,Longitude-90.18215	4.34	5.18	2.26	0.85
Kochupatra (2)	Latitude-22.05898,Longitude-90.18158	4.01	4.05	8.44	2.85
Kochupatra(3)	Latitude-22.05339,Longitude-90.17924	3.96	4.64	3.81	1.4
Moddho kochupatra (4)	Latitude-22.04722,Longitude-90.17924	3.96	5.25	4.62	1.14
Moddho kochupatra (5)	Latitude-22.04716,Longitude-90.17992	4.60	5.36	2.96	0.9
Moddho kochupatra (6)	Latitude-22.09832,Longitude-90.17774	3.87	4.49	4.11	1.36
Moddho kochupatra (7)	Latitude-22.0463,Longitude-90.177	3.89	4.46	3.92	1.19
Moddho kochupatra (8)	Latitude-22.04624,Longitude-90.17702	3.98	4.08	6.51	2.46
Moddho kochupatra (9)	Latitude-22.04167,Longitude-90.17593	4.46	4.62	6.48	1.35
Moddho kochupatra (10)	Latitude-22.04176,Longitude-90.17592	3.93	4.20	2.77	1.81
Moddho kochupatra (11)	Latitude-22.03677,Longitude-90.17424	5.72	5.88	5.55	1.96
Moddho kochupatra (12)	Latitude-22.03688,Longitude-90.17437	4.35	4.96	1.96	0.44
Moddho kochupatra (13)	Latitude-22.0339,Longitude-90.16988	4.58	5.12	5.35	1.41
Nolbunia(1)	Latitude-22.03193,Longitude-90.1689	4.47	4.82	4.56	1.35
Nolbunia(2)	Latitude-22.03193,Longitude-90.1690	4.30	4.95	6.30	2.06
Nolbunia (3)	Latitude-22.02703,Longitude-90.1674	4.24	4.49	7.84	3.15
Nolbunia (4)	Latitude-22.02707,Longitude-90.1674	4.29	4.25	4.45	2.51
Nolbunia (5)	Latitude-22.02509,Longitude-90.16504	4.00	4.38	4.12	1.28
Koroibaria (1)	Latitude-22.0236,Longitude-90.16329	4.74	5.00	8.30	1.3
Koroibaria (2)	Latitude-22.02639,Longitude-90.16323	4.16	4.58	6.61	2.51
Koroibaria (3)	Latitude-22.01823,Longitude-90.15719	3.73	4.48	3.78	1.09
Koroibaria (4)	Latitude-22.01841,Longitude-90.15711	3.96	4.25	6.00	1.79
Koroibaria (5)	Latitude-22.01886,Longitude-90.15201	3.87	4.53	4.62	1.24
Koroibaria (6)	Latitude-22.01892,Longitude-90.15213	3.99	4.41	5.58	1.4
Alirbondor (1)	Latitude-22.01845,Longitude-90.14977	3.87	4.58	3.68	1.09
Alirbondor (2)	Latitude-22.01672,Longitude-90.14647	4.04	4.61	5.57	1.67
Alirbondor (3)	Latitude-22.01674,Longitude-90.14631	3.93	4.01	4.51	2.24
Alirbondor (4)	Latitude-22.01445,Longitude-90.14526	3.98	4.38	1.62	1.01
Alirbondor (5)	Latitude-22.01451,Longitude-90.14512	3.99	4.11	2.39	1.52
Alirbondor (6)	Latitude-22.00614,Longitude-90.14556	4.56	4.45	2.48	0.95
	Average	**4.19**	**4.62**	**4.71**	**1.58**

Table 1.1.3. Spatial variability of pH and EC value in different soil depths at Kalpara upazila of Patuakhali district

Location	GPS. Reading	pH		$EC_{1:5}$ (dS m^{-1})	
		0-5cm	5-10cm	0-5cm	5-10cm
Solimpur (1)	Latitude-21.97553,Longitude-90.21247	4.62	6.02	7.01	1.62
Solimpur (2)	Latitude-21.97489,Longitude-90.21261	3.95	4.89	1.30	0.44
Solimpur (3)	Latitude-21.97454,Longitude-90.21212	4.50	4.51	2.79	1.01
Solimpur (4)	Latitude-21.97461,Longitude-90.21172	4.07	4.55	7.65	3.02
Solimpur (5)	Latitude-21.97559,Longitude-90.21071	4.11	4.61	2.25	0.59
Solimpur (6)	Latitude-21.97608,Longitude-90.21092	4.28	4.93	0.99	0.27
Solimpur (7)	Latitude-21.97591,Longitude-90.21167	3.76	4.34	9.13	2.28
Umidpur (1)	Latitude-21.92318,Longitude-90.15721	3.81	4.59	4.69	1.74
Umidpur (2)	Latitude-21.92313,Longitude-90.15718	4.25	6.13	6.47	1.35
Umidpur (3)	Latitude-21.92271,Longitude-90.1563	3.67	4.67	6.77	1.52
Umidpur (4)	Latitude-21.92297,Longitude-90.15548	4.44	5.12	0.96	0.27
Umidpur (5)	Latitude-21.92386,Longitude-90.15524	3.99	5.46	1.94	0.32
Umidpur (6)	Latitude-21.92371,Longitude-90.15606	3.69	4.51	2.00	0.69
Diaramkhola (1)	Latitude-21.85085,Longitude-90.14153	5.56	5.73	0.56	1.56
Diaramkhola (2)	Latitude-21.85099,Longitude-90.1407	4.16	4.78	17.85	0.67
Diaramkhola (3)	Latitude-21.85183,Longitude-90.14093	4.44	4.40	10.82	2.52
Diaramkhola (4)	Latitude-21.85253,Longitude-90.14064	3.80	4.70	9.80	2.45
Diaramkhola (5)	Latitude-21.85269,Longitude-90.14034	5.20	6.02	6.90	4.26
Diaramkhola (6)	Latitude-21.85242,Longitude-90.13953	3.90	5.84	6.92	1.19
Diaramkhola (7)	Latitude-21.85382,Longitude-90.15943	4.04	5.22	6.00	1.02
Diaramkhola (8)	Latitude-21.85443,Longitude-90.1394	4.91	6.36	7.26	1.23
Hazipur (1)	Latitude-21.89252,Longitude-90.13847	4.71	5.35	3.77	3.19
Hazipur (2)	Latitude-21.89205,Longitude-90.13852	3.65	4.55	4.32	1.12
Hazipur (3)	Latitude-21.83138,Longitude-90.13836	4.57	4.93	3.49	2.72
Hazipur (4)	Latitude-21.89232,Longitude-90.13933	3.94	4.54	6.36	1.31
Hazipur (5)	Latitude-21.8914,Longitude-90.1394	3.55	3.50	7.79	5.05
Monoharpur (1)	Latitude-21.88644,Longitude-90.13867	3.54	3.80	7.75	2.99
Monoharpur (2)	Latitude-21.88574,Longitude-90.13783	3.53	4.06	6.38	1.6
Puranmohipur (1)	Latitude-21.88277,Longitude-90.13673	4.19	4.32	4.53	2.49
Puranmohipur (2)	Latitude-21.88162,Longitude-90.13626	4.68	6.12	7.64	1.6
	Average	**4.18**	**4.95**	**5.74**	**1.74**

The HCO_3^- concentration in 0-5 cm soil depth varied from 0.10 to 1.45% in Amtali, 0.15 to 1.10 % in Taltali and 0.10 to 0.90 % in Kalapara upazila, respectively (Table 1.1.4 to 1.1.6). The corresponding values in 5-10 cm soil depth were 0.10 to 0.90, 0.05 to 0.80 and 0.10 to 0.95 % in Amtali, Taltali and Kalapara, respectively. It was found that surface soil contains more HCO_3^- than subsurface soil and Kalapara upazila had the highest HCO_3^- contents.

The mean chloride ion concentration at 0-5 cm soil depth was 0.16, 0.14 and 0.17 % and at 5-10 cm soil depth was 0.11, 0.10 and 0.14 % at Amtali, Taltali and Kalapara upazila, respectively.

Phosphorus concentration was found higher at 5-10 cm soil depth compared to 0.5 cm soil depth. The P concentration was 16.78, 15.60 and 21.77 ppm at 0-5 cm soil depth; and that of 18.30, 16.97 and 24.36 ppm at 5-10 cm soil depth in Amtali, Taltali and Kalapara upazila, respectively (Table 1.1.7-1.1.9).

There was found a wide variation of S concentration among locations and soil depths. The mean S concentration found in 0-5 cm soil depth was 99.7, 74.16 and 21.24 ppm; and that of 35.5, 31.15 and 10.15 ppm at Amtali, Taltali and Kalapara upazila, respectively (Table 1.1.7-1.1.9).

In the soils of the study area Na concentration was found very high compared to K concentration. The average Na concentration was 16.54, 26.73 and 22.67 meq 100 g^{-1} soil at 0-5cm soil depth and 11.44, 14.08 and 17.47 ppm at 5-10 cm soil depth in Amtali Taltali and Kalapara upazila, respectively (Table 1.1.10-1.1.12). The corresponding mean K concentration was 0.26, 0.31 and 0.28 meq 100 g^{-1} soil in 0-5 cm soil depth; and 0.21, 0.27 and 0.23 meq 100 g^{-1} soil in 5-10 cm soil depth (Table 1.1.10-1.1.12).

Table 1.1.4. Spatial variability of HCO_3^- and Cl^- concentration (%) in different soil depths at Amtali upazila of Barguna district

Location of village	GPS. Reading	HCO_3^- (%)		Cl^- (%)	
		0-5cm	5-10cm	0-5cm	5-10cm
Satdhara(1)	Latitude-22.10322,Longitude-90.2199	0.55	0.25	0.08	0.06
Dakkhin pocchim Amtali(1)	Latitude-22.1008,Longitude-90.20903	0.55	0.55	0.26	0.14
Dakkhin pocchim Amtali(2)	Latitude-22.09751,Longitude-90.207347	0.60	0.60	0.10	0.16
Orpangasia(1)	Latitude-22.09116,Longitude-90.20404	0.10	0.05	0.10	0.14
Moddho Tarikata(1)	Latitude-22.08831,Longitude-90.20288	0.10	0.45	0.08	0.02
Moddho Tarikata(2)	Latitude-22.08689,Longitude-90.20526	0.10	0.15	0.22	0.18
Moddho Tarikata(3)	Latitude-22.08389,Longitude-90.20583	0.20	0.20	0.04	0.06
Moddho Tarikata(4)	Latitude-22.08336,Longitude-90.20489	0.25	0.30	0.06	0.02
Moddho Tarikata(5)	Latitude-22.07576,Longitude-90.20746	0.40	0.35	0.08	0.02
Chakmoia Darogartobok(1)	Latitude-22.06559,Longitude-90.20094	1.25	0.25	0.14	0.14
Chakmoia Darogartobok(2)	Latitude-22.06483,Longitude-90.20093	0.55	0.10	0.12	0.06
Chakmoia Darogartobok(3)	Latitude-22.06372,Longitude-90.19411	0.15	0.30	0.14	0.16
Chakmoia Darogartobok(4)	Latitude-22.06377,Longitude-90.22511	0.75	0.15	0.26	0.14
Pocchim Chakmoia Darogartobok(1)	Latitude-22.06268,Longitude-90.18833	0.25	0.35	0.26	0.10
PocchimChakmoia Darogartobok(2)	Latitude-22.06327,Longitude-90.18822	0.05	0.20	0.10	0.12
Manikjhuri(1)	Latitude-22.09817,Longitude-90.22835	0.10	0.25	0.28	0.14
Manikjhuri(2)	Latitude-22.09836,Longitude-90.2236	0.50	0.10	0.20	0.12
Manikjhuri(3)	Latitude-22.09055,Longitude-90.22991	0.10	0.10	0.12	0.14
Manikjhuri(4)	Latitude-22.09042,Longitude-90.22954	0.70	0.90	0.16	0.20
Tiakhali(1)	Latitude-22.07459,Longitude-90.23528	1.45	0.10	0.06	0.06
Tiakhali(2)	Latitude-22.06412,Longitude-90.23738	0.70	0.15	0.16	0.10
Tiakhali(3)	Latitude-22.06019,Longitude-90.23807	0.40	0.10	0.32	0.26
Tiakhali(4)	Latitude-22.0599,Longitude-90.23804	0.60	0.30	0.36	0.24
Tiakhali(5)	Latitude-22.05288,Longitude-90.23862	0.30	0.60	0.12	0.08
Tiakhali(6)	Latitude-22.053,Longitude-90.23855	0.10	0.15	0.10	0.10
Charghat(1)	Latitude-22.04093,Longitude-90.2419	0.25	0.15	0.16	0.02
Charghat(2)	Latitude-22.04063,Longitude-90.24204	0.30	0.20	0.08	0.12
Charghat(3)	Latitude-22.04063,Longitude-90.242041	0.15	0.30	0.30	0.12
Charghat(4)	Latitude-22.03965,Longitude-90.2426	0.25	0.15	0.08	0.08
Charghat(5)	Latitude-22.03943,Longitude-90.24203	0.60	0.70	0.20	0.12
	Average	**0.41**	**0.28**	**0.16**	**0.11**

Table 1.1.5. Spatial variability of HCO_3^- and Cl^- concentration (%) in different soil depths at Taltali upazila of Patuakhali district

Location	GPS. Reading	HCO_3^- (%)		Cl^- (%)	
		0-5cm	5-10cm	0-5cm	5-10cm
Kochupatra(1)	Latitude-22.0587,Longitude-90.18215	0.70	0.65	0.12	0.06
Kochupatra (2)	Latitude-22.05898,Longitude-90.18158	0.85	0.45	0.18	0.16
Kochupatra(3)	Latitude-22.05339,Longitude-90.17924	0.35	0.25	0.10	0.12
Moddho kochupatra (4)	Latitude-22.04722,Longitude-90.17924	0.40	0.50	0.06	0.10
Moddho kochupatra (5)	Latitude-22.04716,Longitude-90.17992	0.35	0.05	0.10	0.08
Moddho kochupatra (6)	Latitude-22.09832,Longitude-90.17774	0.15	0.25	0.02	0.06
Moddho kochupatra (7)	Latitude-22.0463,Longitude-90.177	0.25	0.10	0.02	0.06
Moddho kochupatra (8)	Latitude-22.04624,Longitude-90.17702	0.30	0.25	0.16	0.10
Moddho kochupatra (9)	Latitude-22.04167,Longitude-90.17593	0.65	0.50	0.12	0.04
Moddho kochupatra (10)	Latitude-22.04176,Longitude-90.17592	0.25	0.15	0.14	0.10
Moddho kochupatra (11)	Latitude-22.03677,Longitude-90.17424	1.10	0.25	0.12	0.14
Moddho kochupatra (12)	Latitude-22.03688,Longitude-90.17437	0.25	0.25	0.12	0.02
Moddho kochupatra (13)	Latitude-22.0339,Longitude-90.16988	0.45	0.25	0.10	0.06
Nolbunia(1)	Latitude-22.03193,Longitude-90.1689	0.25	0.10	0.04	0.06
Nolbunia(2)	Latitude-22.03193,Longitude-90.1690	0.20	0.30	0.04	0.02
Nolbunia (3)	Latitude-22.02703,Longitude-90.1674	0.50	0.50	0.12	0.08
Nolbunia (4)	Latitude-22.02707,Longitude-90.1674	0.30	0.10	0.02	0.02
Nolbunia (5)	Latitude-22.02509,Longitude-90.16504	0.65	0.60	0.16	0.06
Koroibaria (1)	Latitude-22.0236,Longitude-90.16329	0.60	0.35	0.08	0.06
Koroibaria (2)	Latitude-22.02639,Longitude-90.16323	0.25	0.10	0.18	0.16
Koroibaria (3)	Latitude-22.01823,Longitude-90.15719	0.25	0.30	0.06	0.12
Koroibaria (4)	Latitude-22.01841,Longitude-90.15711	0.50	0.35	0.46	0.16
Koroibaria (5)	Latitude-22.01886,Longitude-90.15201	0.25	0.80	0.16	0.16
Koroibaria (6)	Latitude-22.01892,Longitude-90.15213	0.35	0.25	0.22	0.06
Alirbondor (1)	Latitude-22.01845,Longitude-90.14977	0.30	0.35	0.12	0.06
Alirbondor (2)	Latitude-22.01672,Longitude-90.14647	0.50	0.40	0.06	0.12
Alirbondor (3)	Latitude-22.01674,Longitude-90.14631	0.35	0.25	0.32	0.10
Alirbondor (4)	Latitude-22.01445,Longitude-90.14526	0.30	0.40	0.12	0.12
Alirbondor (5)	Latitude-22.01451,Longitude-90.14512	0.65	0.50	0.34	0.32
Alirbondor (6)	Latitude-22.00614,Longitude-90.14556	0.40	0.05	0.30	0.26
	Average	**0.42**	**0.32**	**0.14**	**0.10**

Table 1.1.6. Spatial variability of HCO_3^- and Cl^- concentration (%) in different soil depths at Kalpara upazila of Patuakhali district

Location	GPS. Reading	HCO_3^- (%)		Cl^- (%)	
		0-5cm	**5-10cm**	**0-5cm**	**5-10cm**
Solimpur (1)	Latitude-21.97553,Longitude-90.21247	0.25	0.15	0.24	0.22
Solimpur (2)	Latitude-21.97489,Longitude-90.21261	0.25	0.15	0.16	0.14
Solimpur (3)	Latitude-21.97454,Longitude-90.21212	0.10	0.15	0.16	0.14
Solimpur (4)	Latitude-21.97461,Longitude-90.21172	0.20	0.10	0.04	0.06
Solimpur (5)	Latitude-21.97559,Longitude-90.21071	0.10	0.25	0.14	0.12
Solimpur (6)	Latitude-21.97608,Longitude-90.21092	0.25	0.25	0.22	0.20
Solimpur (7)	Latitude-21.97591,Longitude-90.21167	0.25	0.30	0.06	0.04
Umidpur (1)	Latitude-21.92318,Longitude-90.15721	0.15	0.10	0.14	0.12
Umidpur (2)	Latitude-21.92313,Longitude-90.15718	0.15	0.15	0.12	0.10
Umidpur (3)	Latitude-21.92271,Longitude-90.1563	0.35	0.45	0.32	0.36
Umidpur (4)	Latitude-21.92297,Longitude-90.15548	0.90	0.75	0.28	0.24
Umidpur (5)	Latitude-21.92386,Longitude-90.15524	0.85	0.95	0.10	0.06
Umidpur (6)	Latitude-21.92371,Longitude-90.15606	0.25	0.30	0.14	0.12
Diaramkhola (1)	Latitude-21.85085,Longitude-90.14153	0.20	0.25	0.10	0.10
Diaramkhola (2)	Latitude-21.85099,Longitude-90.1407	0.25	0.30	0.26	0.28
Diaramkhola (3)	Latitude-21.85183,Longitude-90.14093	0.45	0.40	0.24	0.08
Diaramkhola (4)	Latitude-21.85253,Longitude-90.14064	0.60	0.50	0.12	0.04
Diaramkhola (5)	Latitude-21.85269,Longitude-90.14034	0.65	0.35	0.10	0.08
Diaramkhola (6)	Latitude-21.85242,Longitude-90.13953	0.35	0.30	0.06	0.14
Diaramkhola (7)	Latitude-21.85382,Longitude-90.15943	0.90	0.95	0.10	0.10
Diaramkhola (8)	Latitude-21.85443,Longitude-90.1394	0.85	0.60	0.12	0.14
Hazipur (1)	Latitude-21.89252,Longitude-90.13847	0.75	0.10	0.20	0.28
Hazipur (2)	Latitude-21.89205,Longitude-90.13852	0.10	0.30	0.16	0.12
Hazipur (3)	Latitude-21.83138,Longitude-90.13836	0.30	0.25	0.44	0.16
Hazipur (4)	Latitude-21.89232,Longitude-90.13933	0.45	0.40	0.10	0.06
Hazipur (5)	Latitude-21.8914,Longitude-90.1394	0.60	0.50	0.14	0.16
Monoharpur (1)	Latitude-21.88644,Longitude-90.13867	0.25	0.45	0.22	0.08
Monoharpur (2)	Latitude-21.88574,Longitude-90.13783	0.90	0.65	0.06	0.06
Puranmohipur (1)	Latitude-21.88277,Longitude-90.13673	0.35	0.45	0.14	0.24
Puranmohipur (2)	Latitude-21.88162,Longitude-90.13626	0.80	0.85	0.30	0.14
	Average	**0.43**	**0.39**	**0.17**	**0.14**

Table 1.1.7. Spatial variability of phosphorus and sulphur concentration (ppm) in different soil depths at Amtali upazila of Barguna district

Location of village	GPS. Reading	Available P (ppm)		Available S (ppm)	
		0-5cm	5-10cm	0-5cm	5-10cm
Satdhara(1)	Latitude-22.10322,Longitude-90.2199	16.67	18.79	57.3	5.6
Dakkhin pocchim Amtali(1)	Latitude-22.1008,Longitude-90.20903	18.62	14.18	10.8	7.8
Dakkhin pocchim Amtali(2)	Latitude-22.09751,Longitude-90.207347	14.36	17.11	34.1	7.3
Orpangasia(1)	Latitude-22.09116,Longitude-90.20404	9.40	23.67	97.0	40.9
Moddho Tarikata(1)	Latitude-22.08831,Longitude-90.20288	15.78	17.55	56.9	42.7
Moddho Tarikata(2)	Latitude-22.08689,Longitude-90.20526	21.19	25.09	28.1	5.6
Moddho Tarikata(3)	Latitude-22.08389,Longitude-90.20583	27.22	22.15	47.0	43.1
Moddho Tarikata(4)	Latitude-22.08336,Longitude-90.20489	15.34	30.59	114.2	64.2
Moddho Tarikata(5)	Latitude-22.07576,Longitude-90.20746	14.45	12.59	115.1	48.3
Chakmoia Darogartobok(1)	Latitude-22.06559,Longitude-90.20094	16.05	18.00	121.1	23.3
Chakmoia Darogartobok(2)	Latitude-22.06483,Longitude-90.20093	21.28	24.98	94.8	42.2
Chakmoia Darogartobok(3)	Latitude-22.06372,Longitude-90.19411	16.58	16.13	53.0	16.8
Chakmoia Darogartobok(4)	Latitude-22.06377,Longitude-90.22511	7.45	9.66	172.0	86.0
Pocchim Chakmoia Darogartobok(1)	Latitude-22.06268,Longitude-90.18833	19.95	15.87	173.7	73.7
PocchimChakmoia Darogartobok(2)	Latitude-22.06327,Longitude-90.18822	18.44	12.59	102.6	35.3
Manikjhuri(1)	Latitude-22.09817,Longitude-90.22835	14.10	12.32	167.2	125.9
Manikjhuri(2)	Latitude-22.09836,Longitude-90.2236	12.15	14.54	67.2	32.8
Manikjhuri(3)	Latitude-22.09055,Longitude-90.22991	21.72	23.30	23.3	21.6
Manikjhuri(4)	Latitude-22.09042,Longitude-90.22954	16.58	19.86	87.1	7.8
Tiakhali(1)	Latitude-22.07459,Longitude-90.23528	16.76	16.05	147.0	13.4
Tiakhali(2)	Latitude-22.06412,Longitude-90.23738	13.92	17.55	196.1	26.3
Tiakhali(3)	Latitude-22.06019,Longitude-90.23807	13.48	18.00	103.9	13.8
Tiakhali(4)	Latitude-22.0599,Longitude-90.23804	19.24	15.96	141.8	31.9
Tiakhali(5)	Latitude-22.05288,Longitude-90.23862	17.64	11.61	103.9	10.8
Tiakhali(6)	Latitude-22.053,Longitude-90.23855	19.15	29.96	94.4	40.5
Charghat(1)	Latitude-22.04093,Longitude-90.2419	25.09	27.00	92.7	25.0
Charghat(2)	Latitude-22.04063,Longitude-90.24204	19.86	19.50	133.2	33.6
Charghat(3)	Latitude-22.04063,Longitude-90.242041	3.81	15.60	229.3	114.2
Charghat(4)	Latitude-22.03965,Longitude-90.2426	17.64	16.58	50.4	16.8
Charghat(5)	Latitude-22.03943,Longitude-90.24203	19.41	12.32	77.2	7.2
	Average	**16.78**	**18.30**	**99.7**	**35.5**

Table 1.1.8. Spatial variability of phosphorus and sulphur concentration (ppm) in different soil depths at Taltali upazila of Patuakhali district

Location	GPS. Reading	P (ppm)		S (ppm)	
		0-5cm	5-10cm	0-5cm	5-10cm
Kochupatra(1)	Latitude-22.0587,Longitude-90.18215	10.82	15.16	42.4	4.0
Kochupatra (2)	Latitude-22.05898,Longitude-90.18158	16.13	19.04	70.4	20.7
Kochupatra(3)	Latitude-22.05339,Longitude-90.17924	10.37	12.41	53.0	34.8
Moddho kochupatra (4)	Latitude-22.04722,Longitude-90.17924	8.63	11.52	148.5	5.5
Moddho kochupatra (5)	Latitude-22.04716,Longitude-90.17992	9.84	10.46	73.2	26.2
Moddho kochupatra (6)	Latitude-22.09832,Longitude-90.17774	14.01	24.02	81.7	33.8
Moddho kochupatra (7)	Latitude-22.0463,Longitude-90.177	20.48	19.06	87.8	47.3
Moddho kochupatra (8)	Latitude-22.04624,Longitude-90.17702	11.79	11.44	99.4	4.6
Moddho kochupatra (9)	Latitude-22.04167,Longitude-90.17593	18.88	14.54	19.5	8.8
Moddho kochupatra (10)	Latitude-22.04176,Longitude-90.17592	20.74	14.63	74.4	54.9
Moddho kochupatra (11)	Latitude-22.03677,Longitude-90.17424	12.50	18.97	22.3	22.8
Moddho kochupatra (12)	Latitude-22.03688,Longitude-90.17437	6.38	11.52	49.4	8.5
Moddho kochupatra (13)	Latitude-22.0339,Longitude-90.16988	29.61	23.83	31.7	25.3
Nolbunia(1)	Latitude-22.03193,Longitude-90.1689	17.11	18.17	50.6	14.9
Nolbunia(2)	Latitude-22.03193,Longitude-90.1690	24.02	16.40	142.7	36.3
Nolbunia (3)	Latitude-22.02703,Longitude-90.1674	12.41	29.96	57.0	39.0
Nolbunia (4)	Latitude-22.02707,Longitude-90.1674	17.46	18.62	51.2	49.1
Nolbunia (5)	Latitude-22.02509,Longitude-90.16504	15.69	14.72	52.4	30.2
Koroibaria (1)	Latitude-22.0236,Longitude-90.16329	5.05	10.64	56.1	20.1
Koroibaria (2)	Latitude-22.02639,Longitude-90.16323	1.77	10.28	111.6	98.8
Koroibaria (3)	Latitude-22.01823,Longitude-90.15719	3.28	2.48	66.2	28.7
Koroibaria (4)	Latitude-22.01841,Longitude-90.15711	13.92	18.53	86.0	51.8
Koroibaria (5)	Latitude-22.01886,Longitude-90.15201	15.60	27.84	29.0	30.2
Koroibaria (6)	Latitude-22.01892,Longitude-90.15213	21.28	13.12	86.0	25.9
Alirbondor (1)	Latitude-22.01845,Longitude-90.14977	17.82	18.26	86.0	52.7
Alirbondor (2)	Latitude-22.01672,Longitude-90.14647	20.21	13.74	82.3	76.2
Alirbondor (3)	Latitude-22.01674,Longitude-90.14631	18.62	20.21	96.0	20.7
Alirbondor (4)	Latitude-22.01445,Longitude-90.14526	18.53	22.96	225.6	10.7
Alirbondor (5)	Latitude-22.01451,Longitude-90.14512	25.71	28.16	40.2	15.5
Alirbondor (6)	Latitude-22.00614,Longitude-90.14556	29.17	18.53	52.1	36.3
	Average	**15.60**	**16.97**	**74.16**	**31.15**

Table 1.1.9. Spatial variability of phosphorus and sulphur concentration (ppm) in different soil depths at Kalpara upazila of Patuakhali district

Location	GPS. Reading	P (ppm)		S (ppm)	
		0-5cm	5-10cm	0-5cm	5-10cm
Solimpur (1)	Latitude-21.97553,Longitude-90.21247	36.08	28.10	9.2	5.2
Solimpur (2)	Latitude-21.97489,Longitude-90.21261	17.91	31.56	11.9	3.0
Solimpur (3)	Latitude-21.97454,Longitude-90.21212	12.23	21.90	10.7	12.5
Solimpur (4)	Latitude-21.97461,Longitude-90.21172	23.23	25.96	4.3	2.7
Solimpur (5)	Latitude-21.97559,Longitude-90.21071	19.77	34.84	4.3	6.1
Solimpur (6)	Latitude-21.97608,Longitude-90.21092	15.96	14.10	12.5	6.1
Solimpur (7)	Latitude-21.97591,Longitude-90.21167	11.88	11.97	12.2	8.5
Umidpur (1)	Latitude-21.92318,Longitude-90.15721	14.10	13.92	5.2	5.2
Umidpur (2)	Latitude-21.92313,Longitude-90.15718	13.56	26.86	29.9	22.0
Umidpur (3)	Latitude-21.92271,Longitude-90.1563	15.87	34.75	4.0	3.4
Umidpur (4)	Latitude-21.92297,Longitude-90.15548	15.60	15.69	10.1	7.6
Umidpur (5)	Latitude-21.92386,Longitude-90.15524	12.68	17.46	9.2	0.3
Umidpur (6)	Latitude-21.92371,Longitude-90.15606	25.00	25.35	6.7	8.2
Diaramkhola (1)	Latitude-21.85085,Longitude-90.14153	14.72	17.38	46.7	39.3
Diaramkhola (2)	Latitude-21.85099,Longitude-90.1407	31.65	32.36	19.5	6.4
Diaramkhola (3)	Latitude-21.85183,Longitude-90.14093	13.39	35.37	36.0	21.0
Diaramkhola (4)	Latitude-21.85253,Longitude-90.14064	32.36	28.51	8.8	3.4
Diaramkhola (5)	Latitude-21.85269,Longitude-90.14034	30.59	34.66	5.5	3.4
Diaramkhola (6)	Latitude-21.85242,Longitude-90.13953	16.58	25.71	15.2	8.5
Diaramkhola (7)	Latitude-21.85382,Longitude-90.15943	13.83	17.02	34.2	9.1
Diaramkhola (8)	Latitude-21.85443,Longitude-90.1394	29.80	25.00	33.2	11.9
Hazipur (1)	Latitude-21.89252,Longitude-90.13847	15.60	13.39	8.8	8.2
Hazipur (2)	Latitude-21.89205,Longitude-90.13852	24.49	22.34	16.2	3.7
Hazipur (3)	Latitude-21.83138,Longitude-90.13836	24.40	19.95	17.4	0.9
Hazipur (4)	Latitude-21.89232,Longitude-90.13933	35.11	34.89	31.7	16.2
Hazipur (5)	Latitude-21.8914,Longitude-90.1394	37.59	24.02	38.1	33.5
Monoharpur (1)	Latitude-21.88644,Longitude-90.13867	19.95	24.02	32.6	19.8
Monoharpur (2)	Latitude-21.88574,Longitude-90.13783	30.59	33.33	8.8	7.6
Puranmohipur (1)	Latitude-21.88277,Longitude-90.13673	18.09	29.34	38.7	11.9
Puranmohipur (2)	Latitude-21.88162,Longitude-90.13626	15.60	10.99	115.9	8.8
	Average	**21.27**	**24.36**	**21.24**	**10.15**

Table 1.1.10. Spatial variability of sodium and potassium concentration in different soil depths at Amtali upazila of Barguna district

Location of village	GPS. Reading	Na (meq 100 g^{-1} soil)		K (meq 100 g^{-1} soil)	
		0-5cm	5-10cm	0-5cm	5-10cm
Satdhara(1)	Latitude-22.10322,Longitude-90.2199	20.60	15.13	0.14	0.09
Dakkhin pocchim Amtali(1)	Latitude-22.1008,Longitude-90.20903	16.51	13.80	0.13	0.11
Dakkhin pocchim Amtali(2)	Latitude-22.09751,Longitude-90.207347	6.19	8.26	0.09	0.10
Orpangasia(1)	Latitude-22.09116,Longitude-90.20404	13.15	13.07	0.16	0.15
Moddho Tarikata(1)	Latitude-22.08831,Longitude-90.20288	15.13	14.45	0.13	0.16
Moddho Tarikata(2)	Latitude-22.08689,Longitude-90.20526	17.91	13.07	0.30	0.25
Moddho Tarikata(3)	Latitude-22.08389,Longitude-90.20583	15.14	14.45	0.28	0.26
Moddho Tarikata(4)	Latitude-22.08336,Longitude-90.20489	16.56	19.26	0.37	0.32
Moddho Tarikata(5)	Latitude-22.07576,Longitude-90.20746	12.38	11.01	0.23	0.27
Chakmoia Darogartobok(1)	Latitude-22.06559,Longitude-90.20094	24.08	1.38	0.35	0.24
Chakmoia Darogartobok(2)	Latitude-22.06483,Longitude-90.20093	33.71	15.82	0.37	0.31
Chakmoia Darogartobok(3)	Latitude-22.06372,Longitude-90.19411	24.08	7.57	0.34	0.21
Chakmoia Darogartobok(4)	Latitude-22.06377,Longitude-90.22511	6.19	8.26	0.35	0.32
PocchimChakmoia Darogartobok(1)	Latitude-22.06268,Longitude-90.18833	19.26	9.63	0.36	0.39
PocchimChakmoia Darogartobok(2)	Latitude-22.06327,Longitude-90.18822	12.38	12.38	0.27	0.27
Manikjhuri(1)	Latitude-22.09817,Longitude-90.22835	17.20	6.19	0.45	0.27
Manikjhuri(2)	Latitude-22.09836,Longitude-90.2236	8.26	8.26	0.15	0.15
Manikjhuri(3)	Latitude-22.09055,Longitude-90.22991	18.68	13.07	0.26	0.16
Manikjhuri(4)	Latitude-22.09042,Longitude-90.22954	9.63	10.32	0.17	0.17
Tiakhali(1)	Latitude-22.07459,Longitude-90.23528	16.51	15.82	0.18	0.18
Tiakhali(2)	Latitude-22.06412,Longitude-90.23738	26.14	19.95	0.18	0.18
Tiakhali(3)	Latitude-22.06019,Longitude-90.23807	12.38	17.20	0.24	0.17
Tiakhali(4)	Latitude-22.0599,Longitude-90.23804	14.45	6.19	0.28	0.18
Tiakhali(5)	Latitude-22.05288,Longitude-90.23862	12.38	15.13	0.15	0.14
Tiakhali(6)	Latitude-22.053,Longitude-90.23855	15.13	0.69	0.19	0.17
Charghat(1)	Latitude-22.04093,Longitude-90.2419	5.50	8.94	0.27	0.23
Charghat(2)	Latitude-22.04063,Longitude-90.24204	34.40	13.76	0.22	0.23
Charghat(3)	Latitude-22.04063,Longitude-90.242041	16.51	14.45	0.24	0.08
Charghat(4)	Latitude-22.03965,Longitude-90.2426	17.20	3.44	0.28	0.26
Charghat(5)	Latitude-22.03943,Longitude-90.24203	18.57	12.38	0.55	0.20
	Average	**16.54**	**11.44**	**0.26**	**0.21**

Table 1.1.11. Spatial variability of sodium and potassium concentration in different soil depths at Taltali upazila of Patuakhali district

Location	GPS. Reading	Na (meq 100 g^{-1} soil)		K (meq 100 g^{-1} soil)	
		0-5cm	5-10cm	0-5cm	5-10cm
Kochupatra(1)	Latitude-22.0587,Longitude-90.18215	31.65	30.96	0.31	0.30
Kochupatra (2)	Latitude-22.05898,Longitude-90.18158	55.72	17.20	0.32	0.31
Kochupatra(3)	Latitude-22.05339,Longitude-90.17924	23.39	23.39	0.31	0.32
Moddho kochupatra (4)	Latitude-22.04722,Longitude-90.17924	33.71	27.52	0.22	0.19
Moddho kochupatra (5)	Latitude-22.04716,Longitude-90.17992	30.96	10.32	0.29	0.28
Moddho kochupatra (6)	Latitude-22.09832,Longitude-90.17774	32.33	9.63	0.27	0.27
Moddho kochupatra (7)	Latitude-22.0463,Longitude-90.177	28.21	9.63	0.27	0.25
Moddho kochupatra (8)	Latitude-22.04624,Longitude-90.17702	25.45	18.57	0.35	0.37
Moddho kochupatra (9)	Latitude-22.04167,Longitude-90.17593	24.77	6.19	0.35	0.12
Moddho kochupatra (10)	Latitude-22.04176,Longitude-90.17592	23.39	10.32	0.23	0.26
Moddho kochupatra (11)	Latitude-22.03677,Longitude-90.17424	23.39	5.50	0.29	0.22
Moddho kochupatra (12)	Latitude-22.03688,Longitude-90.17437	11.70	9.63	0.24	0.20
Moddho kochupatra (13)	Latitude-22.0339,Longitude-90.16988	24.08	11.70	0.36	0.31
Nolbunia(1)	Latitude-22.03193,Longitude-90.1689	19.95	11.70	0.34	0.22
Nolbunia(2)	Latitude-22.03193,Longitude-90.1690	28.21	11.01	0.28	0.26
Nolbunia (3)	Latitude-22.02703,Longitude-90.1674	44.03	24.08	0.26	0.32
Nolbunia (4)	Latitude-22.02707,Longitude-90.1674	20.64	9.63	0.21	0.23
Nolbunia (5)	Latitude-22.02509,Longitude-90.16504	31.65	19.26	0.31	0.20
Koroibaria (1)	Latitude-22.0236,Longitude-90.16329	39.21	9.63	0.30	0.26
Koroibaria (2)	Latitude-22.02639,Longitude-90.16323	29.58	18.57	0.23	0.24
Koroibaria (3)	Latitude-22.01823,Longitude-90.15719	32.33	16.51	0.39	0.31
Koroibaria (4)	Latitude-22.01841,Longitude-90.15711	39.21	18.57	0.33	0.33
Koroibaria (5)	Latitude-22.01886,Longitude-90.15201	27.52	15.82	0.30	0.22
Koroibaria (6)	Latitude-22.01892,Longitude-90.15213	20.64	20.64	0.57	0.42
Alirbondor (1)	Latitude-22.01845,Longitude-90.14977	13.07	5.50	0.28	0.25
Alirbondor (2)	Latitude-22.01672,Longitude-90.14647	18.57	10.30	0.32	0.33
Alirbondor (3)	Latitude-22.01674,Longitude-90.14631	25.45	9.63	0.40	0.37
Alirbondor (4)	Latitude-22.01445,Longitude-90.14526	6.19	4.82	0.32	0.26
Alirbondor (5)	Latitude-22.01451,Longitude-90.14512	20.64	15.13	0.38	0.30
Alirbondor (6)	Latitude-22.00614,Longitude-90.14556	15.82	11.01	0.25	0.22
	Average	**26.72**	**14.08**	**0.31**	**0.27**

Table 1.1.12. Spatial variability of sodium and potassium concentration in different soil depths at Kalpara upazila of Patuakhali district

Location	GPS. Reading	Na (meq $100g^{-1}$ soil)		K (meq $100g^{-1}$ soil)	
		0-5cm	5-10cm	0-5cm	5-10cm
Solimpur (1)	Latitude-21.97553,Longitude-90.21247	14.49	13.76	0.27	0.17
Solimpur (2)	Latitude-21.97489,Longitude-90.21261	17.89	20.64	0.14	0.14
Solimpur (3)	Latitude-21.97454,Longitude-90.21212	15.82	11.01	0.23	0.20
Solimpur (4)	Latitude-21.97461,Longitude-90.21172	25.45	24.08	0.26	0.17
Solimpur (5)	Latitude-21.97559,Longitude-90.21071	17.20	10.32	0.19	0.19
Solimpur (6)	Latitude-21.97608,Longitude-90.21092	17.90	15.82	0.50	0.17
Solimpur (7)	Latitude-21.97591,Longitude-90.21167	27.52	14.45	0.23	0.25
Umidpur (1)	Latitude-21.92318,Longitude-90.15721	28.21	16.51	0.32	0.24
Umidpur (2)	Latitude-21.92313,Longitude-90.15718	25.45	17.89	0.38	0.39
Umidpur (3)	Latitude-21.92271,Longitude-90.1563	25.45	17.90	0.22	0.22
Umidpur (4)	Latitude-21.92297,Longitude-90.15548	16.51	15.13	0.22	0.15
Umidpur (5)	Latitude-21.92386,Longitude-90.15524	16.51	14.45	0.18	0.12
Umidpur (6)	Latitude-21.92371,Longitude-90.15606	13.07	9.63	0.30	0.18
Diaramkhola (1)	Latitude-21.85085,Longitude-90.14153	37.15	20.64	0.41	0.30
Diaramkhola (2)	Latitude-21.85099,Longitude-90.1407	31.32	25.45	0.30	0.25
Diaramkhola (3)	Latitude-21.85183,Longitude-90.14093	27.52	25.45	0.32	0.22
Diaramkhola (4)	Latitude-21.85253,Longitude-90.14064	31.65	18.57	0.25	0.25
Diaramkhola (5)	Latitude-21.85269,Longitude-90.14034	17.20	17.89	0.21	0.20
Diaramkhola (6)	Latitude-21.85242,Longitude-90.13953	37.84	11.70	0.35	0.36
Diaramkhola (7)	Latitude-21.85382,Longitude-90.15943	19.26	21.33	0.35	0.22
Diaramkhola (8)	Latitude-21.85443,Longitude-90.1394	19.26	22.01	0.25	0.26
Hazipur (1)	Latitude-21.89252,Longitude-90.13847	24.10	23.39	0.27	0.28
Hazipur (2)	Latitude-21.89205,Longitude-90.13852	17.89	28.21	0.21	0.18
Hazipur (3)	Latitude-21.83138,Longitude-90.13836	8.26	12.38	0.23	0.23
Hazipur (4)	Latitude-21.89232,Longitude-90.13933	25.45	25.45	0.30	0.31
Hazipur (5)	Latitude-21.8914,Longitude-90.1394	19.26	12.38	0.27	0.27
Monoharpur (1)	Latitude-21.88644,Longitude-90.13867	39.21	8.94	0.40	0.17
Monoharpur (2)	Latitude-21.88574,Longitude-90.13783	15.82	17.89	0.33	0.27
Puranmohipur (1)	Latitude-21.88277,Longitude-90.13673	23.39	9.63	0.23	0.22
Puranmohipur (2)	Latitude-21.88162,Longitude-90.13626	24.08	21.33	0.27	0.26
	Average	**22.67**	**17.47**	**0.28**	**0.23**

Temporal variability

To determine the temporal variability of salinity and other related chemical parameters soil samples were collected 12 times starting from 15 January 2018 to 30 June 2018 with 15 days interval. The results clearly evidenced that the mean EC value of six study location in 15 January (determined in 1:5 soil water suspension) was 5.93 and it progressively increased with the passes of time, remains in peak from mid February to end of March and thereafter starts to reduce (Table 1.2.1). Finally, at the end of June it recorded the lowest value (1.38 dS m^{-1}). Among the upazilas, the soils of Amtali were most affected by salinity.

The temporal variability data of soil pH is given in Table 1.2.2. The pH value of the soil samples collected in January was found the lowest (5.50) and it progressively increased until 30 June 2018 (6.52).

The soil HCO_3^- concentration was 0.38% in 15 January sampling. It progressively increased with the passes of time. At 30 March highest value of 1.33% was recorded; and it further gradually reduced to 0.64% in 30 June (Table 1.2.3).

The chloride ion concentration was relatively lower compared to HCO_3^- concentration. The mean Cl^- concentration of first soil sample collected in January concentration was 0.14% and it progressively increased up to 30 April (0.30%); thereafter it gradually decreased to 0.06% in 30 June (Table 1.2.4).

The Na^+ concentration was found extremely high in the soils of the study areas. The mean Na^+ concentration in 15 January was 20.1 meq 100 g^{-1} soil which very rapidly increased with passes of time. Highest Na^+ concentration was found at 15 April sampling. Thereafter the value decreased gradually and finally on 30 June it was 5.2 meq 100 g^{-1} soil (Table 1.2.5).

Over the study period mean K^+ concentration varied from 0.218 to 0.332 meq 100 g^{-1} soil. Similar to other parameters the K^+ concentration in soil sharply increased from mid January to late April and then it further goes down (Table 1.2.6).

Table 1.2.7 demonstrated the P concentration of soil. It was observed from the Table 1.2.7 that at January 15 the P content was 25 ppm, and with the passes of time it gradually decreased and in 15 May it attained to 9.4 ppm. Then it further starts to increase.

The S concentration in 15 January was 254.6 ppm. The value progressively increased with the time and attained to 517.5 ppm in 30 March. Thereafter it gradually decreased with the passes of time and it reduced to 38.5 in 30 June (Table 1.2.8).

Table 1.2.1 Temporal variability of soil electrical conductivity ($EC_{1:5}$ in dS/m) in different locations of south coastal region of Bangladesh

Date of sampling	Taltali upazila, Barguna		Amtali upazila, Barguna		Kalapara upazila, Patuakhali		Mean
	North Kochupatra	South Kochupatra	Kollanpur	Charghat	Khanabad College	Diaramkhola	
15.01.18	6.56	4.54	2.39	9.91	4.95	7.25	**5.93**
30.01.18	6.29	5.9	2.25	9.9	5.06	6.99	**6.07**
15.02.18	7.92	4.6	10.5	10.94	8.42	7.85	**8.37**
28.02.18	6.99	4.16	12.08	9.29	7.00	9.55	**8.18**
15.03.18	5.75	4.94	12.6	12.54	6.26	8.95	**8.51**
30.03.18	7.76	4.5	12.39	11.63	6.89	6.18	**8.23**
15.04.18	5.49	3.56	12.5	10.91	5.12	8.39	**7.66**
30.04.18	5.00	3.93	10.22	9.66	6.13	5.95	**6.82**
15.05.18	4.85	3.12	10.12	9.68	7.09	8.00	**7.14**
30.05.18	2.38	2.38	4.33	2.63	1.14	2.72	**2.60**
15.06.18	1.73	0.66	4.28	1.9	0.85	2.16	**1.93**
30.06.18	0.85	0.77	2.69	1.19	0.85	1.93	**1.38**
Mean	**5.13**	**3.59**	**8.03**	**8.35**	**4.98**	**6.33**	

Table 1.2.2 Temporal variability of soil pH in different locations of south coastal region of Bangladesh

Date of sampling	Taltali upazila, Barguna		Amtali upazila, Barguna		Kalapara upazila, Patuakhali		Mean
	North Kochupatra	South Kochupatra	Kollanpur	Charghat	Khanabad College	Diaramkhola	
15.01.18	5.23	5.16	5.13	5.76	6.06	5.66	**5.50**
30.01.18	5.29	5.25	5.11	5.57	6.14	5.98	**5.56**
15.02.18	5.21	5.32	7.15	5.6	6.37	6.01	**5.94**
28.02.18	5.15	5.2	6.79	5.47	6.72	5.57	**5.82**
15.03.18	5.27	5.22	7.03	5.55	6.18	5.67	**5.82**
30.03.18	5.04	5.28	7.72	5.4	6.94	5.83	**6.04**
15.04.18	5.34	5.08	7.27	5.56	6.8	5.9	**5.99**
30.04.18	5.83	5.19	7.17	6.06	6.87	5.53	**6.11**
15.05.18	5.68	5.21	7.14	5.88	6.75	5.5	**6.03**
30.05.18	5.52	5.57	7.11	6.02	6.74	6.47	**6.24**
15.06.18	6.07	5.99	7.06	6.25	6.79	6.86	**6.50**
30.06.18	6.15	5.95	7.45	6.55	6.47	6.55	**6.52**
Mean	**5.48**	**5.37**	**6.84**	**5.81**	**6.57**	**5.96**	

Table 1.2.3 Temporal variability of soil bicarbonate ion (HCO_3^-) concentration (%) in different locations of south coastal region of Bangladesh

Date of sampling	Taltali upazila, Barguna		Amtali upazila, Barguna		Kalapara upazila, Patuakhali		Mean
	North Kochupatra	South Kochupatra	Kollanpur	Charghat	Khanabad College	Diaramkhola	
15.01.18	0.70	0.30	0.35	0.50	0.25	0.20	**0.38**
30.01.18	0.75	0.25	0.25	0.55	0.25	0.20	**0.38**
15.02.18	0.25	0.20	1.00	0.65	0.30	0.45	**0.48**
28.02.18	0.30	0.05	1.45	1.30	1.00	0.85	**0.83**
15.03.18	1.30	1.25	1.45	1.35	1.25	0.85	**1.24**
30.03.18	2.00	0.70	1.40	1.25	1.65	0.95	**1.33**
15.04.18	1.05	0.35	1.40	1.20	1.40	1.05	**1.08**
30.04.18	0.35	0.70	0.75	1.05	1.00	1.00	**0.81**
15.05.18	0.95	1.15	0.90	0.70	1.10	0.95	**0.96**
30.05.18	0.35	1.20	0.80	0.75	0.75	0.60	**0.74**
15.06.18	0.60	0.80	0.75	0.75	0.60	0.55	**0.68**
30.06.18	1.05	0.65	0.70	0.25	0.65	0.55	**0.64**
Mean	**0.80**	**0.63**	**0.93**	**0.86**	**0.85**	**0.68**	

Table 1.2.4 Temporal variability of soil chloride ion (Cl^-) concentration (%) in different locations of south coastal region of Bangladesh

Date of sampling	Taltali upazila, Barguna		Amtali upazila, Barguna		Kalapara upazila, Patuakhali		Mean
	North Kochupatra	South Kochupatra	Kollanpur	Charghat	Khanabad College	Diaramkhola	
15.01.18	0.18	0.12	0.08	0.10	0.16	0.18	**0.14**
30.01.18	0.18	0.16	0.10	0.14	0.19	0.20	**0.16**
15.02.18	0.50	0.18	0.12	0.16	0.16	0.22	**0.22**
28.02.18	0.36	0.26	0.16	0.20	0.16	0.30	**0.24**
15.03.18	0.28	0.28	0.18	0.24	0.16	0.24	**0.23**
30.03.18	0.28	0.48	0.20	0.28	0.30	0.24	**0.30**
15.04.18	0.24	0.20	0.14	0.24	0.26	0.28	**0.23**
30.04.18	0.22	0.20	0.10	0.30	0.20	0.20	**0.20**
15.05.18	0.20	0.14	0.12	0.24	0.22	0.16	**0.18**
30.05.18	0.20	0.16	0.10	0.12	0.10	0.16	**0.14**
15.06.18	0.12	0.12	0.06	0.04	0.09	0.04	**0.08**
30.06.18	0.06	0.06	0.06	0.04	0.08	0.08	**0.06**
Mean	**0.24**	**0.20**	**0.12**	**0.18**	**0.17**	**0.19**	

Table 1.2.5 Temporal variability of soil sodium ion (Na^+) concentration (meq/100g soil) in different locations of south coastal region of Bangladesh

Date of sampling	Taltali upazila, Barguna		Amtali upazila, Barguna		Kalapara upazila, Patuakhali		**Mean**
	North Kochupatra	South Kochupatra	Kollanpur	Charghat	Khanabad College	Diaramkhola	
15.01.18	27.6	24.5	9.2	5.1	28.3	26.0	**20.1**
30.01.18	36.0	27.6	27.6	55.9	32.1	34.9	**35.7**
15.02.18	32.9	20.7	45.2	50.5	45.2	45.9	**40.1**
28.02.18	35.2	22.2	52.8	54.3	37.5	46.7	**41.5**
15.03.18	38.3	24.5	48.2	62.8	34.4	36.7	**40.8**
30.03.18	31.4	29.9	49.0	55.9	32.9	45.9	**40.8**
15.04.18	29.9	33.7	52.1	47.5	39.0	56.6	**43.1**
30.04.18	28.3	35.2	44.4	36.7	31.4	39.0	**35.8**
15.05.18	26.8	15.3	49.0	39.8	33.7	39.8	**34.1**
30.05.18	11.5	14.5	26.8	12.2	7.7	18.4	**15.2**
15.06.18	5.4	1.5	28.3	6.9	3.1	13.8	**9.8**
30.06.18	3.1	0.8	11.5	3.1	2.3	10.7	**5.2**
Mean	**25.5**	**20.9**	**37.0**	**35.9**	**27.3**	**34.5**	

Table 1.2.6 Temporal variability of soil potassium ion (K^+) concentration (meq/100g soil) in different locations of south coastal region of Bangladesh

Date of sampling	Taltali upazila, Barguna		Amtali upazila, Barguna		Kalapara upazila, Patuakhali		**Mean**
	North Kochupatra	South Kochupatra	Kollanpur	Charghat	Khanabad College	Diaramkhola	
15.01.18	0.235	0.299	0.128	0.254	0.339	0.376	**0.272**
30.01.18	0.265	0.316	0.130	0.262	0.345	0.387	**0.284**
15.02.18	0.300	0.343	0.145	0.277	0.328	0.379	**0.295**
28.02.18	0.292	0.355	0.153	0.264	0.329	0.406	**0.300**
15.03.18	0.307	0.358	0.145	0.271	0.302	0.407	**0.298**
30.03.18	0.309	0.331	0.139	0.276	0.311	0.424	**0.299**
15.04.18	0.296	0.377	0.115	0.261	0.310	0.421	**0.297**
30.04.18	0.407	0.417	0.118	0.329	0.302	0.421	**0.332**
15.05.18	0.346	0.362	0.121	0.331	0.296	0.418	**0.313**
30.05.18	0.249	0.415	0.106	0.239	0.312	0.421	**0.290**
15.06.18	0.278	0.288	0.109	0.249	0.277	0.374	**0.263**
30.06.18	0.251	0.118	0.112	0.278	0.240	0.310	**0.218**
Mean	**0.295**	**0.332**	**0.127**	**0.274**	**0.308**	**0.395**	

Table 1.2.7 Temporal variability of soil available phosphorus concentration (ppm) in different locations of south coastal region of Bangladesh

Date of sampling	Taltali upazila, Barguna		Amtali upazila, Barguna		Kalapara upazila, Patuakhali		Mean
	North Kochupatra	South Kochupatra	Kollanpur	Charghat	Khanabad College	Diaramkhola	
15.01.18	28.1	24.1	33.2	23.2	26.4	14.8	**25.0**
30.01.18	28.2	26.7	25.6	17.1	25.8	14.0	**22.9**
15.02.18	28.1	21.7	34.6	13.8	25.9	14.2	**23.0**
28.02.18	11.6	7.6	18.6	15.6	24.9	12.2	**15.1**
15.03.18	13.7	7.5	17.4	12.4	23.4	7.8	**13.7**
30.03.18	15.3	10.0	13.6	10.1	10.2	7.3	**11.1**
15.04.18	16.9	11.7	13.6	7.6	11.4	11.0	**12.0**
30.04.18	14.6	11.0	15.2	7.1	7.1	9.7	**10.8**
15.05.18	7.6	12.0	13.5	8.2	6.8	8.0	**9.4**
30.05.18	12.4	12.9	14.3	9.7	9.6	6.6	**10.9**
15.06.18	14.7	15.0	31.0	13.5	12.9	6.4	**15.6**
30.06.18	15.6	16.4	32.5	15.1	13.9	6.6	**16.7**
Mean	**17.2**	**14.7**	**21.9**	**12.8**	**16.5**	**9.9**	

Table 1.2.8 Temporal variability of soil available sulphur concentration (ppm) in different locations of south coastal region of Bangladesh

Date of sampling	Taltali upazila, Barguna		Amtali upazila, Barguna		Kalapara upazila, Patuakhali		Mean
	North Kochupatra	South Kochupatra	Kollanpur	Charghat	Khanabad College	Diaramkhola	
15.01.18	294.0	262.1	262.1	315.5	212.1	181.9	**254.6**
30.01.18	341.4	367.2	287.9	370.7	294.8	232.8	**315.8**
15.02.18	393.1	369.0	267.2	382.8	286.2	363.8	**343.7**
28.02.18	481.0	417.2	420.7	520.7	410.3	446.6	**449.4**
15.03.18	336.2	620.7	474.1	475.9	310.3	541.4	**459.8**
30.03.18	356.9	650.0	605.2	481.0	279.3	732.8	**517.5**
15.04.18	515.5	677.6	527.6	493.1	269.0	389.7	**478.7**
30.04.18	532.8	655.2	384.5	370.7	320.7	310.3	**429.0**
15.05.18	312.1	400.0	462.1	363.8	77.6	265.5	**313.5**
30.05.18	308.6	163.8	70.7	306.9	44.8	121.6	**169.4**
15.06.18	120.7	198.3	290.5	202.6	48.8	76.7	**156.3**
30.06.18	42.2	36.2	33.6	46.1	19.8	53.0	**38.5**
Mean	**336.2**	**401.4**	**340.5**	**360.8**	**214.5**	**309.7**	

Expt 2.1. Improving bitter gourd yield using polythene mulch and potassium fertilizer management in coastal saline soils of Bangladesh

Results and discussion

Mulch treatments significantly influenced the primary stem length of bitter gourd in Amtali, Taltali and Kalapara upazila (Table 2.1.1). Significantly highest stem length was found in polythene mulch treatment which was 235.8, 268.1 and 288.9 cm in Amtali, Taltali and Kalapara upazila, respectively; in control treatment these values were as 172.7, 197.2 and 227.2 cm. The rice straw mulch treatment had significantly higher primary stem length than control treatment only in Amtali upazila but statistically similar in Taltali and Kalapara upazila.

The number of branches per plant varied from 5.9 to 10.3 in Amtali, 6.2 to 11.6 in Taltali and 9.9 to 15.8 in Kalapara upazila; everywhere the lowest value was found in control (no much) treatment and the highest in polythene mulch treatment (Table 2.1.1). At Amtali upazila rice straw mulch treatment had statistically similar branches of control treatment, but in Taltali and Kalapara it was significantly higher than the no mulch control treatment. The mulch effect on number of leaves per primary stem was very much consistent over the location. Everywhere the lowest performance was observed in control treatment (32.4, 35.3 and 32.9 in Amtali, Taltali and Kalapara upazila, respectively) and the highest value noted was in polythene mulch treatment (41.2, 41.9 and 39.1 in Amtali, Taltali and Kalapara upazila, respectively). The rice straw mulch treatment produced statistically similar number of leaves of control treatment. The number of fruits per plant is extremely influenced by different mulch treatments. The control treatment produced 5.9, 4.9 and 6.0 fruits per plant and polythene mulch treatment produced 12.8, 10.4 and 11.3 fruits per plant in Amtali, Taltali and Kalapara upazila, respectively. The number of fruits per plant in Amtali, Taltali and Kalapara produced by polythene mulch treatment was 117, 112, and 88 % higher and by rice straw mulch treatment was 36, 112 and 88 % higher over control treatment, respectively.

Fruit length was significantly influenced by mulch treatments in Amtali and Taltali upazila but not in Kalapara upazila. The lowest performance was found in control treatment (15.8, 19.1 and 22.8 cm in Amtali, Taltali and Kalapara upazila, respectively) and the highest value was noted in Kalapara upazila (24.2, 24.3 and 25.2 cm in Amtali, Taltali and Kalapara, respectively). Rice straw mulch treatment showed significantly higher performance compared to control in Amtali but statistically similar in Taltali upazila (Table 2.1.1).

Table 2.1.1. Effect of mulch materials on growth and yield contributing parameters of bitter gourd at three coastal upazilas

Mulch materials	Coastal upazilas		
	Amtali	Taltali	Kalapara
	Primary stem length (cm)		
Control (no mulch)	172.7 C	197.2 B	227.2 B
Rice straw mulch	209.4 B	198.8 B	229.6 B
Polythene mulch	235.8 A	268.1 A	288.9 A
Significance level	***	***	***
SE (±)	10.76	9.5	7.46
	Number of branches per plant		
Control (no mulch)	5.9 B	6.2 C	9.9 C
Rice straw mulch	6.9 B	7.7 B	12.9 B
Polythene mulch	10.3 A	11.6 A	15.8 A
Significance level	***	***	***
SE (±)	0.52	0.43	0.54
	Number of leaves per primary stem		
Control (no mulch)	32.4 B	35.3 B	32.9 B
Rice straw mulch	35.0 B	35.7 B	32.8 B
Polythene mulch	41.2 A	41.9 A	39.1A
Significance level	***	***	***
SE (±)	1.05	1.15	1.24
	Number of fruits per plant		
Control (no mulch)	5.89 C	4.9 C	6.0 C
Rice straw mulch	8.00 B	6.3 B	8.8 B
Polythene mulch	12.78 A	10.4 A	11.3 A
Significance level	***	***	***
SE (±)	0.51	0.38	0.54
	Fruit length (cm)		
Control (no mulch)	15.8 C	19.1 B	22.8
Rice straw mulch	19.3 B	20.6 B	23.4
Polythene mulch	24.4 A	24.3 A	25.2
Significance level	***	***	NS
SE (±)	0.48	0.87	1.14

Means with the same capital letter in a column are not significantly different

Mulching effect in salt affected soil on bitter gourd yield was very much encouraging. Bitter gourd yield was 12.20, 9.16 and 10.07 t/ha in control treatment; 13.68, 12.50 and 11.88 t ha^{-1}in rice straw mulch treatment, and 27.25, 27.27 and 19.32 t ha^{-1} polythene mulch treatment, at Amtali, Taltali and Kalapara upazila, respectively (Table 2.1.2). Polythene mulch increases bitter gourd yield by 123, 198 and 92 % over no mulch control treatment at Amtali, Taltali and Kalapara upazila, respectively. Rice straw mulch had comparable fruit yield of control treatment over the location.

Leaf chlorophyll-content was significantly influenced by mulch treatments in Taltali and Kalapara upazila but not in Amtali upazila. Table 2.1.2 indicates that no mulch treatment always had higher chlorophyll-content; rice straw mulch had intermediate and polythene mulch had the lowest chlorophyll-a content. More or less similar trend was also found in chlorophyll-b content. The results clearly evidenced that in no mulch condition plants enjoy severe stress condition in coastal salt affected areas. Chlorophyll content by nature increased in the plant when it subjected to salt stress. For osmotic adjustment plants accumulate large amount of chlorophyll particles in the plant cell. In the experiment polythene mulch had the lowest chlorophyll content compared to other mulch treatments which indicates that in this treatment plant enjoy favourable soil condition.

Leaf Na content was significantly influenced by mulch treatments having 2.38, 1.82 and 2.13 % in no mulch condition; 2.06, 2.08 and 1.45 % in rice straw mulch treatment; and 1.91, 1.63 and 1.33 % in polythene mulch treatment at Amtali, Taltali and Kalapara upazila, respectively (Table 2.1.2). The results further indicates that in control treatment Na content is always higher and in polythene mulch condition it was the lowest. The results are in good indication of soil condition. Perhaps in no mulch condition salts are accumulated in higher concentration in soil and concomitantly increases the uptake of Na. However, polythene mulch successfully reduced the accumulation of salt in the soil. For this reason Na uptake is also minimum in polythene mulch treatment. The higher concentration of Na in plant tissue is very much detrimental for plant survival; polythene mulch rather helps to maintain lower levels of Na even in salt affected areas of Bangladesh.

Soil electrical conductivity was extremely influenced by mulch treatments. The soil EC values were 6.19, 4.36 and 6.90 dS m^{-1} in no mulch and in rice straw mulch treatment was 2.37, 2.08, and 3.19 dS m^{-1} and 2.23, 1.91 and 2.19 dS m^{-1} in polythene much treatment at Amtali, Taltali and Kalapara upazila, respectively (Table 2.1.2). Polythene much treatment thus reduced EC value by 64, 56 and 68 % and rice straw mulch by 62, 52 and 54 % over control treatment in Amtali, Taltali and Kalapara upazila, respectively. The results clearly evidenced that polythene mulch is highly capable to maintain soil EC value in a lower limit.

Table 2.1.2. Effect of mulch materials on fruit yield, leaf and soil parameters of bitter gourd at three coastal upazilas

Mulch materials	Coastal upazilas		
	Amtali	Taltali	Kalapara
	Fruit yield (t/ha)		
Control (no mulch)	12.20 B	9.16 B	10.07 B
Rice straw mulch	13.68 B	12.50 B	11.88 B
Polythene mulch	27.25 A	27.27 A	19.32 A
Significance level	***	***	***
SE (±)	0.87	0.81	0.88
	Leaf chlorophyll-a content (mg/100 g fresh leaf)		
Control (no mulch)	1.45	2.20 A	2.67 A
Rice straw mulch	1.37	1.79 B	2.03 B
Polythene mulch	1.23	1.37 B	1.62 B
Significance level	NS	***	**
SE (±)	0.0843	0.1273	0.2359
	Leaf chlorophyll-b content (mg/100 g fresh leaf)		
Control (no mulch)	0.46 A	0.77	0.51 A
Rice straw mulch	0.36 B	0.66	0.47AB
Polythene mulch	0.42 AB	0.65	0.35 B
Significance level	**	NS	***
SE (±)	0.0241	0.0575	0.0159
	Leaf Na content (%)		
Control (no mulch)	2.38 A	1.82 B	2.13 A
Rice straw mulch	2.06 B	2.08 A	1.45 B
Polythene mulch	1.91 B	1.63 C	1.33 B
Significance level	***	***	***
SE (±)	0.0692	0.0400	0.0662
	Soil $EC_{1:5}$ (dS/m)		
Control (no mulch)	6.19 A	4.36 A	6.90 A
Rice straw mulch	2.37 B	2.08 B	3.19 B
Polythene mulch	2.23 B	1.91 B	2.19 C
Significance level	***	***	***
SE (±)	0.0662	0.0500	0.1363

Means with the same capital letter in a column are not significantly different

Mulch materials had a significant effect on proline, total sugar and reducing sugar content of bitter gourd over three locations. Proline content in control treatment at Amtali, Taltali and Klapara upazila were 22.98, 19.17 and 17.94 mg 100 g^{-1} fruit the corresponding values were 21.75, 15.69 and 15.38 in straw mulch treatment and those of 17.08, 11.97 and 14.24 mg 100 g^{-1} fruit in polythene much treatment, respectively (Table 2.1.3). The results clearly evidenced that at control treatment the proline content was the highest where as polythene mulch consistently had the lowest proline content. Total sugar content and reducing sugar content consistently showed the highest value in polythene mulch treatment over the locations. At Taltali upazila in rice straw mulch and control treatment had identical total sugar content (0.26 g 100 g^{-1} fruit). However, rice straw much treatment had significantly higher total sugar content over control treatment at Kalapara but lower at Amtali upazila. Regarding reducing sugar content rice straw mulch had significantly better performance than control treatment at Amtali and Kalapara but lower in Taltali upazila.

Table 2.1.3. Effect of mulch materials on nutritional parameters of bitter gourd at three coastal upazilas

Mulch materials	Coastal upazilas		
	Amtali	Taltali	Kalapara
	Proline content (mg/100 g fruit)		
Control (no mulch)	22.98 A	19.17 A	17.94 A
Rice straw mulch	21.75 A	15.69 B	15.38 B
Polythene mulch	17.08 B	11.97 C	14.24 B
Significance level	***	***	***
SE (±)	0.78	0.5504	0.63
	Total sugar content (g/100g fruit)		
Control (no mulch)	0.47 B	0.26 B	0.43 C
Rice straw mulch	0.42 C	0.26 B	0.51 B
Polythene mulch	0.68 A	0.52 A	0.64 A
Significance level	***	***	***
SE (±)	0.0073	0.0064	0.0074
	Reducing sugar content (g/100g fruit)		
Control (no mulch)	0.29 B	0.20 B	0.31 B
Rice straw mulch	0.33 A	0.17 C	0.34 A
Polythene mulch	0.33 A	0.23 A	0.34 A
Significance level	***	***	**
SE (±)	0.0072	0.0046	0.0087

Means with the same capital letter in a column are not significantly different

K fertilizer effect

Potassium fertilizer effect was not as prominent as mulch treatment; on the growth and of bitter gourd; although in some cases, the effect was inconsistent. Primary stem length was not significantly influenced by different doses of K. Number of branches per plant was significant at Amtali but not at Taltali and Kalapara. Although not significant, there was an increasing effect due to application of higher doses of potassium (Table 2.1.4). Similar trend was also found in number of leaves per primary stem. Highest performance was found consistently with higher doses of K (150% recommended dose). Number of fruits per plant was significantly influenced in Amtali and Taltali with K application but not in Kalapara. Addition of 100% recommended K increased number of fruit per plant by 11, 6 and 5 %, and 150% recommended K application increased by 65, 31 and 10% over control treatment at Amtali, Taltali and Kalapara upazila, respectively. Fruit length was also significantly influenced at Amtali and Taltali but not at Kalpara upazila. Table 2.1.4 indicated that there is an increasing trend due to application of higher doses of K.

Like other growth and yield contributing parameters fruit yield was significantly influenced by K doses. Application of 100% recommended K increased fruit yield by 8, 12 and 7% , whereas 150% recommended K increased by 24, 28 and 12% over control treatment at Amtali, Taltali and Kalapara upazila, respectively (Table 2.1.5). Over the locations both chlorophyll-a and chlorophyll-b content was significantly influenced by K fertilizer doses. Control treatment consistently had the highest chlorophyll-a and chlorophyll-b content. Both chlorophyll-a and chlorophyll-b content gradually decreased with the increase of the doses of K and obviously 150% recommended K fertilizer dose had the lowest chlorophyll contents. It was probably happened due to salt stress in the soil. In control condition plant enjoy relatively higher rate of salt stress. Due to osmotic adjustment plant accumulate higher rate of chlorophyll granules in the cell. Lower rate of chlorophyll content in 150% recommended K dose rather indicates its relatively comfortable environment of soil.

Leaf sodium content is the good indication of tolerance of crops against salt stress. In the experiment over the locations leaf Na content was significantly influenced by K fertilizer doses. The control treatment where no K was added consistently recorded the highest leaf Na content. The Na content gradually decreased with increase of rate of K application. Thus 100% recommended K reduced leaf Na content by 17, 18, 22%, and 150% recommended K reduced by 29, 22 and 29 % over control treatment at Amtali, Taltali and Kalapara upazila, respectively. Probably higher rates of K compete well with Na for plant uptake.

Electrical conductivity of root rhizosphere soil was significantly influenced by K fertilizer doses. In the experiment control treatment had rather lower EC value and it progressively increased with the increase of rates of MoP fertilizer. Muriate of potash fertilizer contains large amount of chloride ion. When MoP fertilizer was added in excess (150% recommended K) it concomitantly added huge amount of chloride ion which may have effect to increase EC value of soil.

Proline content was significantly influenced by K fertilized doses. Over the locations proline content was consistently higher in control treatment; it gradually decreased with the increase of the rate of K application (Table 2.1.6). Higher proline content in control treatment is a good indicator of soil stress condition. When plants are in stress condition they accumulate huge amount of proline in plant cell for survival. In the experiment lower proline content in K applied treatments indicated that plants were in comfortable soil

condition in this treatment. Total sugar and reducing sugar content was consistently lower in control treatment and highest in 150% recommended K dose.

Table 2.1.4. Effect of potassium (K) on growth and yield contributing parameters of bitter gourd at three coastal upazilas

Potassium fertilizer	Coastal upazilas		
	Amtali	Taltali	Kalapara
	Primary stem length (cm)		
Control (no K)	203.2	220.8	246.7
100% recommended K	203.7	221.9	249.7
150% recommended K	211.0	221.4	249.3
Significance level	NS	NS	NS
SE (±)	10.76	9.5	7.46
	Number of branches per plant		
Control (no K)	6.9 B	8.3	12.3
100% recommended K	7.2 B	8.3	13.0
150% recommended K	9.0 A	8.8	13.2
Significance level	**	NS	NS
SE (±)	0.52	0.43	0.54
	Number of leaves per primary stem		
Control (no K)	35.7	36.3 B	34.1
100% recommended K	36.2	36.8 B	35.0
150% recommended K	36.8	39.8 A	35.7
Significance level	NS	*	NS
SE (±)	1.05	1.15	1.24
	Number of fruits per plant		
Control (no K)	7.1 B	6.4 B	8.3
100% recommended K	7.9 B	6.8 B	8.7
150% recommended K	11.7 A	8.4 A	9.1
Significance level	***	***	NS
SE (±)	0.51	0.38	0.54
	Fruit length (cm)		
Control (no K)	17.8 B	20.0 B	22.7
100% recommended K	20.6 A	21.4 B	24.6
150% recommended K	21.1 A	22.6 A	24.0
Significance level	***	*	NS
SE (±)	0.48	0.87	1.14

Means with the same capital letter in a column are not significantly different

Table 2.1.5. Effect of potassium (K) on fruit yield, leaf and soil parameters of bitter gourd at three coastal upazilas

Potassium fertilizer	Coastal upazilas		
	Amtali	Taltali	Kalapara
	Fruit yield (t/ha)		
Control (no K)	15.98 B	14.35 B	12.94
100% recommended K	17.33 AB	16.20 AB	13.79
150% recommended K	19.82 A	18.38 A	14.54
Significance level	**	***	NS
SE (±)	0.87	0.81	0.88
	Leaf chlorophyll-a content (mg/100 g fresh leaf)		
Control (no K)	1.86 A	2.40 A	2.88 A
100% recommended K	1.53 B	1.49 B	1.75 B
150% recommended K	0.67 C	1.46 B	1.70 B
Significance level	***	***	***
SE (±)	0.0843	0.1273	0.2359
	Leaf chlorophyll-b content (mg/100 g fresh leaf)		
Control (no K)	0.46 A	0.82 A	0.64 A
100% recommended K	0.43 AB	0.75 A	0.39 B
150% recommended K	0.35 B	0.50 B	0.30 C
Significance level	***	***	***
SE (±)	0.0241	0.0575	0.0159
	Leaf Na content (%)		
Control (no K)	2.51 A	2.13 A	1.97 A
100% recommended K	2.08 B	1.75 B	1.53 B
150% recommended K	1.77 C	1.66 B	1.40 B
Significance level	***	***	***
SE (±)	0.0692	0.0400	0.0662
	Soil $EC_{1:5}$ (dS/m)		
Control (no K)	2.62 C	2.34 C	3.82 B
100% recommended K	3.76 B	2.66 B	4.11 AB
150% recommended K	4.41 A	3.36 A	4.36 A
Significance level	***	***	**
SE (±)	0.0662	0.0500	0.1363

Means with the same capital letter in a column are not significantly different

Table 2.1.6. Effect of potassium (K) on nutritional parameters of bitter gourd at three coastal upazilas

Potassium fertilizer	Coastal upazilas		
	Amtali	Taltali	Kalapara
	Proline content (mg/100 g fruit)		
Control (no K)	25.11 A	18.31 A	19.52 A
100% recommended K	18.33 B	16.69 A	14.86 B
150% recommended K	18.38 B	11.83 B	13.17 B
Significance level	***	***	***
SE (±)	0.78	0.5504	0.63
	Total sugar content (g/100 g fruit)		
Control (no K)	0.45 C	0.24 C	0.36 C
100% recommended K	0.49 B	0.37 B	0.58 B
150% recommended K	0.63 A	0.44 A	0.64 A
Significance level	***	***	***
SE (±)	0.0073	0.0064	0.0074
	Reducing sugar content (g/100 g fruit)		
Control (no K)	0.27 B	0.16 B	0.28 B
100% recommended K	0.33 A	0.18 B	0.35 A
150% recommended K	0.34 A	0.25 A	0.36 A
Significance level	***	***	***
SE (±)	0.0072	0.0046	0.0087

Means with the same capital letter in a column are not significantly different

Interaction

Interaction of different kinds of mulch materials and different doses of K fertilizer had no significant effect on primary stem length and number of branches per plant over the locations. The number of leaves per primary stem was significantly higher at Amtali but not in Taltali and Kalapara upazila. Number of fruits per plant increased significantly at Taltali and Kalapara but not at Amtali upazila. Table 4.1.7 indicated that polythene mulch treatment along with 150% recommended K fertilizer dose showed the best performance over the locations. Fruit length increased significantly at Amtali and Taltali upazila but not at Kalapara upazila. Like other parameters fruit length was the highest in polythene mulch vs 150% recommended K treatments.

Over the three locations bitter gourd fruit yield was significantly influenced by the interaction effect of mulches and K fertilizers. It was found that at Amtali upazila the highest fruit yield was recorded in polythene mulch and 100% recommended K interaction (32.67 t/ha). At Taltali upazila highest yield was found in polythene much with 150% recommended K; at Kalapara it was further at polythene mulch versus 150% recommended K, however it was statistically similar with polythene mulch vs 100% recommended K interaction.

Leaf chlorophyll (Chlorophyll-a and chlorophyll-b) content was significantly influenced by interaction effect except chlorophyll-a content at Kalpara. Table 4.1.8 shows that polythene mulch versus 150% recommended K showed consistently the lowest chlorophyll content over the locations. With only one exception (chlorophyll-b at Kalapara upazila) in all cases no mulch with no K fertilizer treatment had the highest chlorophyll-a and chlorophyll-b content.

Leaf Na content was influenced significantly by the interactions at Tatali and Kalapara but not at Amtali. It was observed that at Taltali and Kalapra the leaf Na content was the lowest in polythene mulch versus 150% recommended K. When mulch was not used the leaf Na content was higher and when no mulch and no K fertilizer combine, the Na content was the highest.

Soil electrical conductivity ($EC_{1:5;}$ determined in 1:5 soil water suspension) was significantly influenced by the interaction effects of mulches and K fertilizers. It was observed that when mulches was not used soil EC was extremely high; at that condition application of K fertilizer did not give any additional benefit, rather the EC value progressively increased with the increase of the rate of K fertilizer (MoP). When mulch materials were used the scenario was totally changed. Use of polythene much drastically reduced the EC value, and in this case addition of K fertilizer had no additional benefit rather many cases application of K as MoP increased the EC value of soil.

Table 2.1.7. Interaction effect of mulch and potassium (K) on growth and yield contributing parameters of bitter gourd at three coastal upazilas

Mulch materials	Amtali			Taltali			Kalapara		
	K-control	100% K	150% K	K-control	100% K	150% K	K-control	100% K	150% K
Primary stem length									
No mulch	167.0	163.3	187.7	193.0	199.3	199.3	217.0	237.7	227.0
Rice straw mulch	217.0	207.3	204.0	196.7	209.3	190.3	232.7	225.7	230.3
Polythene mulch	225.7	240.3	241.3	272.7	257.0	274.7	290.3	285.7	290.7
Significance level		NS			NS			NS	
SE (±)		18.64			16.45			12.92	
Number of branches per plant									
No mulch	5.0	5.7	7.0	5.3	7.0	6.3	10.0	9.3	10.3
Rice straw mulch	6.7	6.7	7.3	8.3	7.0	7.7	12.0	14.0	12.7
Polythene mulch	9.0	9.3	12.7	11.3	11.0	12.3	15.0	15.7	16.7
Significance level		NS			NS			NS	
SE (±)		0.90			0.74			0.93	
Number of leaves per primary stem									
No mulch	30.0 Cb	31.3 Cb	36.0 Ba	34.0	34.0	38.0	30.3	34.0	34.3
Rice straw mulch	36.0 Ba	36.3 Ba	32.7 Ba	35.0	35.7	36.3	32.3	33.0	33.0
Polythene mulch	41.0 Aa	41.0 Aa	41.7 Aa	40.0	40.7	45.0	39.7	38.0	39.7
Significance level		*			NS			NS	
SE (±)		1.82			1.99			2.14	
Number of fruits per plant									
No mulch	4.3	5.3	8.0	3.3 Bb	5.7 Ba	5.7 Ba	5.7 Ba	5.7 Ba	6.7 Ba
Rice straw mulch	6.0	6.3	11.7	7.3 Aa	6.3 Bab	5.3 Bb	9.3 Aa	9.7 Aa	7.3 Bb
Polythene mulch	11.0	12.0	15.3	8.7 Ab	8.3 Ab	14.3 Aa	10.0 Ab	10.7 Ab	13.3 Aa
Significance level		NS			***			**	
SE (±)		0.88			0.66			0.93	
Fruit length									
No mulch	12.9 Cb	17.0 Ca	17.6 Ba	19.7 ABa	19.5 Ba	18.0 Ca	21.6	25.6	21.3
Rice straw mulch	17.5 Bb	21.2 Ba	19.1 Bb	18.2 Bb	20.4 Bab	23.2 Ba	24.1	22.2	23.8
Polythene mulch	23.0 Ab	23.6 Ab	26.6 Aa	22.1 Ab	24.3 Aab	26.5 Aa	22.4	26.1	27.0
Significance level		**			*			NS	
SE (±)		0.83			1.51			1.98	

Means with the same capital letter in a column or small letter in row are not significantly different

Table 2.1.8. Interaction effect of mulch and potassium (K) on fruit yield, leaf and soil parameters of bitter gourd at three coastal upazilas

Mulch materials	Amtali			Taltali			Kalapara		
	K-control	100% K	150% K	K-control	100% K	150% K	K-control	100% K	150% K
				Fruit yield (t/ha)					
No mulch	9.34 Cb	9.17 Bb	18.10 Ba	7.52 Cb	8.18 Cb	11.78 Ba	9.83 Ba	11.53 Ba	8.85 Ca
Rice straw mulch	15.01 Ba	10.14 Bb	15.88 Ba	14.87 Ba	14.15 Ba	8.48 Cb	12.11 Bab	9.51 Bb	14.02 Ba
Polythene mulch	23.60 Ab	32.67 Aa	25.48 Ab	20.67 Ac	26.27 Ab	34.88 Aa	16.87 Ab	20.34 Aa	20.76 Aa
Significance level		***			***			*	
SE (±)		1.51			1.40			1.53	
				Leaf chlorophyll-a content (mg/100 g fresh leaf)					
No mulch	2.277 Aa	1.167 Bb	0.911 Ab	3.052 Aa	1.791 Ab	1.755 Ab	3.093	2.579	2.343
Rice straw mulch	1.702 Ba	1.868 Aa	0.554 Bb	1.943 Ba	1.602 Aa	1.810 Aa	3.023	1.630	1.448
Polythene mulch	1.595 Ba	1.560 Aa	0.543 Bb	2.206 Ba	1.071 Bb	0.820 Bb	2.527	1.035	1.309
Significance level		***			**			NS	
SE (±)		0.1461			0.2205			0.4086	
				Leaf chlorophyll-b content (mg/100 g fresh leaf)					
No mulch	0.519 Aa	0.488 Aa	0.361 Ab	1.028 Aa	0.726 Ab	0.549 ABb	0.646 Ba	0.464 Ab	0.423 Ab
Rice straw mulch	0.437 ABa	0.319 Bb	0.319 Ab	0.607 Ba	0.771 Aa	0.590Aa	0.809 Aa	0.391 Bb	0.223 Bc
Polythene mulch	0.415 Bab	0.489 Aa	0.361Ab	0.813 Ba	0.759 Aa	0.363 Ba	0.473 Ca	0.325 Cb	0.263Bc
Significance level		*			*			***	
SE (±)		0.0417			0.0996			0.0275	
				Leaf Na content (%)					
No mulch	2.77	2.344	2.031	2.486 Aa	1.607 Bb	1.376 Bc	2.23 Aa	2.172 Aab	1.988 Ab
Rice straw mulch	2.486	2.131	1.563	2.063 Ba	2.073 Aa	2.115 Aa	1.562 Ba	1.42Ba	1.368 Ba
Polythene mulch	2.273	1.764	1.705	1.847 Ca	1.563 Bb	1.486 Bb	2.13 Aa	0.994 Cb	0.856 Cb
Significance level		NS			***			***	
SE (±)		0.1198			0.0693			0.1146	
				Soil $EC_{1:5}$ (dS/m)					
No mulch	4.82 Ab	7.24 Aa	6.82 Aa	3.22 Ac	4.06 Ab	5.82 Aa	5.54 Ab	7.37 Aa	7.80 Aa
Rice straw mulch	1.70 Bb	1.39 Cb	4.13 Ba	1.88 Bb	2.19 Ba	2.17 Ba	3.64 Ba	3.04 Bb	2.89 Bb
Polythene mulch	1.37 Cc	3.08 Ba	2.33 Cb	1.91 Bb	1.72 Cc	2.10 Ba	2.27 Ca	1.90 Ca	2.40 Ba
Significance level		***			***			***	
SE (±)		0.1147			0.0866			0.2361	

Means with the same capital letter in a column or small letter in row are not significantly different

Table 2.1.9. Interaction effect of mulch and potassium (K) on nutritional parameters of bitter gourd at three coastal upazilas

Mulch materials	Amtali			Taltali			Kalapara		
	K-control	100% K	150% K	K-control	100% K	150% K	K-control	100% K	150% K
Proline content (mg/100 g fruit)									
No mulch	26.97 Aa	20.9 Ab	21.06 Ab	22.45 Aa	21.65 Aa	13.40 Ab	23.66 Aa	16.44 Ab	13.72 Ac
Rice straw mulch	25.48 ABa	17.87 Bc	21.91 Ab	17.93 Ba	16.38 Ba	12.77 Ab	17.67 Ba	14.79 ABb	13.67 Ab
Polythene mulch	22.87 Ba	16.22 Bb	12.16 Bc	14.55 Ca	12.04 Cb	9.31 Bc	17.23Ba	13.35 Bb	12.13 Ab
Significance level		**			**			*	
SE (±)		1.34			0.9533			1.10	
Total sugar content (g/100 g fruit)									
No mulch	0.275 Cc	0.474 Bb	0.660 Ba	0.203 Bc	0.252 Cb	0.327 Ba	0.340 Bc	0.527 Ba	0.417 Bb
Rice straw mulch	0.415 Bb	0.369 Cc	0.471 Ca	0.217 Bb	0.292 Ba	0.285 Ca	0.101 Cc	0.670 Ab	0.768 Aa
Polythene mulch	0.654 Ab	0.629 Ab	0.747 Aa	0.293 Ac	0.57 Ab	0.694 Aa	0.639 Ab	0.528 Bc	0.742 Aa
Significance level		***			***			***	
SE (±)		0.0126			0.0111			0.0129	
Reducing sugar content (g/100 g fruit)									
No mulch	0.245 Bb	0.300 Ba	0.312 Ba	0.133 Bc	0.203 Ab	0.249 Ba	0.314 Aa	0.302 Ca	0.309 Ca
Rice straw mulch	0.300 Ab	0.349 Aa	0.344 Aa	0.143 Bb	0.153 Cb	0.226 Ca	0.210 Bb	0.389 Aa	0.412 Aa
Polythene mulch	0.259 Bb	0.352 Aa	0.365 Aa	0.211 Ab	0.184 Bc	0.284 Aa	0.320 Ab	0.344 Bab	0.353 Ba
Significance level		*			***			***	
SE (±)		0.0125			0.0079			0.0151	

Means with the same capital letter in a column or small letter in row are not significantly different

Fig. 1a. Effect of without mulching in bitter gourd

Fig. 1b. Effects of rice straw mulching on bitter gourd

Fig. 1c. Effects of plastic mulching on bitter gourd

Expt 2.2. Improving snake gourd yield using polythene mulch and potassium fertilizer management in coastal saline soils of Bangladesh

The snake gourd yield was significantly influenced by the use of mulch materials over the three upazilas. The highest snake gourd yield of 18.97, 27.65 and 27.06 t ha^{-1} was obtained in polythene mulch treatment in Amtali, Taltali and Kalapara upzila respectively (Table 2.2.1). Compare to control treatment rice straw mulch treatment had significantly higher yield in Amtali and Taltali upzila but similar in Kalapara upazila.

Application of K fertilizer also had a significant effect of snake gourd yield with highest yield found in 150% recommended K fertilizer dose (Table 2.2.2). Regarding the interaction effect, the highest yield of 22.28, 34.66 and 33.90 t ha^{-1} in Amtali, Taltali and Kalapara upzila, respectively were recorded by the polythene mulch versus 150% recommend K fertilizer dose (Table 2.2.3).

Table 2.2.1. Effect of mulch materials on fruit yield of snake gourd at three coastal upazilas

Mulch materials	Coastal upazilas		
	Amtali	Taltali	Kalapara
Control (no mulch)	4.38 C	6.37 C	9.51 B
Rice straw mulch	10.95 B	8.45 B	9.93 B
Polythene mulch	18.97 A	27.65 A	27.06 A
CV	8.42	6.88	8.32
Significance level	***	***	***
SE (±)	0.454	0.459	0.61
LSD	1.666	1.686	2.232

Table 2.2.2. Effect of potassium (K) on fruit yield of snake gourd at three coastal upazilas

Mulch materials	Coastal upazilas		
	Amtali	Taltali	Kalapara
Control (no K)	9.57 C	10.02 B	13.89 B
100% recommended K	11.32 B	15.48 A	14.85 B
150% recommended K	13.41 A	16.96 A	17.77 A
Significance level	***	***	***
SE (±)	0.454	0.4592	0.610

Fig. 2a. Effect of without mulching on snake gourd

Fig. 2b. Effects of rice straw mulching on snake gourd

Fig. 2c. Effects of plastic mulching on snake gourd

Table 2.2.3. Interaction effect of mulch and potassium (K) on fruit yield of snake gourd at three coastal upazilas

Mulch materials	Amtali			Taltali			Kalapara		
	K-control	100% K	150% K	K-control	100% K	150% K	K-control	100% K	150% K
No mulch	3.57 Cb	4.26 Cab	5.32 Ca	2.48 Bb	9.01 Ca	7.63 Ba	8.315 Bb	9.000 Cab	11.225 Ba
Rice straw mulch	8.43 Bb	11.77 Ba	12.64 Ba	3.53 Bc	13.22 Ba	8.60 Bb	10.350 Bab	11.275 Ba	8.165 Cb
Polythene mulch	16.69 Ab	17.93 Ab	22.28 Aa	24.08 Ab	24.21 Ab	34.66 Aa	23.000 Ab	24.285 Ab	33.905 Aa
Significance level		**			***			***	
SE (±)		0.786			0.795			1.05	

Expt 2.3. Improving sweet gourd yield using polythene mulch and potassium fertilizer management in coastal saline soils of Bangladesh

Sweet gourd fruit yield was significantly influenced by mulch treatment and the highest performance was noted in polythene mulch treatment. At Amtali and Kalapara upazila, the highest yield of sweet gourd was 21.06 and 25.68 t ha^{-1} fruit respectively, recorded by polythene mulch treatment (Table 2.3.1). In both the locations, no-mulch control treatment had the lowest yield. The rich straw mulch treatment had statistically similar yield of control treatment in Amtali upazila and that was significantly higher in Kalapara upazila.

There was no statistically significant effect of K fertilizer doses on yield of sweet gourd (Table 2.3.2). Although single effect of K was not significant, but interaction effect of mulching and K fertilizer was significant at Amtali, unfortunately not in Kalapara upazila (Table 2.3.3). At Amtali upazila polythene mulch with 100% recommended K fertilizer dose had the best performance.

Table 2.3.1. Effect of mulch materials on fruit yield of sweet gourd at three coastal upazilas

Mulch materials	Coastal upazilas	
	Amtali	Kalapara
Control (no mulch)	11.26 B	13.61 C
Rice straw mulch	11.48 B	19.52 B
Polythene mulch	21.06 A	25.68 A
CV	9.94	9.43
Significance level	***	***
SE (±)	0.68	0.87
LSD	2.512	1.847

Table 2.3.2. Effect of potassium (K) on fruit yield of sweet gourd at two coastal upazilas

Mulch materials	Coastal upazilas	
	Amtali	Kalapara
Control (no K)	13.94	18.92
100% recommended K	14.69	19.48
150% recommended K	15.17	20.42
Significance level	NS	NS
SE (±)	0.68	0.58

Table 2.3.3. Interaction effect of mulch and potassium (K) on fruit yield of sweet gourd at three coastal upazilas

Mulch materials	Amtali			Kalapara		
	K-control	100% K	150% K	K-control	100% K	150% K
No mulch	8.79 Cb	11.69 Ba	13.31 Ba	11.97	13.98	14.89
Rice straw mulch	12.59 Ba	9.37 Bb	12.48 Ba	20.45	19.56	18.55
Polythene mulch	20.45 Ab	23.01 Aa	19.71 Ab	24.34	24.90	27.82
Significance level		**			NS	
SE (±)		1.18			1.51	

Expt 2.4. Improving water melon yield using polythene mulch and potassium fertilizer management in coastal saline soils of Bangladesh

Water melon yield was significantly influenced by mulch treatment and the highest yield was observed in polythene mulch treatment and the lowest in no-mulch treatment (Table 2.4.1). Straw mulch treatment had always significantly lower yield than polythene mulch treatment and statistically similar with no-mulch treatment at Amtali upazila and significantly higher in Taltali upazila.

The single effect of K application showed significant effect at Amtali but not significant at Taltali upazila (Table 2.4.2). At Amtali upazila 100% recommended K gave the highest yield (22.94 t ha^{-1}). Excess application of K did not give any extra benefit to fruit production.

The interaction effect of mulching and K fertilization was significant in both Amtali and Taltali upazila. The highest significant interaction effect was found with polythene mulch versus 100% recommended K application at Amtali upazila (Talbe 2.4.3). At Taltali upazila highest interaction effect was found in polythene mulch × 150% recommended K fertilizer dose, however it was statistically similar with polythene mulch × 100% recommended K fertilizer dose.

Table 2.4.1. Effect of mulch materials on fruit yield of water melon at three coastal upazilas

Mulch materials	Coastal upazilas	
	Amtali	Taltali
Control (no mulch)	11.36 B	6.83 C
Rice straw mulch	14.27 B	11.77 B
Polythene mulch	29.23 A	29.97 A
CV	10.26	7.63
Significance level	***	***
SE (±)	0.88	0.58
LSD	3.248	2.139

Table 2.4.2. Effect of potassium (K) on fruit yield of water melon at three coastal upazilas

Mulch materials	Coastal upazilas	
	Amtali	Taltali
Control (no K)	15.02 B	15.83
100% recommended K	22.94 A	16.20
150% recommended K	16.90 B	16.53
Significance level	***	NS
SE (±)	0.88	0.58

Table 2.4.3. Interaction effect of mulch and potassium (K) on fruit yield of water melon at three coastal upazilas

Mulch materials	Amtali			Taltali		
	K-control	100% K	150% K	K-control	100% K	150% K
No mulch	9.70 Bb	9.09 Cb	15.30 Ba	6.35 Ca	6.45 Ca	7.69 Ca
Rice straw mulch	9.40 Bb	23.38 Ba	10.05 Cb	12.61 Ba	12.51 Ba	10.18 Bab
Polythene mulch	25.97Ab	36.36 Aa	25.35 Ab	28.52 Ab	29.64 Aab	31.74 Aa
Significance level		***			*	

SE (±)	1.53	1.01

Fig. 3a. Effect of without mulching on water melon

Fig. 3b. Effects of rice straw mulching on water melon

Fig. 3c. Effects of plastic mulching on water melon

Expt 2.5. Improving melon yield using polythene mulch and potassium fertilizer management in coastal saline soils of Bangladesh

Like other crops melon yield was also significantly influenced by mulch treatments. Polythene mulch treatment consistently had the highest yield with significant difference with other treatments. Without mulching gave the lowest yield and rice straw had the second rank (Table 2.5.1).

Melon fruit yield also significantly influenced by K application. Both Amtali and Taltali upazila 100% recommended K had the highest yield and it was statistically similar with K-control treatment (Table 2.5.2). The 150% recommended K gave worse yield over the locations. Considering interaction effect at Taltali upazila polythene mulch treatment with 100%recommended K had the best performance. However, at Amtali polythene mulch itself had the best performance with any rates of K application (Table 2.5.3).

Table 2.5.1. Effect of mulch materials on fruit yield of melon at three coastal upazilas

Mulch materials	Coastal upazilas	
	Amtali	Taltali
Control (no mulch)	9.26 C	10.28 C
Rice straw mulch	12.83 B	13.76 B
Polythene mulch	27.23 A	27.46 A
CV	8.99	8.09
Significance level	***	***
SE (±)	0.70	0.65
LSD	2.557	2.404

Table 2.5.2. Effect of potassium (K) on fruit yield of melon at three coastal upazilas

Mulch materials	Coastal upazilas	
	Amtali	Taltali
Control (no K)	16.23 AB	16.65 AB
100% recommended K	17.86 A	18.66 A
150% recommended K	15.23 B	16.19 B
Significance level	**	**
SE (±)	0.70	0.65

Table 2.5.3. Interaction effect of mulch and potassium (K) on fruit yield of melon at three coastal upazilas

Mulch materials	Amtali			Taltali		
	K-control	100% K	150% K	K-control	100% K	150% K
No mulch	10.17 Ba	12.06 Ba	5.55 Cb	7.45 Cb	12.34 Ba	11.04 Ba
Rice straw mulch	12.46 Bab	14.42 Ba	11.60 Bb	16.33 Ba	12.02 Bb	12.94 Bb
Polythene mulch	26.06 Aa	27.09 Aa	28.53 Aa	26.16 Ab	31.63 Aa	24.60 ab

Significance level	**	***
SE (±)	1.21	1.13

Fig. 4a. Effect of without mulching on melon

Fig. 4b. Effects of rice straw mulching on melon

Fig. 4c. Effects of plastic mulching on melon

Expt 3. Improving T. Aman rice yield through potassium fertilizer management in coastal saline soils of Bangladesh

T. Aman rice grain yield was significantly influenced by different levels of K application. At Amtali and Taltali upazila grain yield obtained in 75-150% recommended K dose had statistically similar grain yield. Exceptionally at Kalapara upazila 125% recommended K had the significantly higher yield. From Table 3 it can be concluded that 100% recommended K is sufficient for rice yield in the study area. Split application of K had comparatively better performance over the locations.

Table 3. Grain yield of T. Aman rice in different locations

Treatments	Amtali, Barguna		Taltali, Barguna		Kalapara, Barguna	
	Grain yield (t/ha)	% increase over control	Grain yield (t/ha)	% increase over control	Grain yield (t/ha)	% increase over control
T1: Control	3.354 c	-	3.392 c	-	3.332 c	-
T2: 75%RKFD	3.700 bc	10.33	4.238 b	24.93	3.889 c	16.72
T3: 100% RKFD	4.224 ab	25.94	4.476 ab	31.96	4.283 b	28.54
T4: 125% RKFD	4.222 ab	25.87	4.507 ab	32.88	4.727 a	41.86
T5: 150%RKFD	4.422 ab	31.85	4.648 ab	37.04	4.712 a	41.40
T6: 75% RKFD (½ basal + ½ 30 DAT)	4.417 ab	31.70	4.549 ab	34.12	4.148 b	24.48
T7: 100% RKFD (½ basal + ½ 30 DAT)	4.575 a	36.40	4.734 ab	39.58	4.629 ab	38.93
T8: 125% RKFD (½ basal + ½ 30 DAT)	4.615 a	37.59	4.932 a	45.39	4.696 a	40.95
T9: 150% RKFD (½ basal + ½ 30 DAT)	4.633 a	38.13	4.634 ab	36.60	4.776 a	43.34
% CV	5.95		4.54		8.83	
Significance level	***		***		*	
SE(±)	0.206		0.165		0.42	

12. Research highlight / findings :

- Use of polythene mulch to grow vine crops including bitter gourd, snake gourd, sweet gourd, water melon and melon in the salt affected areas of Bangladesh was found very promising to get higher yield. In fact, polythene mulch treatment had several fold higher yield than control treatment.
- Potassium application @ 100% recommendation was found good to obtain better yield of vine crops in Rabi season at south coastal saline soils of Bangladesh.
- Growing T. Aman rice in coastal region of Bangladesh 100% K was found sufficient to get optimum yield over the locations (Amtali, Taltali and Kalapara upazila). However, split application was found somewhat better than the sole basal application of K.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment					
(b) Lab & field equipment	Flamephotometer – 01 No.	499000	Flamephotometer – 01 No.	499000	
(c) Other capital items					

2. Establishment/renovation facilities: Not applicable

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized: Not applicable

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop					

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	415196	357340	357340	0	86.1	Fund not released
B. Field research/lab expenses and supplies	1115864	1076078	1076078	0	96.4	Fund not released
C. Operating expenses	200940	167637	167637	0	83.4	Fund not released
D. Vehicle hire and fuel, oil & maintenance	179000	119133	118920	213	66.4	Fund not released
E. Training/workshop/seminar etc.	0	0	0	0	-	-
F. Publications and printing	30000	4150	4150	0	13.8	Fund not released
G. Miscellaneous	45000	42600	42600	0	94.7	Fund not released
H. Capital expenses	499000	499000	499000	0	100.0	
	2485000	**2265938**	**2265725**	**213**	91.2	Fund not released

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
To determine temporal and special variability in soil salinity in the coastal region of Bangladesh	Spatial variability of soil chemical parameters in different soil depths at Amtali and Taltali upazila of Barguna district and Kalapara upazila of Patuakhali district. Temporal variability of soil chemical parameters in six locations (Two locations from each upazila) of south coastal region of Bangladesh	Data set on the chemical properties of coastal salt affected soils have been generated.	Salinity level in different locations of the coastal region have been identified
To improve crop yield through reduction of salt effect by using polythene mulch and application of K fertilizer in coastal saline soils of Bangladesh.	➢ Improving bitter gourd yield using polythene mulch and potassium fertilizer management in coastal saline soils of Bangladesh ➢ Improving snake gourd yield using polythene mulch and potassium fertilizer management in coastal saline soils of Bangladesh ➢ Improving sweet gourd yield using polythene mulch and potassium fertilizer management in coastal saline soils of Bangladesh ➢ Improving water melon yield using polythene mulch and potassium fertilizer management in coastal saline soils of Bangladesh ➢ Improving melon yield using polythene mulch and potassium fertilizer management in coastal saline soils of Bangladesh ➢ Improving T. Aman rice yield through potassium fertilizer management in coastal saline soils of Bangladesh	Crop yield increased several folds	➢ Crop productivity improved. ➢ Farmers income as well as livelihood improved
To determine the effects of salinity on the nutritional quality of crops	Chemical analysis of plant samples have been done to determine the chances of leaf chlorophyll contents, proline, reducing sugar, non reducing and total sugar contents due to use of polythene mulch and application of K fertilizers.	Good nutritious quality maintained	Polythene mulch helps to keep good nutritious quality of vegetables even in high saline condition.

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.			
Journal publication	01 (under progress)		
Information development			
Other publications, if any			
PhD thesis	01 (under progress)		
MS thesis	03 (under progress)		

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

Use of polythene mulch for management of saline soil

ii. **Generation of new knowledge that help in developing more technology in future**

Polythene mulch improves soil temperature which enhances crop growth. After irrigation it helps to keep soil moist for longer time.

iii. Technology transferred that help increased agricultural productivity and farmers' income

Use of polythene as a mulch material in coastal fresh water shortage area

iv. Policy Support

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):

PIU NATP-II team monitored project activity on 17 February 2018. They gave some suggestions on accounting of the project.

ii) Field Monitoring (time & No. of visit, Team visit and output):

Internal monitoring: Monitoring done by the Chairman, Department of Soil Science, PSTU and MS and PhD students and farmers. Date of monitoring is as follows:

10 September 2017
15 October 2017
8 November 2017

Field monitoring by Dr. M. A. Satter, Director BARC and his team

Field monitoring by PIU-NATP team

Field monitoring by Department Chairman, MS and PhD students and farmers

Result monitoring by the farmers

I. Lesson Learned/Challenges (if any)

i) Characteristics of coastal saline soil.
ii) Saline soil management technology
iii) Procurement rules

J. Challenges (if any)

Fund release was not in time.
Project is over, unfortunately fund release till remaining.

Signature of the Principal Investigator
Date …….
Seal

Counter signature of the Head of the organization/authorized representative
Date ……..
Seal

J. Challenges (if any)

Fund release was not in time.
Project is over, unfortunately fund release till remaining.

Signature of the Principal Investigator
Date .....
Seal

Professor
Department of Soil Science
Faculty of Agriculture
Barani Agricultural College University
Barani, Pakistan

Counter signature of the Head of the organization/authorized representative
Date
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