SOUVENIR • World Soil Day 2021

Ministry of Agriculture

কৃষি মন্ত্রণালয়

মুজিব শতবর্ষে

বিশ্ব মৃত্তিকা দিবস
World Soil Day

৫ ডিসেম্বর ২০২১

লবণাক্ততা রোধ করি
মাটির উৎপাদনশীলতা বৃদ্ধি করি

Halt soil salinization
boost soil productivity

মুজিব শতবর্ষ
MUJIB 100

মুজিববর্ষের অঙ্গীকার
কৃষি হবে দুর্বার

মুজিব শতবর্ষে

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World Soil Day 2021 Souvenir

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8	Representative, Agricultural Information Service	Member
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11	Representative of Practical Action, Bangladesh	Member
12	Chief Scientific Officer, Training & Communication Division, SRDI	Member
13	Director General, Soil Resource Development Institute	Member Secretary

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6	Representative, Bangladesh Agricultural Research Institute	Member
7	Representative, BIRTAN	Member
8	Representative, SRDI	Member
9	Representative, Agricultural Information Service	Member
10	Representative of FAO, Bangladesh	Member
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12	Representative of Practical Action, Bangladesh	Member
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14	Representative of Print & Electronic Media	Member
15	Representative of FAO, Bangladesh	Member
16	Representative, PID	Member
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Soil Care Award and Soil Olympiad Sub-Committee, World Soil Day 2021 Celebration

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4	Representative, Bangladesh Agricultural Research Council	Member
5	Representative, Bangladesh Agricultural Research Institute	Member
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7	Representative of FAO, Bangladesh	Member
8	President, Soil Science Society of Bangladesh	Member
9	Representative of Practical Action, Bangladesh	Member
10	Deputy Secretary (Admin-4), Ministry of Agriculture	Member Secretary

Seminar, Showcasing and Soil Care Award, Soil Olympiad and World Soil Day Prize 2021 giving ceremony on the theme “Halt Soil Salinization, Boost Soil Productivity” (লবণাক্ততা রোধ করি, মাটির উৎপাদনশীলতা বৃদ্ধি করি)

Venue: Hotel Pan Pacific Sonargaon, Dhaka; Date: 05 December 2021

Seminar and Showcasing

Inauguration Session

9:30-10:00	Registration and Guest take their seat
10:00-10:04	Welcome Address
	Md. Hasanuzzaman Kallol, Additional Secretary (Extension), Ministry of Agriculture
10:04-10:08	Documentary Show on World Soil Day 2021
	Speech by the Guest of Honors
10:08-10:13	Robert D Simpson, Representative to FAO, Bangladesh
10:13-10:18	Dr. Shaikh Mohammad Bokhtiar, Executive Chairman, Bangladesh Agricultural Research Council
	Speech by the Special Guests
10:18-10:23	Md. Mesbahul Islam, Senior Secretary, Ministry of Agriculture
10:23- 10:30	Md. Shahab Uddin MP, Honorable Minister, Ministry of Environment, Forest and Climate Change
10:30-10:40	Unwrapping of *Soil Atlas of Bangladesh* on the occasion of Mujib Centenary by the Chief Guest
	Speech by the Chief Guest
10:40-10:55	Dr. Muhammad Abdur Razzaque MP, Honorable Minister, Ministry of Agriculture
	Speech by the Chair
10:55-11:00	Bidhan Kumar Bhander, Director General, Soil Resource Development Institute
11:00-11:30	Visiting Showcase and Tea with Snacks

Technical Session
05 December 2021

11:30-11:40	Video Show made by FAO and SRDI on the occasion of World Soil Day
	Key Note Speech
11:40-11:55	Jalal Uddin Md. Shoaib, General Secretary, Soil Science Society of Bangladesh and Former Chief Scientific Officer, SRDI
	Discussion
11:55-12:00	Prof. Dr. M. Jahiruddin Former Dean, Faculty of Agriculture, Bangladesh Agricultural University
12:00-12:05	Mainul Ahsan Soil Expert (Technical) Crop Zoning Project, BARC and Former Director, SRDI
12:05-12:10	Dr. Carolina Olivera Sanchez Senior International Consultant on Sustainable Soil Management, FAO
12:10-12:20	Awarding Soil Care Award 2021, Soil Olympiad and World Soil Day Prize 2021
	Speech by the Guest Honors
12:20-12.25	Dr. Shawkat Ara Begum, Country Director, Practical Action UK in Bangladesh
12:25-12:30	Prof. Dr. S.M. Imamul Huq, President, Soil Science Society of Bangladesh
	Speech by the Special Guests
12:30-12:40	Md. Mesbahul Islam, Senior Secretary, Ministry of Agriculture
12:40-12:50	Md. Shahab Uddin MP Honorable Minister, Ministry of Environment, Forest and Climate Change
	Speech by the Chief Guest
12:50-13:10	Dr. Muhammad Abdur Razzaque MP, Honorable Minister, Ministry of Agriculture
	Speech by the Chair
13:10-13:15	Bidhan Kumar Bhander, Director General, Soil Resource Development Institute
13:15	Lunch

بسم الله الرحمن الرحيم

রাষ্ট্রপতি
গণপ্রজাতন্ত্রী বাংলাদেশ
বঙ্গভবন, ঢাকা।

২০ অগ্রহায়ণ ১৪২৮
০৫ ডিসেম্বর ২০২১

বাণী

কৃষি মন্ত্রণালয়ের মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট কর্তৃক প্রতি বছরের ন্যায় এবারও ৫ ডিসেম্বর 'বিশ্ব মৃত্তিকা দিবস ২০২১' উদযাপনের উদ্যোগকে আমি স্বাগত জানাই।

লবণাক্ততা মাটির উৎপাদনশীলতা ও বাস্তুতন্ত্রকে বিনষ্ট করে এবং কৃষি উৎপাদন ও খাদ্য নিরাপত্তার ক্ষেত্রে হুমকি সৃষ্টি করে। উপকূলীয় এলাকার লবণাক্ত মাটি বাংলাদেশের অন্যান্য অবক্ষয় সাধিত মাটির মধ্যে অন্যতম। বিশ্ব মৃত্তিকা দিবসের এবারের প্রতিপাদ্য 'লবণাক্ততা রোধ করি, মাটির উৎপাদনশীলতা বৃদ্ধি করি' এ প্রেক্ষাপটে যথার্থ হয়েছে বলে আমি মনে করি।

মাটির লবণাক্ততা বিশ্বের যেকোনো দেশের উপকূলীয় অঞ্চলের একটি সাধারণ ঘটনা এবং বাংলাদেশের উপকূলীয় এলাকাও প্রাকৃতিক এ বিপত্তি থেকে মুক্ত নয়। বাংলাদেশের উপকূলীয় অঞ্চল বিশাল এলাকা নিয়ে বিস্তৃত, যেখানে সাড়ে তিন কোটির বেশি লোক বাস করে। এই এলাকায় ফসলের নিবিড়তা বৃদ্ধির প্রধান অন্তরায় লবণাক্ততা। তবে এ বিস্তীর্ণ লবণাক্ত এলাকায় কৃষি উন্নয়নের অপার সম্ভাবনা রয়েছে। এই অঞ্চলের মাটি ও পানির লবণাক্ততার মাত্রা স্থানভেদে ভিন্ন ভিন্ন। উপকূলীয় এলাকায় বাঁধ, সুইস গেট নির্মাণ, উপকূলীয় লবণাক্ত এলাকা জোনিং, বৃক্ষরোপণ এবং জনসচেতনতামূলক কর্মসূচি বাংলাদেশের উপকূলীয় অঞ্চলে টেকসই জীবিকা নিশ্চিত করতে অবদান রাখতে পারে বলে আমি মনে করি।

আমাদের ভবিষ্যৎ খাদ্য নিরাপত্তা উপকূলীয় লবণাক্ত এলাকার মতো প্রান্তিক ভূমিতে খাদ্য উৎপাদনের ক্ষমতার ওপর অনেকাংশে নির্ভর করবে। এ জন্য ফসল নির্বাচন, চাষ পদ্ধতি, সামাজিক কার্যক্রম এবং আধুনিক প্রযুক্তির ব্যবহার খুবই জরুরি। টেকসই পানি, জলবায়ু, পরিবেশ ও ভূমি ব্যবস্থার জন্য দীর্ঘমেয়াদি চ্যালেঞ্জ মোকাবিলা করে একটি সমৃদ্ধ ও উন্নত দেশের মর্যাদা অর্জনের লক্ষ্যে ডেল্টা প্ল্যান ২১০০ প্রণয়ন করা হয়েছে। পরিকল্পিত ও টেকসই ভূমি ব্যবস্থাপনার মাধ্যমে এ লক্ষ্য বাস্তবায়নে এগিয়ে আসতে আমি সংশ্লিষ্ট সকলের প্রতি আহ্বান জানাচ্ছি।

আমি 'বিশ্ব মৃত্তিকা দিবস ২০২১' উপলক্ষ্যে গৃহীত সকল কর্মসূচির সাফল্য কামনা করছি।

জয় বাংলা।
খোদা হাফেজ, বাংলাদেশ চিরজীবী হোক।

মোঃ আবদুল হামিদ

بسم الله الرحمن الرحيم

PRESIDENT
PEOPLE'S REPUBLIC OF BANGLADESH
BANGABHABAN, DHAKA.

20 Agrahayan 1428
05 December 2021

Massage

I welcome the initiative of the Soil Resources Development Institute of the Ministry of Agriculture to celebrate 'World Soil Day 2021' on 5th December like every year.

Salinity destroys soil's productivity and ecosystems, and threatens agricultural production and food security. The saline soil of the coastal areas is one of the degraded soils of Bangladesh. I think the theme of this year's World Soil Day 'Halt soil salinization, boost soil productivity' is time befitting in this regard.

Salinization is the common phenomenon of any coastal region of the world and Bangladesh coast is not free from such type of natural hazards. Bangladesh has a vast area of coastal region that accommodate more than 35 million people. Salinity is considered as the main obstacles to crop production. However, this vast area has a great potentiality for agriculture. The soil and water of this region are associated with different levels of salinity. I think coastal embankment, construction of dam and sluice gates, zoning of coastal salinity areas, plantation programs and public awareness programs can contribute to uphold the sustainable livelihood in the coastal region of Bangladesh.

The future of our food security will largely depend on our ability to produce food in marginal lands such as the coastal salt belt. For this, crop selection, cultivation methods, social activities and use of modern technology are important. The government has formulated 'Delta Plan 2100' with the aim of achieving the status of a prosperous and developed country by addressing the long standing challenges for sustainable management of water, climate, environment and land system. I urge all concerned to come forward to implement this goal through planned and sustainable land management.

I wish success to all the programs adopted on the occasion of 'World Soil Day 2021'.

Joi Bangla.
Khoda Hafez, May Bangladesh Live Forever.

Md. Abdul Hamid

بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

প্রধানমন্ত্রী
গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
২০ অগ্রহায়ণ ১৪২৮
০৫ ডিসেম্বর ২০২১

বাণী

বিশ্বের অন্যান্য দেশের মতো বাংলাদেশেও এ বছর ৫ ডিসেম্বর 'বিশ্ব মৃত্তিকা দিবস' পালিত হচ্ছে জেনে আমি আনন্দিত। দিবসটির এবারের প্রতিপাদ্য 'লবণাক্ততা রোধ করি, মাটির উৎপাদনশীলতা বৃদ্ধি করি'- যা দেশের উপকূলীয় লবণাক্ত এলাকার বর্তমান প্রেক্ষাপটে যথাযথ হয়েছে।

জলবায়ু পরিবর্তনের কারণে সমুদ্র পৃষ্ঠের উচ্চতা বৃদ্ধি পেয়ে বাংলাদেশের উপকূলীয় অঞ্চলের নতুন নতুন এলাকা লবণাক্ততায় আক্রান্ত হওয়ার আশঙ্কা রয়েছে, যা মোট ফসল উৎপাদনে ক্ষতিকর প্রভাব ফেলতে পারে। মাটির লবণাক্ততা সমস্যা বাংলাদেশসহ সারাবিশ্বের কৃষি বিজ্ঞানীদের নিকট উদ্বেগের বিষয়ে পরিণত হয়েছে। বিভিন্ন দেশের বিজ্ঞানীদের পাশাপাশি বাংলাদেশের বিভিন্ন কৃষি শিক্ষা প্রতিষ্ঠান, গবেষণা প্রতিষ্ঠানসহ মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট- এর বিজ্ঞানীরা মাটির লবণাক্ততা ব্যবস্থাপনা কৌশল নিয়ে ক্রমাগত গবেষণা কার্যক্রম পরিচালনা করছেন।

বাংলাদেশের উপকূলীয় এলাকার প্রায় ৫৩ শতাংশ জমি সরাসরি লবণাক্ততায় আক্রান্ত। বর্তমানে মাটির লবণাক্ততা সমস্যা উপকূলীয় এলাকার বাইরেও ছড়িয়ে পড়ছে। মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউটের ২০০৯ সালের জরিপ প্রতিবেদন অনুসারে, বাংলাদেশের প্রায় ১.০৫৬ মিলিয়ন হেক্টর আবাদযোগ্য জমি বিভিন্ন মাত্রার লবণাক্ততা দ্বারা আক্রান্ত। ইতিমধ্যে, মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউটের লবণাক্ত ব্যবস্থাপনা ও গবেষণা কেন্দ্রের বিজ্ঞানীগণ লবণাক্ত এলাকায় ফসল উৎপাদনের জন্য বেশ কিছু প্রযুক্তি উদ্ভাবন করেছেন, যা কৃষক পর্যায়ে সম্প্রসারিত হচ্ছে। লবণাক্ততার কারণে এই এলাকার ফসলের নিবিড়তা মাত্র ১৮৯ শতাংশ। শুষ্ক মৌসুমে এ এলাকার অধিকাংশ জমি পতিত থাকে।

আওয়ামী লীগ সরকার কৃষি উন্নয়নে সব সময় আন্তরিক। ফসল উৎপাদন বাড়াতে আমরা ভর্তুকি মূল্যে সার ও বীজ সরবরাহ করছি। কৃষি যান্ত্রিকীকরণের জন্য যন্ত্রপাতি ক্রয়ের জন্যও ভর্তুকি প্রদান করা হচ্ছে। কৃষিতে আমাদের অগ্রগতি অভূতপূর্ব। কোভিড-১৯ মহামারির মধ্যেও বাংলাদেশের কৃষি দেশের খাদ্য নিরাপত্তায় গুরুত্বপূর্ণ অবদান রেখেছে।

টেকসই মাটি ব্যবস্থাপনার জন্য বিজ্ঞানভিত্তিক উপায়ে নীতি প্রণয়ন ও বাস্তবায়ন করতে হবে। লবণাক্ত মাটির উৎপাদনশীলতা বৃদ্ধির জন্য উদ্ভাবিত টেকসই প্রযুক্তিসমূহের ব্যবহারও প্রচার করতে হবে। আমাদের কৃষি ও পরিবেশের ওপর লবণাক্ত মাটির বিরূপ প্রভাব সম্পর্কে গবেষক, বিজ্ঞানী, শিক্ষক, কৃষক সবাইকে আরও সচেতন হতে হবে। মাটির অবক্ষয় কিভাবে সর্বোত্তম উপায়ে নিয়ন্ত্রণ করা যায়, তা নির্ধারণের জন্য লবণাক্ত মাটি সম্পর্কে আরও বিশদ জ্ঞান অর্জনের প্রয়োজনীয় ব্যবস্থা নিতে হবে।

আমি 'বিশ্ব মৃত্তিকা দিবস ২০২১'- এর সার্বিক সাফল্য কামনা করছি।

জয় বাংলা, জয় বঙ্গবন্ধু
বাংলাদেশ চিরজীবী হোক।

শেখ হাসিনা

بِسْمِ اللهِ الرَّحْمٰنِ الرَّحِيْمِ

প্রধানমন্ত্রী

PRIME MINISTER
GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

20 Agrahayan 1428
05 December 2021

Message

I am happy to know that 'World Soil Day' is going to be celebrated on 5 December in Bangladesh like other countries of the world. The theme of the day 'Halt soil salinization, boost soil productivity'- is appropriate in the current context of the country.

As sea level is rising due to climate change, a vast area of Bangladesh will be affected by salinity, which will have a detrimental effect on crop cultivation in coastal areas. Soil salinity disrupts normal crop production. The problem of soil salinity has become a concern of agricultural scientists all over the world including Bangladesh. Scientists from different countries as well as scientists from different agricultural institutes and Soil Resource Development Institute in Bangladesh are continuously researching on soil salinity management strategies.

About 53 percent lands of the coastal areas of Bangladesh are directly affected by salinity. At present, this salinity-affected area is increasing beyond the coastal areas of the country. According to Salinity Survey Report-2009 of Soil Resource Development Institute, about 1.056 million hectares of arable lands in Bangladesh are affected by various levels of salinity. Meanwhile, Soil Resource Development Institute has developed a number of technologies for crop production in saline areas, which are being disseminated among the farmers. Due to salinity, the cropping intensity of this area is only 189 percent. Most of the lands in this area remain fallow during the dry season.

The Awami League government is always sincere in agricultural development. We are providing fertilizers and seeds at subsidized prices to increase crop production. Subsidies are being also provided for the purchase of machinery for agricultural mechanization. The COVID-19 pandemic could not stop the progress of our agriculture development.

For sustainable soil management, policies need to be formulated and implemented in a scientific manner. In order to expand technological innovation for saline soil management, researchers, scientists, teachers and farmers need to raise awareness about the impact of saline soils on agriculture and the environment. In order to determine the best way to control soil degradation, it is necessary to gain more detailed knowledge about saline soils.

I wish the 'World Soil Day 2021' a grand success.

Joi Bangla, Joi Bangabandhu
May Bangladesh Live Forever.

Sheikh Hasina

মন্ত্রী
কৃষি মন্ত্রণালয়
গণপ্রজাতন্ত্রী বাংলাদেশ সরকার

বাণী

কৃষি মন্ত্রণালয়ের উদ্যোগে প্রতি বছরের ন্যায় এবারও ৫ ডিসেম্বর, ২০২১ তারিখে **'বিশ্ব মৃত্তিকা দিবস'** উদযাপিত হতে যাচ্ছে জেনে আমি অত্যন্ত আনন্দিত। এ বছর বিশ্ব মৃত্তিকা দিবসের প্রতিপাদ্য বিষয় হচ্ছে **"Halt soil salinization, boost soil productivity-লবণাক্ততা রোধ করি, মাটির উৎপাদনশীলতা বৃদ্ধি করি"**। লবণাক্ত মাটি বাংলাদেশের অন্যান্য অবক্ষয় সাধিত (Degraded Soil) মাটির মধ্যে অন্যতম। লবণাক্ত মাটি বাস্তুতন্ত্রকে বিনষ্ট করে এবং কৃষি উৎপাদন ও খাদ্য নিরাপত্তার ক্ষেত্রে হুমকি সৃষ্টি করে। এবারের প্রতিপাদ্য আমাদেরকে লবণাক্ত মাটি ব্যবস্থাপনার মাধ্যমে উৎপাদনশীলতা বৃদ্ধিতে মনোনিবেশ করতে উদ্বুদ্ধ করবে।

মৃত্তিকা লবণাক্ততা একটি বৈশ্বিক সমস্যা, যা দ্বারা বিশ্বের প্রায় সব দেশের উপকূলীয় এলাকার ভূমি আক্রান্ত হয়েছে। বাংলাদেশও এর ব্যতিক্রম নয়। ১৯৭৩ সালে বাংলাদেশে মোট লবণাক্ত জমির পরিমাণ ছিল ০.৮৩ মিলিয়ন হেক্টর, যা ২০০০ সালে ১.০২ মিলিয়ন হেক্টরে এবং ২০০৯ সালে ১.০৫ মিলিয়ন হেক্টরে উন্নীত হয়। অর্থাৎ বাংলাদেশে লবণাক্ত জমির পরিমাণ ক্রমাগত বৃদ্ধি পাচ্ছে।

বাংলাদেশে লবণাক্ততার প্রধান প্রধান কারণগুলোর মধ্যে নদীর লবণাক্ত পানি দ্বারা জমি প্লাবিত হওয়া, শুষ্ক মৌসুমে কৌশিক রন্ধ্রের মাধ্যমে লবণাক্ত পানি উপরে উঠে আসা, লবণাক্ত পানি ব্যবহার করে সেচ প্রদান করা, ঝড়-জলোচ্ছ্বাসের লবণাক্ত পানি দ্বারা উপকূলীয় এলাকা প্লাবিত হওয়া এবং লোনা পানিতে চিংড়ি চাষ করা অন্যতম। পানি ও মাটির লবণাক্ততা ফসল ও গবাদি পশুর খাদ্য উৎপাদনে, এমনকি মানুষের জীবন ধারণেও মারাত্মক বিরূপ প্রভাব ফেলে।

এমতাবস্থায়, বাংলাদেশের ২.৮ মিলিয়ন হেক্টর উপকূলীয় এলাকার ১.০৫ মিলিয়ন হেক্টর লবণাক্ত জমির মাটি ও পানির লবণাক্ততা ব্যবস্থাপনার জন্য উপযোগী কলা-কৌশল উদ্ভাবন করে খাদ্য উৎপাদন নিশ্চিত করতে হবে।

মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট (এসআরডিআই) ১৯৭৩, ২০০০ এবং ২০১০ সালে মাটির লবণাক্ততার উপর প্রতিবেদন প্রকাশ করেছে, যা লবণাক্ত মাটি ব্যবস্থাপনা এবং ফসলের উৎপাদনশীলতা বৃদ্ধির কৌশল প্রণয়নে সহায়তা করছে। লবণাক্ততা প্রতিবেদন ২০২১ প্রণয়নের জন্য ইতোমধ্যে মাঠ জরিপ কাজ শেষ হয়েছে। খুলনার বটিয়াঘাটায় অবস্থিত লবণাক্ততা ব্যবস্থাপনা ও গবেষণা কেন্দ্র (SMRC)-এর বিজ্ঞানীরা ইতোমধ্যে লবণাক্ত এলাকায় ফসল উৎপাদনের অনেকগুলো প্রযুক্তি উদ্ভাবন করেছে, যা কৃষি সম্প্রসারণ অধিদপ্তরের (ডিএই) মাধ্যমে কৃষক পর্যায়ে সম্প্রসারণ করা হচ্ছে।

দেশের প্রধান প্রাকৃতিক সম্পদ মাটি। আসুন, মাটির স্বাস্থ্য সংরক্ষণে সবাই সচেষ্ট হই। বিশ্ব মৃত্তিকা দিবস ২০২১- এর সকল কর্মসূচির সাফল্য কামনা করছি।

জয় বাংলা, জয় বঙ্গবন্ধু।
বাংলাদেশ চিরজীবি হোক।

ড. মো: আব্দুর রাজ্জাক, এমপি

Dr. Muhammad Abdur Razzaque MP
Minister
Ministry of Agriculture
Government of the People's
Republic of Bangladesh

Message

I am very happy to know that 'World Soil Day' is going to be celebrated on December 05, 2021 like every year on the initiative of the Ministry of Agriculture. The theme of this year's World Soil Day is **"Halt soil salinization, boost soil productivity"**. Saline soil is one of the major degraded soils in Bangladesh. Saline soils destroy the ecosystem and pose a threat to agricultural production and food security. This year's theme will motivate us to focus on the harmful effects of saline soils.

Soil salinity is a global problem, affecting the coastal areas of almost every country in the world. This problem is also evident in Bangladesh. The total area under salinity in Bangladesh was 0.83 million hectares in 1973, which increased to 1.02 million hectares in 2000 and 1.05 million hectares in 2009. In other words, the area of salinity affected land in Bangladesh is constantly increasing. Salinity of water and soil poses a serious obstacle to crop production, livestock rearing and also has a negative impact on fish diversity in coastal areas.

In this context, we need to explore all the possibilities to increase agricultural production for the growing population of the coastal areas of Bangladesh. The country needs to ensure sustainable food security by adopting long-term land management strategies and adopting effective measures to increase the flow of river water from upstream to the sea estuary.

Soil Resources Development Institute (SRDI) published reports on soil salinity in 1973, 2000 and 2012, which are being used in the formulation of strategies for saline soil management and increasing of crop productivity. Field survey work has already been completed for the preparation of Salinity Report 2021. Scientists of Salinity Management and Research Center (SMRC) in Batiaghata, Khulna, have already developed a number of technologies for crop production in saline areas, which have been expanded among the farmers. Bangladesh Agricultural Research Institute, Bangladesh Rice Research Institute and Bangladesh Institute of Nuclear Agriculture have developed salt tolerant varieties of different crops. As a result, cultivation of rice, sunflower, maize, watermelon, sweet karla etc. is being expanded day by day.

Soil is the main natural resource of the country, let's all try to preserve the health of the soil. I wish every success to all the programs of World Soil Day 2021.

Joy Bangla, Joy Bangabandhu
Long live Bangladesh.

(Dr.Muhammad Abdur Razzaque, MP)

MESSAGE

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বাণী

আমি আনন্দিত যে, কৃষি মন্ত্রণালয়ের তত্ত্বাবধানে মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট বিশ্বের অন্যান্য দেশের মতো বাংলাদেশেও এবার ৫ ডিসেম্বর বিশ্ব মৃত্তিকা দিবস ২০২১ পালন করতে যাচ্ছে। এ বছর বিশ্ব মৃত্তিকা দিবসের প্রতিপাদ্য 'Halt soil salinization, boost soil productivity- লবণাক্ততা রোধ করি, মাটির উৎপাদনশীলতা বৃদ্ধি করি।' বাংলাদেশের উপকূলীয় লবণাক্ত এলাকার বর্তমান বাস্তব প্রেক্ষাপটের সাথে যা খুবই সামঞ্জস্যপূর্ণ ও সময়োপযোগী।

বিশ্ব মৃত্তিকা দিবস ২০২১ পালন উপলক্ষ্যে আমি গভীর শ্রদ্ধা নিবেদন করতে চাই সর্বকালের সর্বশ্রেষ্ঠ বাঙালি, জাতির পিতা বঙ্গবন্ধু শেখ মুজিবুর রহমান-এর প্রতি, যিনি ত্রিশ লাখ জীবনের বিনিময়ে প্রাপ্ত এ বাংলাদেশকে সোনালি ফসলে ভরপুর দেখতে চেয়েছিলেন, আর সে কারণেই স্বাধীনতার পর ডাক দিয়েছিলেন সবুজ বিপ্লবের।

মাটির লবণাক্ততা বাংলাদেশে ফসল উৎপাদনে বাধা সৃষ্টিকারী প্রধান প্রাকৃতিক বিপত্তিগুলোর একটি। মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট-এর তথ্য ভান্ডার থেকে দেখা যায় যে, ১৯৭৩, ২০০০ ও ২০০৯ সালে বাংলাদেশে লবণাক্ত জমির পরিমাণ ছিল যথাক্রমে প্রায় ০.৮৩, ১.০২ ও ১.০৫ মিলিয়ন হেক্টর। অর্থাৎ বাংলাদেশে লবণাক্ত জমির পরিমাণ ক্রমাগত বৃদ্ধি পাচ্ছে, যা আমাদের টেকসই কৃষি উৎপাদন এবং খাদ্য নিরাপত্তার জন্য হুমকিস্বরূপ। বাংলাদেশ খাদ্য উৎপাদনে স্বয়ংসম্পূর্ণতা অর্জন করলেও ক্রমবর্ধমান জনসংখ্যার চাপে খাদ্যের চাহিদা বাড়ছে। সুতরাং মাটির উৎপাদনশীলতা বৃদ্ধির মাধ্যমে ফসল উৎপাদন বৃদ্ধির জন্য মাটির লবণাক্ততা রোধ করা খুবই গুরুত্বপূর্ণ।

মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট (এসআরডিআই) অতি সম্প্রতি লবণাক্ত এলাকার জরিপ কাজ সমাপ্ত করেছে এবং লবণাক্ততা প্রতিবেদন ২০২১ প্রকাশের অপেক্ষায় আছে। মাটির লবণাক্ততা ব্যবস্থাপনার জন্য মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট কর্তৃক উদ্ভাবিত প্রযুক্তিসমূহ যেমন- কলস সেচ, খামার পুকুর প্রযুক্তি, ডিবলিং ও চারা রোপণ পদ্ধতিতে ভুট্টা চাষ এবং টু লেয়ার মালচিং লবণাক্ত এলাকার কৃষকদের মধ্যে জনপ্রিয়তা পেয়েছে।

আমি আশা করি যে, বিশ্ব মৃত্তিকা দিবস ২০২১ পালনের সকল কর্মসূচি জনসাধারণের মধ্যে মাটির লবণাক্ততার বিরূপ প্রভাব সম্পর্কে সচেতনতা সৃষ্টি করতে সক্ষম হবে।

আমি বিশ্ব মৃত্তিকা দিবস ২০২১ পালন উপলক্ষ্যে গৃহীত সকল কর্মসূচির সাফল্য কামনা করছি।

মোঃ মেসবাহুল ইসলাম

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Message

I am happy to know that Soil Resource Development Institute under the supervision of Ministry of Agriculture is going to celebrate World Soil Day 2021 0n 5 December in Bangladesh like other countries of the world. The theme of World Soil Day 2021 is "Halt Soil Salinization, Boost Soil Productivity".

On the occasion of World Soil Day 2021, I would like to pay my deepest respects to the greatest bengali of all time, Father of the Nation Bangabandhu Sheikh Mujibur Rahman, who wanted to put a smile on the face of the farmers by building a prosperous agricultural system

Salinization is one of the major natural disasters in the coastal area of Bangladesh that hampers crop production. According to Soil Resource Development Institute (SRDI), the area of salt affected land in Bangladesh in 1973, 2000 and 2009 was about 0.83, 1.02 and 1.05 million hectares respectively. The salinity area of Bangladesh is constantly increasing, which is a threat to the sustainable agricultural production and food security.

Although Bangladesh has become self-sufficient in cereal crop production, demand for food is increasing under the pressure of growing population. Thus, it is very important to halt soil salinity in order to increase crop production by improving soil productivity.

Already survey work of salt affected area has been completed and Salinity Report 2021 is awaiting for publication. The Institute has developed technologies such as pitcher irrigation, farm pond technology and two layer mulching have gained popularity among the farmers in salinity affected areas.

I hope that all the programs to mark World Soil Day 2021 will be able to create awareness among the people about the adverse effects of soil salinity.

I wish every success on the occasion of World Soil Day 2021.

Md. Mesbahul Islam

Food and Agriculture Organization of the United Nations

World Soil Day 2021
Message from Robert D. Simpson
FAO Representative in Bangladesh

World Soil Day 2021 (#WorldSoilDay) focuses on salinization. FAO's campaign, 'Halt soil salinization, boost soil productivity', aims to raise awareness about this problem that affects many countries, including Bangladesh.

If water is the source of life, then soil is the mother of all creatures. Healthy soils are a pre-requisite to achieve the UN Sustainable Development Goals and form the basis of FAO's Four Betters - better production, better nutrition, a better environment, and a better life.

Soil salinization degrades soil health, threatens ecosystems, and at a global level decreases agricultural productivity significantly, posing a threat to food security. Build-up of excessive salt in soils degrades water quality, reduces soil biodiversity, and increases soil erosion. Salt-affected soils also have a decreased ability to act as a buffer and filter against pollutants.

Soils can become salt-affected very quickly for a variety of reasons: due to human mismanagement, excessive or inappropriate use of fertilisers, deforestation, sea level rises, or seawater intrusion into groundwater that is then used for irrigation. Climate change is raising the stakes.

It is estimated that more than half of coastal Bangladesh is affected by salinization. Last month, FAO launched the Global Map of Salt-Affected Soils, a key tool for halting salinization and boosting productivity. The map estimates that there are more than 833 million hectares of salt-affected soils around the globe (8.7% of the planet). The map also shows that 20 to 50 percent of irrigated soils in all continents are too salty, meaning that more than 1.5 billion people worldwide face significant challenges in growing food due to soil degradation.

We must look for innovative ways to transform our agri-food systems to be more efficient, more inclusive, more resilient and more sustainable — but we can not do that if we do not have healthy soil.

Robert D. simpson
FAO Representative in Bangladesh

Additional Secretary (Extension)
Ministry of Agriculture
Government of the People's
Republic of Bangladesh

MESSAGE

I am happy to know that 'World Soil Day 2021' is going to be celebrated on 05 December like every year by Soil Resource Development Institute (SRDI) under the overall supervision of Ministry of Agriculture. The theme of this year's World Soil Day is 'Halt Soil Salinization, Boost Soil Productivity'. The theme will inspire us to focus on increasing productivity through combating soil salinity management. Soil salinity is a global problem for crop production. This problem exists in the south and south-western part of Bangladesh. I hope that the theme of this year's World Soil Day will be able to create awareness about soil salinity.

Salinity reduces soil productivity, destroys ecosystems and threatens agricultural production and food security. The saline soils of the coastal areas are one of the main degraded soils in Bangladesh. Problems related to soil salinity have not been given much attention in the past. Currently, problems of degraded soil due to salinity are becoming very alarming. Exploring the potentials of saline soils has become essential to increase food production. Addressing the salinity problem is vital for the country's food security through the adoption of long-term land management strategies. In this situation, it is important to control the intrusion of saline water so that more new areas do not become saline.

During the dry season most of the land in the salt affected area remains fallow. In some areas sesame or pulses are cultivated to a limited extent. On the other hand, due to lack of safe water (salt free) in the dry season, it is not possible to cultivate Boro rice after Aman in this area. As a result a huge area remains fallow. In order to overcome this situation, Salinity Management and Research Center (SMRC) under Soil Resource Development Institute (SRDI) has been conducting research to innovate technologies for crop production in dry season in the salinity-affected areas.

Natural disasters like floods, droughts, storms and surges are the major obstacles to crop production in Bangladesh. But soil salinity also disrupts the normal production of crops. Due to climate change, new areas will be affected by soil salinity and will have a detrimental effect on crop production in coastal areas.

It is possible to cultivate multiple crops instead of one in the saline soils by reducing salinity and creating a conducive environment using different salinity management technologies. If safe (salt-free) water is used in saline soils for irrigation, then the salinity of that soil is reduced, making it easier to cultivate crops there.

I welcome the celebration of World Soil Day 2021.

Md. Hasanuzzaman Kallol

FEW WORDS

Director General
Soil Resource Development Institute

I am proud and delighted that Soil Resource Development Institute (SRDI) is going to celebrate World Soil Day 2021 on December 5 under the supervision of the Ministry of Agriculture. This year's theme for World Soil Day 2021 is 'Halt soil salinization, Boost soil productivity'. The theme of the world soil day 2021 will raise awareness of the importance of soil health and healthy ecosystem for the human wellbeing and will encourage governments, organizations, communities and individuals around the world to commit improving soil health proactively.

Salinity is a global problem that not only reduces soil health and crop productivity severely but also reduces the area under arable land gradually. We all need to learn how to live with salinity. The future of the food system depends on its ability to produce food in marginal lands. Crop selection, social and technological innovation, and change in the way we cultivate and understand are essential.

By reducing salinity through salinity management, it is possible to cultivate multiple crops instead of one in the saline lands of the south and south-west by creating suitable environment in the soil. Irrigation using safe (salt-free) water in saline soils reduces soil salinity and increases soil productivity.

Soil Resource Development Institute (SRDI) has published several reports on soil and water salinity to develop management strategies for combatting soil salinity as well as enhancing crop productivity. Salinity Management and Research Center (SMRC) has developed almost 22 technologies like Pitcher Irrigation, farm pond technology, two-layer mulching etc. have got popularity among the farmers of the salt affected area. Cultivation of modern variety of rice, sunflower, maize, watermelon and sweet gourd are being expanded due to the expanding of these technologies.

I wish every success to all the programs of the World Soil Day-2021.

Bidhan Kumar Bhander

ACKNOWLEDGEMENT

It is a matter of immense joy that this year World Soil Day is going to be celebrated on occasion of 50th anniversary of independence of Bangladesh and the 100th birth anniversary of father of the nation Bangabandhu Sheikh Mujibur Rahman, the greatest bangalee of all time.

Theme of World Soil Day, “Halt Soil Salinization, Boost Soil Productivity”is very appropriate for the world and is very most relevant to Bangladesh Agriculture. Coastal saline area occupies about 2.86 million hectares of land, covering 18 districts and 100 upazilas (sub-districts) and belongs to three physiography, Ganges tidal Floodplain, Meghna estuarine floodplain and Chattogram coastal floodplain. About 0.833 million hectares of coastal land was under various degree of salinity in 1973, which increased to 1.02 million hectares in 2000 and further increased to 1.056 million hectares in 2009. Soil salinity is increasing with an alarming rate of about 0.74 percent annually. Soil salinity in our country is a temporary situation. It varies spatially and starts increasing from late November and attain its peak during May/June, when rainfall is low. As a result, it is difficult to brought coastal land under cropping in dry period. Due to soil salinity about 53 percent of coastal area limits crop production. Cropping intensity is low compare to national average. There is a lot of scope to work in the coastal area with the present theme of World Soil Day 2021.

It is my great pleasure to express my heartfelt gratitude to Ministry of Agriculture, Government of the People`s Republic of Bangladesh for observing World Soil Day, 2021 on December 05, as it will observed all over the world. In addition to that SRDI is publishing a souvenir on this auspicious occasion. Bangladesh is observing “World Soil Day” on 05 December, every year, since it has been declared as by United Nations General Assembly in 2013.

This year World Soil Day2021 is observing under the direct supervision of Ministry of Agriculture of Government of Bangladesh, within the framework of Global Soil partnership (GSP) and with full support of Soil Resource Development Institute (SRDI) and in collaboration of FAO of UN., Soil Science Society of Bangladesh and Practical Action UK in Bangladesh.

I would like to express all of my gratefulness to His Excellency Mohammad Abdul Hamid, President of Government of the People`s Republic of Bangladesh, for giving message which has encouraged us to observe this day. I would like to convey my heartfelt gratitude to Her Excellency Sheikh Hasina, Honorable Prime Minister, People`s Republic of Bangladesh, for her precious message, which gave us strength to work in stopping soil salinization and boost soil productivity. Sincere and heartfelt thanks to Dr. Muhammad Abdur Razzaque MP, Honorable Minister, Ministry of Agriculture, for his kind consent to attend in the daylong seminar to be held on 05 December 2021 in observance of World Soil Day and in addition to his directional message for the souvenir.

I am sincerely grateful to Mr. Md. Mesbahul Islam, Honorable Secretary, Ministry of Agriculture for his kind support and guidance. It is worthy to express my heartfelt gratitude to Mr. Md. Hasanuzzaman Kallol, Additional Secretary (Extension), Ministry of Agriculture for his guidance and supervision in publishing the souvenir.

My utmost gratitude to Mr. Robert D. Simpson, FAO Representative in Bangladesh, Practical Action Bangladesh for their support in observing World Soil Day 2021. We also appreciate Soil Science Society of Bangladesh for their eagerness to observe World Soil Day.

I would like to acknowledge Mr. Bidhan Kumar Bhander, Director General, SRDI, for his continuous inspiration in observation of the day as well as publication of the souvenir.

I would like to thank all the members of convening committee and sub-committee of World Soil Day 2021 observation for their suggestions and active role to observe the day and in the publication of this souvenir as well.

Finally, I would like to convey our thanks to SRDI officers and staffs for their continuous effort in observing World Soil Day in befitting manner and publication of the souvenir.

Dr. Md. Abdul Bari
Editor
&
Project Director & Chief Scientific Officer
Soil Resource Development Institute

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কৃষির অগ্রযাত্রায় পরিবর্তিত জলবায়ুতে টেকসই মাটি ব্যবস্থাপনা

মোঃ হাসানুজ্জামান কল্লোল
অতিরিক্ত সচিব (সম্প্রসারণ), কৃষি মন্ত্রণালয়, বাংলাদেশ সচিবালয়, ঢাকা

মহান বিজয়ের মাসে সর্বকালের সর্বশ্রেষ্ঠ বাঙালি জাতির পিতা বঙ্গবন্ধু শেখ মুজিবুর রহমানসহ মহান মুক্তিযুদ্ধে সকল শহিদ ও বীর মুক্তিযোদ্ধাদের প্রতি জানাই বিনম্র শ্রদ্ধা।

মুজিববর্ষে স্বাধীনতার সুবর্ণজয়ন্তীতে উজ্জীবিত হয়ে ৫ ডিসেম্বর পালিত হতে যাচ্ছে বিশ্ব মৃত্তিকা দিবস ২০২১। কৃষি মন্ত্রণালয় এর তত্ত্বাবধানে মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট, জাতিসংঘের খাদ্য ও কৃষি সংস্থা, সয়েল সাইন্স সোসাইটি অব বাংলাদেশ, বেসরকারি প্রতিষ্ঠানসমূহের সমন্বয়ে দিবসটি উদ্‌যাপন হয়ে থাকে। এ বছরের প্রতিপাদ্য 'Halt soil salinization, boost soil productivity-লবণাক্ততা রোধ করি, মাটির উৎপাদনশীলতা বৃদ্ধি করি। যা পরিবর্তিত জলবায়ুতে মৃত্তিকার স্বাস্থ্য ও মৃত্তিকা সম্পদের টেকসই ব্যবস্থাপনার সাথে সামঞ্জস্যপূর্ণ।

জাতির পিতা বঙ্গবন্ধু স্বাধীনতার পর যুদ্ধবিধ্বস্ত অর্থনীতির পুনর্গঠনে সর্বশক্তি নিয়োগ করেন। এ দেশকে সোনার বাংলা হিসেবে গড়ে তোলার লক্ষ্যে কৃষি বিপ্লবসহ সব প্রস্তুতি তিনি গ্রহণ করেছিলেন। জাতির পিতা বলেছিলেন, 'আমাদের উর্বর জমি, আমাদের প্রাকৃতিক সম্পদ, আমাদের পরিশ্রমী মানুষ, আমাদের গবেষণা-সম্প্রসারণ কাজ সমন্বয় করে আমরা খাদ্যে স্বয়ম্ভরতা অর্জন করব। এটা শুধু সময়ের ব্যাপার।' বঙ্গবন্ধুর স্বপ্নের ক্ষুধা ও দারিদ্র্যমুক্ত সোনার বাংলা গড়তে মাননীয় প্রধানমন্ত্রী শেখ হাসিনার নেতৃত্বে ২০৪১ সালের মধ্যে সমৃদ্ধ বাংলাদেশ বিনির্মাণের প্রত্যয়ে বর্তমান সরকার নিরলসভাবে কাজ করে যাচ্ছেন, সরকার শুরু থেকেই কৃষিবান্ধব নীতি গ্রহণ ও বাস্তবায়নকে অগ্রাধিকার প্রদান করছেন। মাননীয় প্রধানমন্ত্রীর সময়োপযোগী নির্দেশনায় বরেণ্য কৃষি বিজ্ঞানী মাননীয় কৃষিমন্ত্রীর প্রজ্ঞাসম্পন্ন কর্মপ্রচেষ্টায় আজ কৃষি ক্ষেত্রে উত্তরোত্তর সাফল্য অর্জিত হচ্ছে। নানামুখী চ্যালেঞ্জ মোকাবিলা করে দেশ আজ দানাদার খাদ্যে স্বয়ংসম্পূর্ণ হয়েছে। এ ছাড়াও কৃষি মন্ত্রণালয়ের দূরদর্শী ও যুগোপযোগী উদ্যোগের ফলে চলমান করোনাকালেও দেশের কৃষির উৎপাদন ও সরবরাহের ধারা অব্যাহত রয়েছে। ফলে বাংলাদেশ আজ পাট রপ্তানিতে ১ম, পাট ও কাঁঠাল উৎপাদনে ২য়, ধান, সবজি ও পেঁয়াজ উৎপাদনে ৩য়, আম ও আলু উৎপাদনে ৭ম, পেয়ারা উৎপাদনে ৮ম এবং সামগ্রিকভাবে খাদ্য উৎপাদনে বিশ্বে ১১তম স্থানে রয়েছে। সাফল্যের এই ধারায় বাংলাদেশ বিশ্বের দরবারে উন্নয়নের রোল মডেল হিসেবে স্বীকৃতি পেয়েছে। যার মূলে রয়েছে আমাদের দেশের উর্বর মাটি।

মাটিই মানুষের অধিকাংশ মৌলিক চাহিদার জোগান দেয়। বৈশ্বিক উষ্ণায়নে জলবায়ু পরিবর্তনে সর্বোচ্চ ঝুঁকিতে আছে বাংলাদেশ। বিশ্বব্যাপী কার্বন নির্গমনের ক্ষেত্রে বাংলাদেশের অবদান ০.৪৭ শতাংশের কম। সারা বিশ্বে কার্বন ও মিথেন নিঃসরণ বৃদ্ধিতে বাড়ছে বৈশ্বিক তাপমাত্রা। ঘটছে অনিয়মিত বৃষ্টিপাত, বন্যা, খরা, অধিকতর তীব্র গ্রীষ্মমণ্ডলীয় ঘূর্ণিঝড়, জলোচ্ছ্বাস, নদীভাঙন, সমুদ্রের অম্লকরণ, সমুদ্রপৃষ্ঠের উচ্চতা বৃদ্ধি, ঋতু পরিবর্তন প্রভৃতি। পরিবর্তিত জলবায়ুতে সমুদ্রপৃষ্ঠের উচ্চতা ১ মিটার বেড়ে গেলে বাংলাদেশের উপকূলীয় এলাকার অর্থনীতি ও মানুষের স্বাভাবিক জীবন হুমকির মুখে পড়বে। জমিতে লবণাক্ততা বৃদ্ধির ফলে ভূমির উর্বরতা হ্রাস পাবে। এতে কৃষি খাত সবচেয়ে বেশি ক্ষতিগ্রস্ত হবে। কৃষিকে এই ক্ষতির হাত থেকে রক্ষা করার জন্য কৃষি মন্ত্রণালয় ও দপ্তর সংস্থা সবিশেষ গুরুত্ব দিয়ে কাজ করছে।

মাটিকে সুস্থ, উৎপাদনক্ষম, পরিবেশবান্ধব ও টেকসই রাখতে বর্তমান সরকার প্রতিশ্রুতিবদ্ধ। টেকসই উন্নয়ন অভীষ্ট ২০৩০ এর ১৭টি লক্ষ্যের মধ্যে ছয়টি মৃত্তিকা সম্পর্কিত। মাটির টেকসই ব্যবস্থাপনার ছয়টি লক্ষ্যমাত্রা অর্জনে প্রত্যক্ষ ও পরোক্ষভাবে কৃষি মন্ত্রণালয় এবং পরিবেশ ও বন মন্ত্রণালয়ের সাথে সহযোগী হিসেবে বিভিন্ন পরিকল্পনা গ্রহণ ও বাস্তবায়ন করে যাচ্ছে। ভূমি ও মৃত্তিকা সম্পদের যুক্তিযুক্ত ও লাভজনক ব্যবহার নিশ্চিতকরণ এবং মৃত্তিকা স্বাস্থ্য সুরক্ষার লক্ষ্যে মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট কর্তৃক ২০২০-২১ অর্থবছরে ৪৮টি উপজেলার আধা-বিস্তারিত মৃত্তিকা জরিপ সম্পন্ন করা হয়েছে। ডিজিটাল পদ্ধতিতে দেশের সবগুলো উপজেলার মাটির উর্বরতামান অনুযায়ী সুষম সার সুপারিশের লক্ষ্যে অনলাইন ফার্টিলাইজার রিকমেন্ডেশন সিস্টেমে ৫০টি উপজেলার তথ্য-উপাত্ত হালনাগাদ করা হয়েছে। এ ছাড়া ভ্রাম্যমাণ মৃত্তিকা পরীক্ষাগারের মাধ্যমে রবি ও খরিফ মৌসুমে ৫৬টি উপজেলায় সরেজমিন মাটি পরীক্ষা করে মোট ৫,৬০০ জন কৃষককে ফসলভিত্তিক সার সুপারিশ প্রদান করা হয়েছে। মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউটের লবণাক্ত ব্যবস্থাপনা ও গবেষণা কেন্দ্র, বটিয়াঘাটা, খুলনা কর্তৃক ফসলের নিবিড়তা বৃদ্ধির লক্ষ্যে ২০২০-২১ অর্থবছরে উপকূলীয় লবণাক্ত এলাকায় ডিবলিং এবং চারা রোপণ পদ্ধতিতে ভুট্টা চাষ, টপ সয়েল কার্পেটিংয়ের মাধ্যমে চিংড়ি ঘেরের পাড়ে বর্ষাকালীন তরমুজ চাষ করা হচ্ছে। মাদা ফসলের জন্য কলস সেচ ও দ্বিস্তর মালচিং পদ্ধতি, শ্যালো ফারো-রিজ সিস্টেম, ফ্লায়িং বেড এগ্রিকালচার ইত্যাদি প্রযুক্তি উদ্ভাবন করেছে। বিভিন্ন মাদা ফসলের লবণাক্ততা সহনশীলতা নিরূপণ করা হয়েছে।

এ ছাড়া ইনস্টিটিউটের লবণাক্ততা মনিটরিং কার্যক্রমের আওতায় উপকূলীয় এলাকার মনিটরিং স্পট থেকে নিয়মিত লবণাক্ততার তথ্য সংগ্রহ করা হচ্ছে। উদ্ভাবিত প্রযুক্তি এবং লবণাক্ত পরিবীক্ষণ তথ্য ব্যবহার করে উপকূলীয় এলাকার সম্প্রসারণ কর্মী ও কৃষক ভাইয়েরা মৃত্তিকা ও পানির লবণাক্ততা ব্যবস্থাপনার মাধ্যমে ফসল চাষের এলাকা সম্প্রসারণ, নিবিড়তা বৃদ্ধি ও অধিক ফসল আহরণ করতে সক্ষম হয়েছেন। এ ছাড়া টেকসই মৃত্তিকা ও ভূমি ব্যবস্থাপনা বিষয়ে দক্ষতা বৃদ্ধির লক্ষ্যে ১২,৫০০ জন কৃষক, কৃষিকর্মী ও ইউনিয়ন উদ্যোক্তাদের প্রশিক্ষণ দেয়া হয়েছে।

বিশ্ব খাদ্য ও কৃষি সংস্থা টেকসই মৃত্তিকা ব্যবস্থাপনার জন্য বেশকিছু সুপারিশমালা প্রদান করেছে। এরমধ্যে কনজারভেশন পদ্ধতিতে জমি চাষ, ফসল বিন্যাস, ফসল আবর্তন, লিগিউম ফসল চাষ, অধিক পরিমাণে ফসলের অবশিষ্টাংশ জমিতে সংরক্ষণ, জৈবসারের প্রয়োগ বাড়ানো, সঠিক মাত্রায় এবং সঠিক সময়ে রাসায়নিক সার প্রয়োগ ইত্যাদি অন্যতম। টেকসই মৃত্তিকা ব্যবস্থাপনার জন্য এসব সুপারিশ অনুসরণ করে ফসল আবাদ একান্ত জরুরি। বাংলাদেশে কোনো একটি সীমিত এলাকার মধ্যেই মাটির ভৌত ও রাসায়নিক গুণাগুণ ও ভূমিরূপের ব্যাপক বৈচিত্র্য পরিলক্ষিত হয়, তাই বাংলাদেশে ভূমি ও মৃত্তিকা ব্যবস্থাপনা একটি জটিল সমস্যা। সেক্ষেত্রে, স্থানভিত্তিক কৃষি উৎপাদন পরিকল্পনা সর্বশেষ মাটি ও ভূমি সম্পদের তথ্যভাণ্ডারের উপর ভিত্তি করে প্রণয়ন করা প্রয়োজন।

কৃষি বিজ্ঞানীরা তাদের উদ্ভাবনী শক্তি দিয়ে অগ্রাধিকারভিত্তিতে লবণাক্ত সহিষ্ণু, খরাসহিষ্ণু, জলমগ্নতা সহনশীল, উচ্চ তাপমাত্রা সহনশীল প্রতিকূল পরিবেশে চাষের উপযোগী ধান, গম, ভুট্টা, বার্লি, তরমুজ, ডাল, সূর্যমুখী, শাকসবজিসহ বিভিন্ন ফসলের জাত ও প্রযুক্তি উদ্ভাবন করেন। কৃষি সম্প্রসারণ অধিদপ্তরের কর্মকর্তাগণ সম্প্রসারণে সহায়তা করছেন। এভাবে সবার সম্মিলিত প্রচেষ্টায় দক্ষিণাঞ্চলে লবণাক্ত এলাকায় কৃষি বিপ্লব ঘটবে। এ লক্ষ্য অর্জনে রোডম্যাপ প্রণয়নের কার্যক্রম চলমান রয়েছে। জলবায়ু পরিবর্তনের বিরূপ মোকাবিলায় মাননীয় প্রধানমন্ত্রীর নেতৃত্বে বর্তমান সরকার ক্লাইমেট চেঞ্জ স্ট্র্যাটেজিক প্ল্যান ও অ্যাকশন প্ল্যান প্রণয়ন এবং ৭০০ কোটি টাকার জলবায়ু পরিবর্তন ট্রাস্ট ফান্ড গঠন করেন। মুজিববর্ষ উদ্‌যাপনকালে সারা দেশে বৃক্ষরোপণ করেছেন। বজ্রপাতে মৃত্যুর ঝুঁকি কমাতে এবং কার্বন হ্রাসে তালগাছ রোপণসহ ব্যাপক কর্মসূচি গ্রহণ করেছেন। জলবায়ু পরিবর্তন মোকাবিলায় সম্প্রতি স্কটল্যান্ডের গ্লাসগোতে ২৬তম জলবায়ু সম্মেলন বা কপ২৬ অনুষ্ঠিত হয়। ক্লাইমেট ভালনারেবল ফোরামের (সিভিএফ) চেয়ারপারসন শেখ হাসিনা ১ নভেম্বর ২০২১ গ্লাসগোতে কপ২৬ সম্মেলনস্থলের কমনওয়েলথ প্যাভিলিয়নে 'সিভিএফ-কমনওয়েলথ হাইলেভেল ডিসকাসন অন ক্লাইমেট প্রসপারিটি পার্টনারশিপ' শীর্ষক আলোচনায় সিভিএফ এবং কমনওয়েলথের মধ্যে কার্যকর সহযোগিতার জন্য ৪ দফা প্রস্তাব পেশ করেছেন। সে সাথে প্রধান গ্যাস নির্গমনকারী দেশগুলোকে 'জলবায়ু পরিবর্তনের প্রভাব মোকাবিলায় আমাদের প্রচেষ্টায় সমর্থন করার জন্য তাদের বাধ্যবাধকতা' পূরণ করার বিষয়টি উল্লেখ করেন।

পরিশেষে পরিবর্তিত জলবায়ুতে টেকসই খাদ্য নিরাপত্তার লক্ষ্যে টেকসই মাটি ব্যবস্থাপনার মাধ্যমে মাটির লবণাক্ততার বিরূপ প্রভাবগুলো মোকাবিলা করে সুস্থ বাস্তুতন্ত্র গড়ে তোলাই বিশ্ব মৃত্তিকা দিবসের সফলতা। সবার সম্মিলিত প্রচেষ্টায় মাটির স্বাস্থ্য ভালো রাখি, দেশের কৃষিকে সমৃদ্ধ করি।

WORLD SOIL DAY 2021

ওদের সাথে মিলাও যারা চরায় তোমার ধেনু

ওয়াহিদা আক্তার
অতিরিক্ত সচিব, প্রশাসন অনুবিভাগ, কৃষি মন্ত্রণালয়

'আমরা যে ধরনের যুদ্ধে জড়িয়ে পড়েছিলাম সেখানে দেখা গেল কৃষকেরাই আমাদের সবচেয়ে ভালো সম্পদ। তাদের না ছিল কোনো আত্মম্ভরিতা, না কোনো মিথ্যা গর্ব। স্বাধীনতার জন্য তারা ছিল আন্তরিক এবং নিবেদিত। এক জোড়া জাংগল বুট; লুঙ্গি, কম্বল অথবা নিয়মিত খাবার, এ কোনো কিছুর জন্যই আমি তাদের কখনো এতটুকু কথা বলতে শুনিনি। সামান্যতম লোভ ও দেখায়নি কখনো তারা। এই সহজ, সরল, উচ্চাভিলাষহীন মানুষগুলোকে যখনই যেখানে গিয়ে পাকিস্তানিদের বিরুদ্ধে যুদ্ধ করার নির্দেশ দেওয়া হয়েছে সে নির্দেশ তা পালন করেছে হাসিমুখে' (লক্ষ প্রাণের বিনিময়ে, পৃ: ২৮৪)। এই কৃষককে নিয়ে কাজ করে কৃষি মন্ত্রণালয়।

কৃষি মন্ত্রণালয়কে কৃষক কল্যাণ মন্ত্রণালয় বললে ও অত্যুক্তি হবে না। বাংলাদেশের মাটি সোনা ফলা মাটি এই মাটির সাথে মিশে আছে এই বাংলার কৃষক যাদের অন্যায় দাবিতে রাস্তার নামার সময় নেই। কারন তাঁকে রোদেপুড়ে, বৃষ্টিতে ভিজে সময়মত ফসল রোপন করতে হয়, সময়মত নিবিড় পরিচর্যা করতে হয়, সময়মত ফসল ঘরে তুলতে হয়। তবে এই নিবেদিত প্রান কৃষককে কোন কোন সময় রাস্তায় নেমে আসতে দেখেছি সার না পেয়ে। কৃষি মন্ত্রণালয় খাদ্যশস্যের উৎপাদন লক্ষ্যমাত্রা নির্ধারণ করে এবং কৃষকের নিজস্ব জমিতে উৎপাদন করিয়ে লক্ষমাত্রা অর্জন করে। কৃষক তাঁর নিজ জমিতে কি ফসল ফলাবে সে স্বাধীনতা তাঁর থাকে কিন্তু আমাদের কৃষি সম্প্রসারণ কর্মীরা পরামর্শ, সার, বীজ ও নিত্য নতুন প্রযুক্তির প্যাকেজ নিয়ে পাশে থেকে সিদ্ধান্ত নিতে কৃষককে সহায়তা করেন।

মাননীয় প্রধানমন্ত্রীর নির্দেশনা মোতাবেক খাদ্য উৎপাদন বৃদ্ধির লক্ষ্যে কৃষি মন্ত্রণালয় নিরলস ভাবে কাজ করে যাচ্ছে। করোনা অতিমারি কালে গত ২০২০-২১ অর্থ বছরে ৪৫৮ কোটি ৮৭ লক্ষ টাকা কৃষিতে উপকরণ সহায়তার মাধ্যমে প্রণোদনা দেয়া হয়েছে। এ প্রণোদনা পেয়েছে ৭৪ লক্ষ ৫৯ হাজার ৫৪১ জন কৃষক। যেখানে ২০১৯-২০ অর্থ বছরে এই প্রণোদনার পরিমান ছিল ১৩১ কোটি ২৯ লক্ষ টাকা এবং কৃষকের সংখ্যা ছিল ১২ লক্ষ ২০ হাজার ৪৫৫ জন। এ বছর মোট ৩ কোটি ৮৬ লক্ষ মে:টন চাল উৎপন্ন হয়েছে হয়েছে, তারমধ্যে ৪৮ লক্ষ ৭২ হাজার ৬শত হেক্টর জমি থেকে ২ কোটি ৮ লক্ষ ৮৫ হাজার মে:টন বোরো ধান উৎপন্ন হয়েছে । এই তথ্য থেকে অনুধাবন করা যায় বিশ্বব্যাপী করোনা অতিমারিতে খাদ্য সংকট দেখা দিতে পারে মাননীয় প্রধানমন্ত্রী শেখ হাসিনা পূর্বেই অনুধাবন করেছিলেন।

বিশ্ব বাজারে গমের মূল্য যেখানে টন প্রতি ২০০-২২৫ ইউএস ডলারের মধ্যে ওঠা-নামা করে, সেখানে বর্তমানে তা বেড়ে দ্বিগুনের বেশী প্রায় ৪৭০ ইউএস ডলার হয়েছে। বাংলাদেশের খাদ্যশস্য উৎপাদনের নিশ্চয়তা থাকায় ভয়াবহ করোনা অতিমারিতে বাংলাদেশের খাদ্যের বাজার অস্থির হয়নি। মাননীয় প্রধানমন্ত্রীর দূরদর্শিতার সাথে খাদ্য উৎপাদনের পাশাপাশি লক্ষমাত্রা নির্ধারণে কৃষি মন্ত্রণালয় প্রাধান্য দিয়ে থাকে প্রধান খাদ্যশস্য ধান উৎপাদনের উপর। খাদ্য নিরাপত্তা বলতে বাংলাদেশে চালের পর্যাপ্ততা, প্রাপ্যতা ও ক্রয় সীমার মধ্যে মূল্যের উপর নির্ভর করে। নিরবচ্ছিন্ন দীর্ঘ সূর্যালোক প্রাপ্তি, সেচের জমির সহজলভ্যতায় বাংলাদেশের ফসল উৎপাদনের উত্তম মৌসুম শীতকালের রবি মৌসুমকেই গণ্য করা হয়।

দু:খের বিষয় হচ্ছে প্রতিবছর মাথাপিছু কৃষি জমির পরিমান কমে যাচ্ছে। শুধুমাত্র রবি মৌসুমে বোরো ধান, গম, ভূট্টা, শীতকালীন শাকসব্জি, সূর্যমুখী, ডাল জাতীয়, তেলজাতীয় ফসলের মধ্যে জমির প্রতিযোগিতায় বোরো ধান প্রাধান্য পায়। ২০০৮-০৯ অর্থ বছরে মোট খাদ্যশস্য চাল, গম ও ভূট্টা উৎপাদন ছিল ৩ কোটি ২৮ লক্ষ ৯৬ হাজার মে:টন। সেখানে ২০২০-২১ অর্থ বছরে তা বেড়ে ৪ কোটি ৫৫ লক্ষ ৫ হাজার মে:টন হয়েছে। প্রতি বছর আমাদের গম আমদানী করতে হয়। এ বৎসর মাত্র ১২.৩৪ টন গম দেশে উৎপাদন হয়েছে। আমাদের দেশে গম চাষের সম্ভাবনা থাকা সত্ত্বেও বোরো ধান চাষের সাথে প্রতিযোগিতায় গম উৎপাদনের জন্য জমি অপ্রতুল হয়ে পড়ে। একই জমিতে ভূট্টার চাহিদা ও বিক্রয়ের নিশ্চয়তা থাকায় উৎপাদন বেড়ে ৫৬.৬৩ লক্ষ মে:টন হয়েছে। যে ফসলকে কৃষক লাভজনক মনে করে সেই ফসল চাষে তারা উদ্বুদ্ধ হয়। এতসব সীমাবদ্ধতার মধ্যেই সরকার প্রণোদনা দিয়ে কৃষকদের কে কৃষি মন্ত্রণালয়ের লক্ষমাত্রা অর্জনে বিভিন্ন ফসল চাষে উদ্বুদ্ধ করে। আলু, ডাল জাতীয়, তেলবীজ জাতীয়, সবজি জাতীয় এসব ফসলকেও শীতকালে বোরো জমির সাথে প্রতিযোগিতায় টিকে থাকতে হয়। গত বছর আলু উৎপাদন হয়েছিল ১০৭ লক্ষ মে:টন। আলুতে গত বৎসর কৃষকরা দাম পেয়েছে। তাই কৃষকরা এবার আলু উৎপাদনে ঝুঁকেছিল। ১১০ লক্ষ মে:টন আলু এ বছর উৎপাদন হয়, কিন্তু কৃষক দাম না পাওয়ায় হতাশ হয়েছে। ধারণা করা হয় করোনা কালে ত্রাণ সামগ্রীর মধ্যে আলু থাকায় এবং বন্যার কারনে অন্যান্য সবজি উৎপাদন তুলনামূলক কম হওয়ায় গত বছর আলুর চাহিদা বেশী ছিল। গ্রীষ্মকালীন পিঁয়াজ এ বছর ৭ লক্ষ মে:টন উৎপাদন হয়েছে। এজন্য পেঁয়াজের বাজার এবার এখনও অস্থির হয়নি। একটি দেশ সব ধরনের খাদ্য-পণ্য উৎপাদন করে না। অগ্রাধিকার প্রদান করে চাহিদা ভিত্তিক ফসল উৎপাদন করে এবং আমদানীর মাধ্যমে অন্যান্য ফসলের ঘাটতি পূরণ করে থাকে। কৃষি মন্ত্রণালয় কৃষি পণ্যের রপ্তানী বাজার সম্প্রসারণের জন্য কোন্ কোন্ দেশে চাহিদা রয়েছে তা নিরুপনে এবং চাহিদা মোতাবেক যোগান দেবার প্রস্তুতি, বিনিয়োগ ও উৎপাদন করার সুযোগ সৃষ্টি করছে। কৃষি যান্ত্রিকিকরণের ব্যবস্থা করে শিক্ষিত তরুণ উদ্যোক্তা সৃষ্টি জন্য উদ্যোগ গ্রহণ করেছে। কৃষি মন্ত্রণালয়ের তথ্যের সঠিকতা নিয়ে অনুযোগ রয়েছে, কৃষি সম্প্রসারণ অধিদপ্তর এর অধীন ১৪ হাজার ৯২টি বক আছে। প্রতিটি বকে একজন করে উপসহকারী কৃষি কর্মকর্তা দায়িত্বে থাকেন। তাদের মাধ্যমে সুনির্দিষ্টভাবে কৃষি সংক্রান্ত সকল তথ্য মাঠ পর্যায় থেকে কৃষি সম্প্রসারণ অধিদপ্তরের মাধ্যমে মন্ত্রণালয়ে আসে। কৃষি মন্ত্রণালয়ের লক্ষ্য আমদানী বিকল্প খাদ্যশস্য উৎপাদন ও উৎপাদিত কৃষি পণ্যের মধ্যে দেশের চাহিদার অতিরিক্ত বিদেশে রপ্তানীর সুযোগ সৃষ্টি করা এবং কৃষি প্রক্রিয়াজাত শিল্পের প্রসার ঘটানো।

সম্প্রতি কৃষি মন্ত্রণালয়ের উচ্চ পর্যায়ে একটি টীমের সংগে সফরে খুলনা, সাতক্ষীরা ও যশোর অঞ্চলে কৃষি গবেষণা উদ্ভাবিত কিছু নতুন প্রযুক্তি দেখতে যাই। উপকূলীয় অঞ্চলে অভাবনীয় সফলতার মুখ দেখতে পেয়েছে ঐ অঞ্চলের কৃষি ও কৃষকগণ। কৃষি মন্ত্রণালয়ের উচ্চমূল্যের ফসল হিসেবে স্বীকৃতি পেয়েছে অসময়ের উৎপাদিত শীম, গ্রীষ্মকালীন টমেটো ও তরমুজ। লবণাক্ত অঞ্চল খ্যাত খুলনা অঞ্চলে ইতোপূর্বে ফসলের জমিতে শুধুমাত্র ঘের করে চিংড়ী উৎপাদনে কৃষকরা উৎসাহিত হত। এখন তারা ঘেরের চতুর্দিকের আইলে গ্রীস্মকালীন শীম উৎপাদন করছে। শত শত হেক্টর ঘেরের জমির আইলে ও রাস্তায় দু'পাশে বিশেষ ব্যবস্থাপনায় এই শীম উৎপাদনে ঐ অঞ্চলে এক ইঞ্চি জমিও যেন অনাবাদী পড়ে নেই। এছাড়া এক দৃষ্টিতে যতদূর চোখ যায় সবুজের সমারোহ। ঘেরের আইলে তরমুজের গাছ রোপন করে ঘেরের উপর জালির মাধ্যমে বিছিয়ে দেয়া লতানো গাছের নীচে ঘেরের পানিতে মাছ ও পানির উপরে ঘেরের চতুর্দিকে সবুজ, হলুদ বিভিন্ন জাতের তরমুজ ধরে আছে। তরমুজ গাছের পাশেই রোপন করা হয়েছে মরিচ গাছ। কোথাও তরমুজ, কোথাও শসা, কোথাও ঝিংগা, রাস্তার দু'ধারে ঢেড়স গাছ। লতানো জাতীয় সবজি চাষে ঘেরের আইল ব্যবহারে উৎপাদনশীলতা বৃদ্ধি করা হচ্ছে। লবণাক্ত অঞ্চল সাতক্ষীরার কলারোয়া অঞ্চলে দেখা যায় অধিকাংশ ফসলী জমিতে ধানের পাশাপাশি পলিথিন শেড নির্মান করে নিয়ন্ত্রিত প্রযুক্তির মাধ্যমে কৃষি গবেষণা ইনস্টিটিউট ও কৃষি সম্প্রসারণ কর্মীদের সহায়তায় ৮৪ হেক্টর জমিতে গ্রীষ্মকালীন টমেটোর বাম্পার ফলন হয়েছে। প্রতি বিঘাতে তারা গত বৎসর এক থেকে দেড় লাখ টাকার গ্রীষ্মকালীন টমেটো বিক্রি করতে পেরেছে। এ বার উৎপাদন সীজনে প্রতিবেশী দেশ থেকে টমেটো এসে যাওয়ায় কৃষক গতবারের তুলনায় দাম কম পাচ্ছে বলে জানায়। বাংলার কৃষির বৈচিত্র বৃদ্ধি পাচ্ছে। এক সময় যে সব ফল ধরা ছোঁয়ার বাইরে ছিল সে সব বিদেশী ফল এখন আমাদের দেশীয় ফলে পরিণত হয়েছে। কি না যোগ হয়েছে বাংলার ফলের ঝুড়িতে। ড্রাগন ফ্রুট, কমলা, মাল্টা, স্ট্রবেরী, উন্নতজাতের পেয়ারা, আম, পার্সিমন, এভোকেডো, রামভুটান, খেজুর, ত্বীনফলসহ উচ্চমুল্যের বিভিন্ন ফল উৎপাদন হচ্ছে আমাদের দেশে। বান্দরবান জেলায় কফি ও কাজু বাদাম চাষের অপার সম্ভাবনা দেখা দিয়েছে। কফি ও কাজু রপ্তানী যোগ্য পন্য হিসেবে প্রতিষ্ঠিত করতে প্রকল্প হাতে নেয়া হয়েছে। অপ্রচলিত ফল এবং ফসলের সমাহারের এ অভাবনীয় দৃশ্য না দেখলে বোঝা যাবে না বাংলার কৃষকের সক্ষমতা ও বাংলার কৃষির বৈচিত্র্যরূপ!

বাংলাদেশে ফিরে এসে ১৯৭২ সালের ১০ জানুয়ারিতে ভাষনে বঙ্গবন্ধু বলেছিলেন "বাংলার মানুষ পেট ভরে ভাত খাবে, এ আমার জীবনের সাধনা, এ আমার জীবনের কাম্য"। বঙ্গবন্ধুর কন্যা সেই বাংলাদেশকে নিয়ে গেছেন উন্নয়নশীল দেশের মর্যাদায়। শুধু ভাত খেয়ে আমরা এখন পেট ভরাতে চাইনা, চাই পুষ্টি সমৃদ্ধ সুষম খাবার। মাননীয় কৃষিমন্ত্রী ড. আব্দুর রাজ্জাক তাঁর বক্তব্যে প্রায়ই বলেন 'পুষ্টিসমৃদ্ধ জাতি ও মেধাবি প্রজন্ম তৈরীতে ভাতের পাশাপাশি অন্যান্য পুষ্টিসমৃদ্ধ সুষম খাবার গ্রহণ করা প্রয়োজন, ভাতের পাশাপাশি বিভিন্ন ধরনের খাবার যেমন: দুধ, ডিম, মাছ, মাংস, ফল-মূল, শাকসবজি খাদ্য তালিকায় রাখতে হবে। সকল মানুষের জন্য পুষ্টি সম্মত নিরাপদ খাদ্য উৎপাদন নিশ্চিত করতে কৃষি মন্ত্রণালয় নিরলসভাবে কাজ করে যাচ্ছে'। করোনার সময় পুষ্টিসমৃদ্ধ খাবারের গুরুত্ব সকলে অনুধাবন

করেছে। এখন জিংকসমৃদ্ধ ধানের জাত উদ্ভাবিত হয়েছে। আমরা দারিদ্রের দুষ্টচক্র থেকে বের হয়েছি। এখন অপুষ্টির দুষ্টচক্র থেকে বের হতে চাই। মাননীয় প্রধানমন্ত্রী করোনাকালে পারিবারিক পুষ্টি বাগানের উপর গুরুত্ব দিয়েছেন। মুজিববর্ষ উপলক্ষে ৪৩৮.৪৭ কোটি টাকার 'অনাবাদি পতিত জমি ও বসতবাড়ির আঙ্গিনায় পারিবারিক পুষ্টি বাগান স্থাপন' শীর্ষক একটি প্রকল্প গ্রহণ করা হয়। উক্ত প্রকল্পের আওতায় দেশের ৪,৫৫৪ ইউনিয়ন এবং ৩৩০টি পৌরসভায় ১০০টি করে মোট ৪,৮৮,৪০০টি পারিবারিক সবজি পুষ্টি বাগানের প্রদর্শনী স্থাপনের কার্যক্রম চলমান আছে। আমাদের খাদ্যাভ্যাসে পরিবর্তন আনতে হবে।

আমি ব্যক্তিগত অভিজ্ঞতায় বলছি দেশের বাইরে কিছুদিন থাকার পর শতরকমের উপাদেয় খাবারেও মন ভরে না কখনও মনে হয় একটু খিচুড়ী বা ঝাল মাংস কোথাও পাওয়া যেত বা পান্তা ভাত কাঁচা মরিচ পাওয়া যেত! এখানেই আমাদের রক্তে মাংসে সংস্কৃতির জড়িয়ে যাওয়াকে অনুভব করা যায়। দেশের বাইরে হোটেল থেকে ১ কি.মি হেটে একটু ভাত ও গরুর মাংস খেয়ে গুনে গুনে ৩০ ডলার দিয়েও মন খারাপ হয় না, আফসোস হয় না। আমাদের দেশের মানুষ তিন বেলা পেটপুরে ভাত খায়, এখন মাছ, মাংস, ডিম, দুধের কোন অভাব নেই। স্পল্প আয়ের মানুষেরা ও শর্করার পাশাপাশি আমিষ খাবার যোগাড় করতে পারছে। ছোট একটি সুন্দর দেশ আমাদের বাংলাদেশ। ফুল, ফল, ফসলে সমৃদ্ধ এ দেশের আনাচে কানাচে মোড়ে মোড়ে ফসলে, সবজিতে বাজার উপচে পড়ছে। খাবারের কোন অভাব নেই।

বিগত কয়েক বছরের মধ্যে বরেন্দ্র অঞ্চলের চেহারার অমূল পরিবর্তন হয়েছে। হেক্টরের পর হেক্টর জমিতে ধান চাষের পাশাপাশি ফলের সাথে বিস্তীর্ণ বাগান তৈরী হচ্ছে। বরেন্দ্র অঞ্চলের ঐতিহ্যবাহী আম বাগানের পাশাপাশি মাল্টা, কমলা, ড্রাগন ফ্রুট, কূল বরই এর বাগান চোখে পড়ে। ধানের জমিতে ফল বাগান কোথাও ফল বাগানে ধান চাষ হচ্ছে। আগে শুধুমাত্র বছরে বৃষ্টি নির্ভর আমন ধানই ছিল এ এলাকার মূল ফসল। নতুন নতুন জমি সেচের আওতায় এনে উর্বর বরেন্দ্র অঞ্চলে সবুজের সমারোহ চোখে পড়ে। জাতিসংঘের খাদ্য ও কৃষি সংস্থার হিসেবে বছরে ১০-১১ শতাংশ করে ফসলের জমি ক্রমান্বয়ে ফলের জমিতে পরিনত হওয়ায় ধানী জমি ফলের বাগান পরিনত হচ্ছে। স্বল্প সময়ের শস্য আম সংরক্ষণের ব্যবস্থা করলে কৃষক ন্যায্যমূল্য পেত। এক সময় বরেন্দ্র অঞ্চলের বিস্তীর্ন জমি ঠা ঠা ছায়াহীন ধু ধু প্রান্তর হিসেবে শূন্য থাকতো। বরেন্দ্র উন্নয়ন কর্তৃপক্ষ ধীরে ধীরে এসব জমি সেচের আওতায় এনে আমন ছাড়াও উফশী বোরো ধান, শাকসবজি ফলমূল ব্যাপক চাষাবাদ হচ্ছে। কৃষকের আর্থ সামাজিক অবস্থার উন্নতি হচ্ছে। বরেন্দ্র আঞ্চলেও আগাম সিম, লাউ, চালকুমড়া, মিস্টিকুমড়া, বেগুন, পেঁপে, বাধাকপি, ফুলকপি, টমেটো, করলা, শসা, লতিরাজ কচু, মাচায় তরমুজ, কুল চাষসহ ব্যাগিং পদ্ধতিতে আম, পেয়ারা, পেয়াজ বীজ উৎপাদন শুরু হয়েছে। ৯৫,৩০০ হেক্টর জমিতে ১২ লক্ষ মে: টন আম রাজশাহী, চাপাঁইনবাবগঞ্জসহ দেশের প্রায় ২২টি জেলায় বাণিজ্যিকভাবে চাষ হচ্ছে। আম উৎপাদনে বিশ্বে ৭ম স্থানে আছে বাংলাদেশ।

১৯৯৬ সালে ৪০ লক্ষ মে:টন খাদ্য ঘাটতি ছিল। বর্তমানে দেশে খাদ্য ঘাটতি না থাকলেও কতটুকু উদ্বৃত্ত থাকলে খাদ্য পণ্যের দাম নিয়ন্ত্রন হবে সে বিষয়ে পরিসংখ্যানের অভাব আছে। মাননীয় প্রধানমন্ত্রী বলেন "আমাদের দেশের খাদ্য বাজার কখনো সঙ্কুচিত হবে না বরং সম্প্রসারিত হবে। আমাদের দেশের লোকসংখ্যা বৃদ্ধি পাচ্ছে আর এর প্রয়োজনও আছে। বাংলাদেশ বৃদ্ধদের দেশ হোক আমরা চাই না বরং আমাদের যুব সমাজ, শিক্ষিত ও কর্মঠ ও প্রশিক্ষিত হোক এটাই কাম্য"। তিনি আরো বলেন বাংলাদেশের মাটিও পানি বড় সম্পদ। অভ্যন্তরীন ও আঞ্চলিক বাজার সম্প্রসারণ হচ্ছে। গ্রামে আর্থ-সামাজির কর্মকান্ড গতিশীল হওয়ায় দেশের মানুষের ক্রয় ক্ষমতা বেড়েছে, নিত্য নতুন পণ্য ও খাদ্য পন্যের চাহিদা বাড়ছে। দেশের অভ্যন্তরেই পণ্য বাজার সম্প্রসারিত হচ্ছে। আমাদের উন্নয়নের লক্ষ্য হল আমাদের গ্রামের মানুষের উন্নয়ন, আর্থিক স্বচ্ছলতা তথা ক্রয় ক্ষমতা বৃদ্ধি করা। আমাদের নিজস্ব বাজার সৃষ্টি হয়েছে। গ্রামের নাগরিক সুবিধা বৃদ্ধি পাওয়ায় জীবনমান উন্নত হয়েছে এবং পুষ্টি চাহিদার বৃদ্ধি পেয়েছে। বাংলাদেশে এ অগ্রগতি ও সমৃদ্ধির পেছনে সরকারের কৃষিবন্ধব নীতি ও কৃষকের অবদান কৃতজ্ঞতার সঙ্গে উল্লেখ করা যেতে পারে। পরিশেষে রাজিয়া খাতুন চৌধুরানী রচিত 'চাষী' কবিতার চরণ উদ্ধৃতি দিয়ে আজকের লেখা শেষ করছি।

'সব সাধকের বড় সাধক আমার দেশের চাষা,
দেশ মাতার-ই মুক্তিকামী, দেশের সে যে আশা।
দধীচি কি তাহার চেয়ে সাধক ছিল বড়?
পুণ্য অত হবে না'ক সব করিলে জড়।
মুক্তিকামী মহাসাধক মুক্ত করে দেশ,
সবারই সে অন্ন জোগায় নাইক গর্ব লেশ।
ব্রত তাহার পরের হিত, সুখ নাহি চায় নিজে,
রৌদ্র দাহে শুকায় তনু, মেঘের জলে ভিজে।
আমার দেশের মাটির ছেলে, নমি বারংবার
তোমায় দেখে চূর্ণ হউক সবার অহংকার।'

উপকূলীয় লবণাক্ত এলাকার সমস্যা ও উন্নয়ন সম্ভাবনা

বিধান কুমার ভান্ডার
মহাপরিচালক, মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট

বঙ্গোপসাগরের তীরবর্তী পাহাড় ও নদীবাহিত পললভূমি বেষ্টিত ১,৪৭,৬১০ বর্গকিলোমিটার আয়তন বিশিষ্ট এ দেশ বাঙালি জাতির পিতা বঙ্গবন্ধু শেখ মুজিবর রহমানের সুজলা, সুফলা সোনার বাংলাদেশ। এ দেশে ১৫টি ভূপ্রকৃতি ও ৩০টি কৃষি পরিবেশ অঞ্চল রয়েছে। ৪১৭ কিলোমিটার দৈর্ঘ্য বিশিষ্ট সমুদ্র উপকূলবর্তী এলাকার আয়তন ২৮,৬০০ বর্গ কিলোমিটার, যা দেশের প্রায় ২০ ভাগ এলাকাজুড়ে বিস্তৃত। সমুদ্র বিজয়ের পর বাংলাদেশের উপকূলীয় এলাকার দৈর্ঘ্য বেড়ে ৭১০ কিলোমিটার হয়েছে, যা দেশের প্রায় ৩০ শতাংশের বেশি। দক্ষিণাঞ্চলে গংগা পললভূমি, গঙ্গার জোয়ার ভাটা পললভূমি, মেঘনা মোহনা পললভূমি, চট্টগ্রামের সমুদ্র উপকূলবর্তী জোয়ার ভাটা পললভূমি ও পিট বেসিন নামক ৫টি ভূপ্রাকৃতিক অঞ্চল রয়েছে। এ অঞ্চলে বর্ষা মৌসুমে প্রধানত স্থানীয় উন্নত জাতের ধানের আবাদ করা হয়ে থাকে। শুষ্ক মৌসুমে অধিকাংশ জমি মৌসুমি পতিত থাকে; কারণ শুষ্ক মৌসুমে দক্ষিণাঞ্চলের অধিকাংশ এলাকা বিভিন্ন মাত্রার লবণাক্ততা দ্বারা মারাত্মকভাবে আক্রান্ত হয়। তখন সেচের জন্য উপযোগী পানির অভাব দেখা দেয়। শুষ্ক রবি মৌসুমে ব্যাপক এলাকা লবণাক্ততার কারণে পতিত থাকে। বিশ্ব উষ্ণায়নের ফলে জলবায়ুর বিরূপ পরিবর্তনের কারণে দক্ষিণাঞ্চলের ইকোসিস্টেমের এবং কৃষি পরিবেশের উপর ঋণাত্মক প্রভাব দেখা যায়। বাংলাদেশের উপকূলবর্তী বিস্তীর্ণ এলাকা কার্বন নির্গমনের ফলে ওজন স্তর হালকা হওয়া, পরিবেশগত ক্ষতি ও হুমকি দ্বারা বিপন্ন অঞ্চল। ধারণা করা হচ্ছে, আবহাওয়ার মারাত্মক ক্ষতিকর প্রভাবের ফলে পৃথিবীর মধ্যে দক্ষিণ এশিয়ার অন্তর্গত বাংলাদেশের দক্ষিণাঞ্চলের কৃষি (শস্য), মৎস্য ও জনবসতি সর্বাধিক হুমকির সম্মুখীন; মাননীয় প্রধানমন্ত্রী যা অত্যন্ত সফলভাবে বিশ্ব দরবারে তুলে ধরেছেন। বাংলাদেশের আবাদি জমির শতকরা ১০ ভাগের বেশি দক্ষিণাঞ্চলের উপকূলবর্তী এলাকায়। এ দেশের ২৮.৬০ মধ্যে এলাকার উপকূলবর্তী হেক্টর লাখ ১০.৫৬ হেক্টর লাখ আবাদি জমি বিভিন্ন মাত্রার লবণাক্ততা দ্বারা আক্রান্ত। মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট ১৯৭৩ সাল থেকেই উপকূলীয় এলাকার পানি ও মৃত্তিকার লবণাক্ততা পরিবীক্ষণ কার্যক্রম নিবিড়ভাবে পরিচালনা করে আসছে। দেশের দক্ষিণ-পশ্চিমাঞ্চলের উপকূলীয় এলাকার ১৮টি জেলার ৯৩টি উপজেলার অধিকাংশ জমি বিভিন্ন মাত্রায় লবণাক্ততায় আক্রান্ত। ১৯৭৩ সালে উপকূলীয় এলাকার ৮ লক্ষ ৩৩ হাজার হেক্টর, ২০০০ সালে ১০ লক্ষ ২০ হাজার হেক্টর এবং ২০০৯ সালে ১০ লক্ষ ৫৬ হাজার হেক্টর জমিতে লবনাক্ততা লক্ষ্য করা যায়। জমিতে লবণাক্ততার কারণে এ এলাকায় বর্ষাকালে শুধুমাত্র আমন ধানের উৎপাদন ছাড়া সারা বছর পতিত থাকে, কারণ এলাকায় জমিতে জোঁ আসে ফেব্রুয়ারি বা মার্চ মাসে। শুষ্ক মৌসুমে মিষ্টি পানির অভাবের কারণে বোরো ধান আবাদ করা সম্ভব হয় না।

লবণাক্ততা বৃদ্ধি পেতে পারে বিভিন্ন কারণে। বাংলাদেশে বিশেষ করে উপকূলীয় এলাকায় লবণাক্ততা বৃদ্ধি পায় দু'টি প্রাকৃতিক কারণে। এক- জোয়ারের সময় লবণাযুক্ত পানি জমিতে পাবিত হয়ে; দুই- ভূগর্ভস্থ লবণাক্ত পানি কৈশিক রন্ধ্র দিয়ে মাটির উপরে চলে আসা। সাধারণত শুকনো মৌসুমে (মার্চ-মে) লবণাক্ত জোয়ারের পানিতে বহু জমি তলিয়ে যায়। তখন লবণাক্ত পানি জমিতে ছড়িয়ে যায়। এ পানি সেচ কাজে ব্যবহার করা হলে মাটি বা জমি লবণাক্ত হয়। অন্যদিকে বর্ষা শেষ হলে জানুয়ারি-ফেব্রুয়ারি মাস হতে মাটি শুকাতে শুরু করে। এর ফলে মাটিতে অনেক ফাটল সৃষ্টি হয়। যখন মাটির উপরে রোদ পড়ে তখন মাটির উপরিস্তর হতে পানি বাস্পীভূত হয়ে উড়ে চলে যায় এবং ভূগর্ভস্থ লবণাক্ত পানি ঐ ফাটল দিয়ে ভূমির উপরিস্তরে চলে আসে। তখন জমির উপরিস্তর লবণাক্ততায় আক্রান্ত হয়। এছাড়া মনুষ্য সৃষ্ট কারণেও লবণাক্ততা বৃদ্ধি পায়। যেমন, উপকূলীয় অনেক এলাকায় মৎস্য চাষীরা লবণ পানির ঘের তৈরি করে চিংড়ি চাষ করে। এতে করে ঐসব ঘেরের মাটিতে লবণাক্ততা বৃদ্ধি পায়।

গবেষণায় দেখা গেছে যে, লবণাক্ততার কারণে ফসলের ফলন বিভিন্ন মাত্রায় কমে যায়। লবণাক্ততার কারণে উদ্ভিদের বৃদ্ধি কমে যায়, ফুলের সংখ্যা হ্রাস পায়, অনেক ক্ষেত্রে পরাগায়নও হয় না। মাটি লবণাক্ত হওয়ার কারণে মৃত্তিকা দ্রবণের ঘনত্ব বৃদ্ধি পায়। তখন অল্প ঘনত্বের গাছের রস চলে যায় মাটিতে। ফলে গাছ

WORLD SOIL DAY 2021

পানিশূন্য হয়ে নেতিয়ে পড়ে। লবণাক্ত জমিতে দ্রবীভূত লবণের মাত্রা বা পরিমাণ বেশি থাকায় গাছ মাটি থেকে খাদ্য উৎপাদন ও পানি কোনটিই সহজে শোষণ করতে পারে না। প্রতিকূলতার সৃষ্টি হয় শোষিত উপাদানসমূহের আত্তীকরণেও।

এইসব প্রতিকূলতা ছাড়াও উপকূলীয় এলাকায় আরও অনেক প্রতিকূলতা রয়েছে। উপকূলীয় এলাকায় বর্ষাকালে মিষ্টি পানির আধিক্য থাকায় নদী ও খালের পানি এবং মাটিতে লবণাক্ততা দেখা যায় না। তবে বৃষ্টি শেষ হলে জানুয়ারি-ফেব্রুয়ারি মাসে নদী ও খালের পানিতে লবণাক্ততা চলে আসে। পাশাপাশি মাটির স্বল্প গভীরে লবণাক্ত পানির স্তর থাকায় মাটিও লবণাক্ত হয়ে পড়ে। কারণ, এই এলাকার মাটির বুনট এটেল দোঁআশ বা এটেল। মাটি যখনই শুকিয়ে যায়, তখনই দ্রুত এই মাটিতে ছোট বা বড় ফাটল তৈরি হয়, যার মাধ্যমে পানি সহজেই মাটির উপরি স্তরে চলে আসে। এতে করে শুকনো মৌসুমে (এপ্রিল/মে মাসে) মাটির লবণাক্ততা বৃদ্ধি পায়। ফলে খরিপ-১ মৌসুমে এই এলাকায় ফসল চাষ সম্ভব হয় না। জমি মাঝারি উঁচু হওয়ায় এবং মাটির স্বল্প গভীরে ভূগর্ভস্থ পানি অবস্থান করায় এই এলাকার পানি দেরিতে অপসারিত হয়। ফলে জমিতে সময়মতো “জো” না আসার কারণে রবি ফসল চাষ করা সম্ভব হয় না। এই এলাকায় পটাশিয়াম ও সালফার ব্যতীত অন্যান্য খাদ্যোপাদানের অভাব রয়েছে। এই এলাকার মাটি ও পানির লবণাক্ততা দেরিতে (জুলাই/আগস্ট মাসে) অপসারিত হয়। ফলে এই এলাকার কৃষকেরা দেরিতে আমন ধান চাষ করে। এতে করে এই এলাকার ধান দেরিতে কর্তন করা হয়। ফলে রবি ফসল চাষ করার সময় থাকে না। স্থানীয় জাতের আমন ধান (দীর্ঘ জীবনকাল) চাষ করার কারণে এই এলাকায় দেরিতে (ডিসেম্বর মাসের শেষে) ধান কর্তন করতে হয়, এতে করেও রবি ফসল চাষ সম্ভব হয় না। শুষ্ক মৌসুমে বিশেষ করে রবি ও খরিফ-১ মৌসুমে মিষ্টি পানির অভাব দেখা দেয়। কারণ, এই এলাকার নদীর পানি ঐ সময়ে লবণাক্ত থাকে। অন্য দিকে এলাকার খালগুলো ভরাট হওয়ায় সেচের পানির অভাব দেখা দেয়। জলবায়ু পরিবর্তনের ফলে অনিয়মিত বৃষ্টিপাতের কারণে খরিপ-১ মৌসুমে এই এলাকার পূর্বের অন্যতম জনপ্রিয় ফসল তিল ও মুগ ডাল চাষবাদ সম্ভব হচ্ছে না। ফলে খরিপ-১ মৌসুমে এই এলাকার বিরাট একটি অংশ পতিত থাকে। এছাড়া জলবায়ূ পরিবর্তনের কারণে, অনেক বেশি ঘূর্ণিঝড় ও জলোচ্ছ্বাসে এই এলাকার ফসল বিনষ্ট হয়। এছাড়া, দুর্বল পোল্ডার ও স্লুইচ গেট যথাযথ ব্যবস্থাপনার অভাবে সময়ে-অসময়ে লবণাক্ত পানি ফসলি জমিতে প্রবেশ করে। এতে অনেক ফসল ক্ষতিগ্রস্থ হয়। লবণ সহিষ্ণু ফসল ও জাতের অপ্রতুলতার কারণে কৃষকেরা অধিক লবণাক্ততার সময়ে ফসল চাষ করতে পারে না। লবণাক্ততা ব্যবস্থাপনার জন্য কারিগরি জ্ঞানের ও প্রশিক্ষণের অপ্রতুলতার কারণে কৃষকেরা অধিক লবণাক্ততার সময়ে ফসল চাষ করতে পারে না। উপকূলীয় দক্ষিণ এলাকায় শীতকাল ক্ষণস্থায়ী হওয়ায় লবণাক্ততা সহিষ্ণু গমের মতো সম্ভাবনাময় ফসল চাষ করা সম্ভব হয় না। উপকূলীয় অনেক এলাকার স্থানীয় রাস্তা নদীর পাড়ের বেড়ি বাঁধের উপর থাকার কারণে ঝড়-জলোচ্ছ্বাসে ক্ষতিগ্রস্থ হওয়ায় যোগাযোগ ব্যবস্থা ভেঙ্গে পড়ায় কৃষি উপকরণ সংগ্রহ ও উৎপদিত কৃষি পণ্য বিপননে সমস্যা সৃষ্টি হয়। এই এলাকায় অনেক খাল প্রভাবশালী মহল ইজারা নিয়ে মাছ চাষ করে। ফলে শুকনো মৌসমে (খরিপ ১) কৃষকরা সেই সকল খালের পানি ফসল চাষে ব্যবহার করতে পারে না। উপকূলীয় এলাকায় দুর্বল যোগাযোগ এবং বাজার ব্যবস্থার কারণে কৃষি পণ্য বিক্রয়ে কৃষকেরা ন্যায্যমূল্য পায় না। উপকূলীয় এলাকায় বিশেষ করে দেশের দক্ষিণ-পশ্চিমাঞ্চলে প্রভাবশালীরা ফসলী জমিতে লবণ পানির ঘের তৈরি করে মাছ চাষ করছে। এতে করে এসব এলাকায় ফসল চাষ সম্ভব হচ্ছে না। এবং সেই সাথে লবণাক্ততা বৃদ্ধি পাচ্ছে।

লবণাক্ত এলাকার উন্নয়ন সম্ভাবনা

লবণ সহিষ্ণু ফসল ও জাতের উদ্ভাবন ও আবাদ বৃদ্ধি করতে হবে। ভুট্টা একটি লবণ সহিষ্ণু ফসল। তাই, কৃষকদের উদ্বুদ্ধকরণের মাধ্যমে স্থানীয় জাতের ধানের পরিবর্তে স্বল্প মেয়াদি আধুনিক জাতের বা হাইব্রিড জাতের ভূট্টা আবাদ করা যেতে পারে। এতে করে আমন ধান কাটার পর জমি ভুট্টা চাষের জন্য ব্যবহার করা যাবে। যেহেতু উপকূলীয় এলাকায় শুষ্ক মৌসুমে নদীর পানি লবণাক্ত থাকে, তাই বর্ষাকালে খালে মিষ্টি পানি জমিয়ে রেখে ভুট্টা চাষ করা যেতে পারে। যেহেতু এই এলাকার খালগুলো ভরাট হওয়ায় পানি ধরে রাখা যায় না, তাই খালগুলো খননের মাধ্যমে পানি ধরে রাখতে পারলে শুকনো মৌসুমে ফসলের আবাদ বৃদ্ধি পাবি। লবণাক্ত এলাকায় “খামার পুকুর প্রযুক্তি”র সম্প্রসারণের মাধ্যমে রবি ও খরিপ-১ মৌসুমে ফসল চাষ সম্ভব হবে। কারণ, এই প্রযুক্তিতে মাটির উচ্চতা বৃদ্ধি পায়। এতে আগাম “জো” আসে এবং মিষ্টি পানির যোগান সম্ভব হয়। কলস সেচ প্রযুক্তি, ডিবলিং পদ্ধতি, দ্বিস্তর মালচিং প্রযুক্তি, টপ সয়েল কার্পেটিং/মালচিং, রিজ-ফারো পদ্ধতি, লবণাক্ততা সহনশীল জাত স্ক্রিনিং, ফ্লাইং বেড এগ্রিকালচার, জিরো টিলেজ ও বপনের সময় পরিবর্তন পদ্ধতিসমূহ ব্যবহার করলে মাটি ও পানির লবণাক্ততা কমিয়ে ফসল চাষ সম্ভব হবে। যে সব জমিতে দেরিতে “জো” আসে সে সব জমিতে পলি ব্যাগ/ট্রে-তে উৎপাদিত চারা রোপন করে খরিপ-১ মৌসুমে আগাম তরমুজ চাষ করা সম্ভব। এই লবণাক্ত এলাকায় লবণাক্ত সহনশীল ফসল যেমন সূর্যমুখী, রেড বিট, সয়াবিন ইত্যাদি চাষাবাদ করতে হবে। উপকূলীয় দক্ষিণ-পশ্চিমাঞ্চলের সাতক্ষীরা, খুলনা ও বাগেরহাট জেলায় প্রায় ২,৩০,০০০ মাছের ঘের রয়েছে। এর মধ্যে মিষ্টি পানিতে গলদা চিংড়ি চাষ হয় এবং লবণাক্ত পানিতে বাগদা চিংড়ির চাষ হয়। এছাড়া ব্যক্তি মালিকানাধীন ছোট ছোট ঘেরের পাড়ে প্রায় সারা বছর সবজি ও তরমুজ চাষ করা যেতে পারে। আর বড় আকারের লীজ নেওয়া ঘেরসমূহের পানি বর্ষাকালে লবণমুক্ত হয়ে যায়। তখন মাটি, সার ও পানি ব্যবস্থাপনার মাধ্যমে বর্ষাকালে ঘেরের পাড়ে সবজি ও তরমুজ চাষ সম্ভব। উপকূলীয় এলাকার সকল খালের ইজারা প্রদান বন্ধ করে কৃষকদের জন্য পানি ব্যবহার উন্মুক্ত করে দিতে হবে। জমি সমতল রাখতে হবে এবং সব সময় ফসল দ্বারা আচ্ছাদিত রাখার চেষ্টা করতে হবে, এতে কৌশিক ছিদ্র দিয়ে লবণ কম উঠবে। পলি মাল্‌চ পদ্ধতিতে চাষাবাদের সম্ভাব্যতা যাচাই করা যেতে পারে।

সবশেষে বলা যেতে পারে যে, বাংলাদেশের দক্ষিণ অঞ্চলের লবণাক্ত কবলিত জমির লবণাক্ততা কমাতে হলে লবণ পানির ব্যবহার কমাতে হবে। পোল্ডার ব্যবস্থাপনাসহ স্লুইজ গেট ব্যবস্থাপনা উন্নত করতে হবে। লবণাক্ততা সহিষ্ণু বিভিন্ন জাতের ফসল চাষ করতে হবে। সবোর্পরি মাটি ও পানির লবণাক্ততা বিষয়ে সকলকে সচেতন থাকতে হবে।

Key note speech on WSD 2021
APPROACH TO HALT SALINAZATIONIN BANGLADESH

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" We can waste the planets resources for a few decades more...we must realize that one day the storm will break on the heads of future generations. For them it will be too late"- (UN Secretary General Boutros-Ghali, UNCED, 1992)

CONTEXT

On the World Soil Day-21 to halt the salinization process it is expected that awareness will be raised on the importance of maintaining healthy ecosystems and human well-being by addressing the challenges in managing soil salinization, encouraging societies to improve and invest for soil health management services. Nevertheless, the soil is an essential resource and a vital part of the natural environment from which most of the global food is produced. At the same time, soil provides living space for humans, as well as essential ecosystem services which are important for other resource management. Having this context, time has come to recap the world leader's commitments and stamped to comply the declarations of the Earth Summit 3-14 June 1992, at Rio De Jenario, Brazil (Halting land degradation, protecting biodiversity and to combat climate change). Thereafter on 20-22 June 2012 world leaders again met in the same city to reaffirm their approval on the new United Nations declaration on sustainable development, titled the 'Future We Want' and in 2015, COP12 at Ankara to achieve Land Degradation Neutrality (LDN) by 2030and Bangladesh is one of the signatories. Therefore, government has general obligations to adopt an integrated approach to address the physical, biological and socio-economic aspects of the processes of land degradation. To augment the understanding the theme of World Soil Day 2021 is "Halt Salinization, boost soil productivity" bears a great value.

"Soils" are under pressure from increases in population, higher demands for food and competing land uses. No doubt, importance of soils seems to be very clear, but it has not received due attention in terms of its usage and management at large. It is often considered an infinite resource that will always be able to provide us services. By and large this is not the case, now there is an urgent call to raise awareness on the importance of healthy soils, especially the need to protect soils and use them sustainably.

SOIL SALINIZATION: WHAT IT IMPLIES

"Salinization" is one of the major land degradation types of all continents that decreases soil fertility and impede crop production. It is also a significant component of desertification processes in the world's dryland and can be result from the proximity of semi-arid sites to the sea, or due to saline ground water rising into the root zone and concentrating there when evaporation becomes excessive (Thomas and Middleton, 1993). Accumulation of excess salts in the root zone resulting in a partial or complete loss of soil productivity is a worldwide phenomenon. The problems of salt-affected soils are old but their magnitude and their intensity have been increasing fast due to large-scale efforts to bring additional areas under irrigation in recent decades. The problems have been made worse by development of irrigation systems without adequate provision for drainage and are being aggravated by poor water management practices and unsound reclamation procedures (FAO, 1988). Soil salinity is a major impediment in achieving increased crop yields and considered as one of the drivers of land degradation and it occurs in all continents and under almost all climatic conditions. Recent Global Symposium of Salt Affected Soil 2021 (GSAS-21) mapped that about 63.2 and 120.0 million hectares of top soil (0-30 cm) and Sub-soil (30-100cm) of Asia are affected by soil salinity respectively. The situation is worsening with time and space.

Soil becomes saline when excessive accumulation of water soluble salts-NaCl present in the soil profile and the process of increasing the salt content is termed as salinization. The soluble salts are chiefly sodium chloride and sodium sulphate. But saline soils also contain appreciable quantities of chlorides and sulphates of calcium and magnesium. In field conditions, saline soils can be recognized by the spotty growth of crops and often by the presence of white salt crusts on soil surface. (FAO, 1988).A soil is considered saline, where high concentration of solute salts including Na+, Ca2+, and Mg2+ in soils is present and if the electrical conductivity of its saturation extract (ECe) is above 4 dS/m (US Salinity Laboratory Staff, 1954;Rengasamy, 2002). However, the threshold value above which deleterious effects occur can vary depending on several factors including plant type, soil-water regime and climatic condition (Maas, 1986). For example, in rainfed agriculture, soil water can be far below field capacity and the salt concentration under field conditions is several-fold higher than measured at soil saturation water content (Rengasamy, 2002). The distinguishing characteristic of saline soils from the agricultural standpoint, is that they contain sufficient neutral soluble salts to adversely affect the growth of most crop plants. For purposes of definition, saline soils are those which have an electrical conductivity of the saturation soil extract of more than 4 dS/m at 25°C (Richards 1954). This value is generally used the world over although the terminology committee of the Soil Science Society of America has lowered the boundary between saline and non-saline soils to 2 dS/m in the saturation extract. Soluble salts most commonly present are the chlorides and sulphates of sodium, calcium and magnesium. Nitrates may be present in appreciable quantities only rarely. Sodium and chloride are by far the most dominant ions, particularly in highly saline soils, although calcium and magnesium are usually present in sufficient quantities to meet the nutritional needs of crops. Many saline soils contain appreciable quantities of gypsum ($CaSO_4$, $2H_2O$) in the profile. Soluble carbonates are always absent. The pH value of the saturated soil paste is always less than 8.2 and more often near neutrality (Abrol et al., 1980).

EXTENT OF SALINITY

Global perspectives

For centuries, humankind and salinity have lived one aside the other. There is good evidence for Mesopotamia that early civilizations flourished and then failed due to human-induced salinization (Shahid, S.A., et.al.2018).The earth's land surface is 13.2 × 10^9 ha, but only 7 × 10^9 ha of this is arable, of which only 1.5 × 10^9 ha is currently cultivated (Massoud 1981). Of the cultivated lands, about 0.34 × 10^9 ha (23%) are saline and 0.56 × 10^9 ha (37%) are sodic. Older estimates (Szabolcs 1989) described 10% of the total arable land as being affected by salinity and sodicity, with the effects extending to over 100 countries in all continents. One billion hectares of the 13.2 × 10^9 hectares of the land is, thus, covered with saline and/or sodic soils, and between 25% and 30% of irrigated lands are salt-affected and essentially commercially unproductive (Shahid, S.A., et.al.2018). More recent estimates of the regional distribution of saline soils do not exist. There is a need to update this information in order to better understanding the extent of the problem and to develop soil use and management policies. Such estimates are essential given the continuing decline of soil resources for food production. Using the FAO/UNESCO soil map of the world (1970-1980), FAO estimated that globally the total area of saline soils was 397 million ha and that of sodic soils 434 million ha. There is still the need for data on the rate of change in areas affected by salinization, sodification and waterlogging at regional and global level (FAO soils portal).

National perspectives

Coastal region covers three major Agro-ecological regions. They are the Ganges Tidal Floodplain (AEZ-13, 17,066 sq.km), Young Meghna Estuarine Floodplain (AEZ-18, 9,269 sq km) and Chittagong Coastal plain (AEZ-23, 3,720 sq km) and mapped as salinity affected area. Of the 2.85 million hectares of coastal area of Bangladesh about 0.833 million hectares of land was recognized as saline soils based on reconnaissance survey data of 1965-75 (Karim et. al, 1990). However, SRDI, 2010 database manifest

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progressive increase of saline area from 0.83, 1.02 and 1.056 million hectares in 1973, 2000 and 2009 respectively (SRDI,2010). In the last 35 years, salinity has increased by around 26 percent in this country. Salinity intrusion is spreading continuously into the northern non-coastal areas as well (Mahmuduzzaman, et.al., 2014). Extent and degree of salinity with time and space reported by SRDI in 2010 are presented in Table (1 &2). These data are too old to predict or map the present situation. Regular updating mechanism is essential to address the coastal dynamics.

Table-1: Extent of soil salinity during the last four decades (1973-2009) in coastal areas (SRDI, 2010).

Salt affected area (mha)

1973	2000	2009
0.83	1.02	1.056

Zahid, A. M.(2021) mapped 1.06 m ha area as saline in Coastal region, of which 0.20, 0.42, 0.25 and 0.19 mha are graded as Very Severe, Severe, Moderate and Light saline area respectively (It has also been reported that saline aquifer has penetrated to about 151 km from the coast towards the Khulna region (Habiibullah, 1986).

Salt accumulation on top soils is highest in Ganges Tidal Floodplain (GTF) where range of soil salinity varies from 0.3 to 70.0 dS/m. Soil salinity decreases with depth. Identified cations are Na^+, Ca^+, Mg^+ and K^+ and anions are SO_4 = and Cl- in different areas (SRDI, 2010). In dry season water salinity of major rivers is highest ECe>5.0 dS/m in water near the coast and ECe around 2.0 dS/m in northern parts of coastal zone. Influence of massive abstraction of ground water and cut off of most of the river flow from the Ganges catchment salinity ingression is also spectacular where the ratio has been estimated to be 1:40 (Karim, et.al, 1982). Data as recorded by SRDI revealed that river water salinity at Narail Ferry Ghat (Chitra river), Narail was 0.40 dS/m (Non Saline) in 1988, which is 0.80dS/m (Saline) in 2013. On the other hand river salinity at Nayapara, Avoynagar, Jessore (Bhairab river) in 1988 and 2013 is 1.5dS/m and 2.5dS/m respectively. Those points were not recorded as saline in 1980s (Islam, 2013). Salinity of shallow and deep tube well water have a very wide range, which ranges from 0.55 to 2.0 dS/m (Sayma and Mashfique, 2012).

Large areas of land remain fallow in the dry season (January–May) because of soil salinity, lack of good quality irrigation water, and conflicts with water control, mostly drainage (Haque, 2006, Mondal et al. 2006; SRDI 2010). In the recent past, it has been observed that normal crop production has become more restricted due to increasing degree of salinity of some areas and expansion of salt affected area as a cause of further intrusion of saline water, causing an enhancement of shrimp and salt production area. In general, soil salinity is believed to be increasing

Table-2: Intensity of soil salinity during the last four decades (1973-2009) in coastal areas (SRDI, 2010)

Salinity class and area (mha)											
S_1			S_2			S_3+S_4			S_5		
1973	2000	2009	1973	2000	2009	1973	2000	2009	1973	2000	2009
2.87	2.90	3.28	4.26	3.07	2.74	0.80	3.37	3.52	0.40	0.87	1.02

Note: S1= 2.0–4.0; S2 = 4.1–8.0; S3= 8.1–12.0 dS/m; S4 = 12.1–16.0 dS/m; S5 => 16.0 dS/m.

Relative productivity loss according to land degradation class

Degradation class	Very severe	Severe	Moderate	Light
Relative productivity loss	50-75%	25-50%	10-25%	<10%

(After Zahid,2020)

with time and space though the area was within the embankments. Although the area affected by the salinity problem did not receive enough attention in the past, but now much emphasis has been given on this issue.

There are spectacular increase in soil salinity observed in southern districts like Satkhira, Khulna, Bagherhat, Pirojpur, Barguna, Patuakhali, Bhola, Noakhali and Cox's Bazar; on the other hand there are newly salinity intruded districts namely, Narail, Gopalgonj, Madaripur, Barishal and Jhalakati (Gurang and Azad(Eds), 2013).

The salinity is seasonal and varies in place to place due to variation in the fluctuation of ground water. The extent of salinity increases with dryness and falls with the advent of the rainy season. The salinity starts augmenting from the end of November and attains its peak during the months of May-June and then it starts declining with monsoon. The dominant crop grown in the saline areas is local transplanted Aman rice crop with low yields. The factors involved in the salinization are land relief, degree of flooding, the nature of the soil, precipitation, tidal action, the effect of the river system and their discharges, depth of the groundwater table and salt deposits, the slope of the ground and the proximity to drainage channels (Huq and Shoaib, 2013).

The polders- a Dutch word, refers to an area enclosed by embankments/dikes (locally called বেড়ীবাঁধ-Beriband) make as an independent hydrological unit. These are only connected with surrounding natural water system. through some manually operated water control structures. The immediate results from the coastal polder were very much positively significant for the socio-economic development of the coastal lives and livelihoods. But from early 1980s, poldered area cutoff from the surrounding tidal riverbed due to rapid sedimentation and declined river gradients. Despite heavy investment for construction and maintenance of embankments and sluice gates, drainage congestion and risk of flood increased, the coastal livelihood became threatened, agricultural productivity remained low and widespread poverty persisted in the coastal region. Therefore, these polders are not effective in many areas as anticipated due to lack of maintenance, non-functional sluice gates, regular breaching, and a resultant effect of the present global climate change. (CGIAR,2015, Jakia, 2017, Mohammad, et.al.,2019).

Box-1: Soil salinity classification

Very slightly Saline (S1) 2-4 dS/m
Slightly Saline (S2) 4-8dS/m
Moderately saline (S3) 4-12dS/m
Strongly saline (S4) 12 -16 dS/m
Extremely saline (S5) >16dS/m

Water salinity classification

Safe < 0.75 dS/m
Unsafe or Harmful 0.75-3.0 dS/m
Extremely harmful > 3.0 dS/m

(SRDI,2010;Gurang and Kalam (Eds), 2013)

Box-2: Krug Mission[1]

After the Krug Mission in 1957 embankments were constructed to protect farms and farmers from sea water intrusion and tidal water in 1960s and 1970s. Total 139 coastal embankments have been constructed to protect low-lying lands from tidal inundation and salinity intrusion through large-scale and small-scale Flood Control Drainage (FCD), Flood Control, Drainage & Irrigation (FCDI) projects. Those interventions protected 1.2 million hectares of land for supporting 8 million inhabitants.

(Jakia, 2017)

1: The KKrug Mission Report, 1957 was a product of a study on flood control and water management in East Pakistan after the disastrous floods of 1954, 1955 and 1956 that drew world attention.

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Coastal zone management is now standing in a multiple challenge. It is very challenging, it must be addressed with related all stakeholders to match with socio-economic and natural capitals of the area. Ahmed, H. (2019) stated that Integrated Coastal Zone Management (ICZM)is a dynamic, continuous and iterative process designed to promote sustainable management of coastal zones which covers full cycle of information collection, planning, decision making, management and monitoring of implementation setup. It is a widely accepted approach at all levels of governance as a means of delivering sustainable development in the coastal areas. A peer review of this approach will definitely enrich its outcome.

ECONOMIC LOSS DUE TO SALINITY

Zahid, (2021) estimated total soil saline affected area as 0.87 mha in 2021 (of which moderate, severe and very several soil salinity are 0.25, 0.42 and 0.20 mha respectively).On the basis of degree of salinity classifications economic loss of land degradation of these areas due to salinity had been calculated by Islam and Shoaib, (2021) as 367.12 and 13.56 million US$ per year r in terms of productivity loss and cost of nutrient replacement respectively.

LAND USE/ LANDCOVER OF COASTAL AREA

Major cropping patterns are Fallow-Fallow-Transplanted Aman (38.5%), Rabi-Broadcast Aus-Transplanted Aman (24%), Fallow-Transplanted Aus-Transplanted Aman (14.1%), Fallow-Boro-Transplanted Aman (13.7%) and others (9.6%), which include Rabi crops- Mixed Aus and Aman (2.5%), Fallow-B. Aman (2.1%), Boro-Fallow-Fallow (1.01%) etc (MoA and FAO, 2013).

IMPACTS OF SOIL SALINITY IN BANGLADESH COAST

Many scholars described impacts of soil salinity on the ecosystem services of the area. Those could be summarized as:

- Loss of biodiversity,
- Rapid change in physiographic structure of the saline areas,
- Embankments failed to protect salinity intrusion,
- Declining tree species production,
- Reducing soil fertility and productivity,
- Increasing disease and pest infestation in field crops,
- Increasing human and animal diseases,
- Decreased native fish species both in open and fresh water bodies.
- Green belt of coastal zones destroyed,
- Increase in temperature,
- Increased heavy showers, drought events, etc.
- Gradual decrease in grazing lands (shortage of feed, forage, straw etc.) leading to the decrease in the number of livestock.
- Increased climatic hazards.(Md. Yunus Mia, et.al.,2020)

DRIVERS OF SOIL SALINITY

The major drivers of soil salinity in Bangladesh coastal region are as follows:

- Saline water intrusion from sea/rivers in both protected and unprotected polders;
- Capillary rise of saline ground water in dry season;
- Depth to ground water table;
- Seepage of saline water to adjacent agricultural lands of the polders;
- Irrigation with saline GW:
- Shrimp farming and poor water governance and polder management;
- Conflict among the land users (deliberate invasion of sea water for shrimp, salt etc.);
- Grabbing canals/creeks in the polders; and
- Cyclone and storm surge, sea level rise (due to climate change) etc.

(Rashid and Islam 2007; Haque et al. 2008; SRDI, 2010; Rasel et al. 2013;Salehin M. et al.,2018).

WHAT COULD BE DONE

If coastal resource system is to remain productive, their management requires a holistic and comprehensive approach. To predict salination problem the main pre-requisite is to identify the-source of salts and to characterize the main factors determining the regime of water and salts in the soil. This is not easy, because the hydrological and chemical conditions involved in the process of salinization are usually very complicated. Therefore, we have to simplify some of them to be able to develop models that can be put into practice. Without adequate leaching and drainage, it is not possible to control soil salinization under irrigation. (Ildefonso PlaSentis, 2005).

Brammer, H. (2014) recommended for immediate action plan to halt or reverse the growing problem of saline-water intrusion in the south west of Bangladesh. In addition, strategies or approaches to better use of the salt affected soils could be adoption of Sustainable Land Management (SLM) good practices. It has a central role to minimize land degradation due to salinization by generating multiple co-benefits including climate change mitigation, resilience, improved biodiversity and enhanced production. SLM directly supports to halt/avoid, reduce or reverse salinization process and contribute to restore ecosystem services. It also creates space for investment. Coastal zone management is essential for implementing sustainable development strategy in Bangladesh. Any approach taken thereof, must have interlink with that at the national level, sub-national level and local community level. This is likely to ensure safety, security and sustainability for the coastal communities.

Managing soil salinity at early stage helps to reverse it. However, heavy contamination leads to complete loss of farmlands and desertification due to negative effect of salinity on soil properties. (Earth Observing System).

There are a good number of interventions in soil salinity management.

a) Adoption with appropriate salt tolerant cultivar,

b) Sustainable Land management (SLM),

c) Halt or Reclamation,

a) Adoption with appropriate salt tolerant cultivar

This intervention is mostly agronomic measures. NARS institutions have developed salt tolerant varieties of crops to adapt to different degrees of salinity at different growing stages. These interventions are mainly observed for rice. There are a good number of salt tolerant rice varieties selected and cultivated in coastal area. They are:Boro (Rabi) BRRI dhan-28, 29, 47; Transplanted Aman (Kharif-2) BR10, BR11, BR22, BR23, BRRI dhan- 27, 28, 30, 39, 40, 41, 47,49 and BINA-7 and Transplanted Aus (Kharif-1) BRRI dhan- 26, 27, 28,42,43,48 and BR14. Abedin,2010 recommended Boro (BRRI dhan47) followed by Transplanted Aman (BRRI dhan41 or BRRI dhan44) for saline area as a suitable cropping pattern.

There are other crops reported to be suitable for saline area(BARI, 2012 and Aziz, 2013):

- Pulses:Khesari -BARI Khesari1,2, BARI Chola-4, BARI Felon-1; Mungbean: BM-01 & BM-08.
- Oil seeds: Soybean- BARI Soyabean-5, BARI Sharisha-9 &11 as relay crop,Sesame: Aatshira.
- Forage: Maize-Barnali, Khaibhutta, BARI Hybrid Maize 3,4,5, Pacifi11 and 60; Barley- BARI Barley-6, BHL-15,18;

There are some rabi vegetables (Red Amaranth, Spinach, Okra etc) screened as suitable at salinity 2dS/m in early stage and 6-8 dS/m at vegetative stage (Gurung and Azad (Eds), 2013). Soyabean (BARI soyabean5) , sesame (BARI til4) and watermelon (Hybrid) suitable at as high as 10-12dS/m. Crops like okra, groundnut, mungbean, chili, maize and cowpea is suitable for area with salinity up to 8dS/m (Bashar, 2013).

Besides varietal interventions there are some other practices to adapt soil salinity such as Pitcher (Kolosh) irrigation, Dibbling, Mulching (putting the seed at certain depth or in furrows followed by mulching with rice husk etc).

b) Sustainable Land Management (SLM) best practices

Halting soil salinity in coastal region of Bangladesh is not too challenging as of it's sources or drivers concern, but necessitates integrated institutional framework. In some parts of polders where saline water intrusion has not happened after polderization remained non-saline and year-round crops are practiced. Yet, there are ample of soil and land management best practices on the coastal region that halt salinization. Tidal River Management (TRM),

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Transforming landform, Fresh water (Non-saline) reserve in internal creeks/khals, Tree plantation along embankments, enhancing mangrove outside the embankments, etc. are practiced in coastal areas. Following landform change farmers of Satkhira, Khulna and Bagherhat are growing year-round crops (Rice, Vegetables, Fish, etc). These practices are able to halt and/or reduce soil salinity by flashing salt in rainy season, increased production, reduce capillary rise of shallow ground water by keeping soil surface covered in dry season and usage of ditch area for aquaculture in the same parcel. This type of approach is practically three dimensional to halt or reduce soil salinity:

1. Year-round vegetables on raised desalinized dykes/bunds,
2. Kharif-2 rice on level land and
3. Aquaculture in the ditch (excavated area) either one side of the land or around the land.

The configuration of changing landform depends on the farmers choice, fund availability, market, land conditions, expected crops to be grown and hydrological situation.

c) Reclamation (Limited practiced in Bangladesh)

Food and Agriculture Organization (FAO) of the United Nations proposed to reclaim salt-affected soils in FAO Soils Bulletin 39. Generally, reclaim or desalinization of salt effected soils are to remove soluble salts from root zone. Common methods adopted or proposed to desalinization are (FAO, 1988):

Scraping: Removing the salts that have accumulated on the soil surface by mechanical means has had only a limited success although many farmers have resorted to this procedure. Although this method might temporarily improve crop growth, the ultimate disposal of salts still poses a major problem.

Flushing: Washing away the surface accumulated salts by flushing water over the surface is sometimes used to desalinize soils having surface salt crusts. Because the amount of salts that can be flushed from a soil is rather small, this method does not have much practical significance.

Leaching: This is by far the most effective procedure for removing salts from the root zone of soils. Leaching is most often accomplished by ponding fresh water on the soil surface and allowing it to infiltrate. Leaching is effective when the salty drainage water is discharged through subsurface drains that carry the leached salts out of the area under reclamation. Leaching may reduce salinity levels in the absence of artificial drains when there is sufficient natural drainage, i.e. the ponded water drains without raising the water table. Leaching should preferably be done when the soil moisture content is low and the groundwater table is deep. Leaching during the summer months is, as a rule, less effective because large quantities of water are lost by evaporation. The actual choice will however depend on the availability of water and other considerations. In some parts of India for example, leaching is best accomplished during the summer months because this is the time when the water table is deepest and the soil is dry. This is also the only time when large quantities of fresh water can be diverted for reclamation purposes (FAO, 1988).

Improving drainage: In soils with poor drainage, deep tillage can be used to break up the soil surface as well as claypans and hardpans, which are layers of clay or other hard soils that restrict the downward flow of water. Tilling helps the water move downward through the soil.

Reducing evaporation: Applying residue or mulch to the soil can help lower evaporation rates.

Chemical treatments: Before leaching saline-sodic and sodic soils, you must first treat them with chemicals, to reduce the exchangeable sodium content. To remove or exchange with the sodium, add calcium in a soluble form such as gypsum. Again, the laboratory analysis can determine how much calcium to be added (Tony Provin and J.L. Pitt.).

STRATEGY TO HALT SOIL SALINITY

To halt salinization in Bangladesh should be focused on efficient polder (as an independent hydrological unit) management with a very robust soil and water governance framework which will stop or reduce saline water intrusion from sea/river and limit ground water abstraction either for irrigation or any other purposes. The process deserves multisectoral (GO/NGO) involvement with rational policy support and investment. Areas of interventions are (but not limited to) enabling fresh water storage in creeks/khals/rivers within the polders, establishing effective internal drainage system to escape water logging, restricting deliberate saline water intrusion for shrimp or salt, limiting abstraction of ground water (saline) for irrigation and developing supervised green infrastructure (developing mangrove and tree plantation outside or along embankment, etc.) could be focused to get better output from the coastal landscape. Following areas could be considered to halt salinization in coast.

a) Halt or reverse salt-water intrusion in the polders considering climate change,

b) Identify and document SLM best practices-preferable following "WOCAT tool" (WOCAT SLM database) and scale up/scale out for wider use in the landscape. There are abundant best practices adopted by the farmers as indigenous practices and/or promoted by GO/NGO initiatives to manage soils to grow crops in dry season, like vegetables, water melon, fruits, etc.,

c) Increased investment,

d) Creating strong awareness on the modus operandi of polder management,

e) Research and Development program on polder management (Like Tidal River Management-TRM, changing landform, dyke and ditch, etc.),

f) Establishing a monitoring system,

g) Implementing "Soil Doctor" program to involve the community to promote sustainable soil management program (FAO,2020),

h) Establishing green infrastructure in coastal region (along embankments, dykes, gher,etc.),

i) Finally, compliance of "World Soil Charter" by all stakeholders (Government, Private, Individual, etc.) to establish an achievable soil management framework,

Let's be honest with what we could do. Our future is not guaranteed. The resources that we depend on, the oceans, the arable land and so on are under increasing pressure. The only viable development for the 21st century is sustainable development. We need to preserve our resources and protect our environment (Roi+20, The Future We want).

RECOMMENDATIONS:

a) Concerned Ministries, Institutions (R&D), Academia, Civil Society and NGO are to be on one agenda- "To halt salinization, boost soil productivity"-(Integrated Coastal Zone Management, Coastal Development Board, etc.),

b) An extensive and effective campaign on soil management, good practices with community involvement in addition.

c) Regular data acquisition and reporting system on soil-water salinity could be restored,

d) An efficient and credible Global Soil Partnership-Soil doctor program could be established,

e) Bangladesh is one of the champions of champions that has a database covering whole country acquired by a well-designed methodology. AEZ database, upazila nirdeshika etc could be used extensively for soil-water management at large. These resources could be scaled up to adopt changing scenarios.

f) A doable or achievable implementation strategic framework supplemented by investment support.

INSTITUTIONAL INVOLVEMENT: The following ministries, institutions could be in the implementation (not limit to) framework. They are MoA, MoEFCC, MoL, MoLGD, MoWR, MoFL, BWD, WARPO, LGED, DAE, SRDI, NARS, BFD, BMD, BBS, BRDB, DPHE, Universities, Local NGO, Civil Society, local community, etc.

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Nutrient Management for Profitable Crop Production in Saline Soils of Bangladesh

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Abstract
Soil salinity is a problem of accumulation of soluble salts in the root zone which affects crop growth and yield.In Bangladesh, the extent of saline soil has shown an increase over the last decade, possibly due to global climate change and anthropogenic factor. Consequently, cultivation of crops in the saline soil faces difficulties that require efficient soil–water–fertilizer–crop management practices to make the soils productive. Excessive salts in the soil causes stunted plant growth and diminished vigor by reduced uptake of nutrients and water. Though soil salinity problems are more complex to manage, establishment of proper irrigation and good drainage system might a good option for saline soil management in the country. However, in terms of economically sustainable crop production and improved soil health, judicious fertilizer management that includes chemical fertilizers, organic amendments, plant growth regulators etc. is a major concern. As the fertility status of saline soils is poor, there are many considerations of nutrient management for successful crop production in the saline soils. At the very first, the causes, fertility and chemistry of saline soils should be explored well before going for nutrient management for crop production.

Key words: Fertilizer Management; Gypsum; Nitrogen; Phosphorus; Potassium; Saline soils.

Introduction
Soil salinity is a major abiotic stress and simultaneously it is a major problem in Bangladesh that poses obstacles to successful crop production. Salt affected soils are developed by the accumulation of high amount of soluble and/or exchangeable salts that adversely affects the plant growth and limits crop yield. Although soil salinity varies (Luedeling and Wichern, 2007), about 20% of cultivable land and 50% of arable land in the world is affected by a certain salinity level (Flowers and Yeo, 1995).In Bangladesh, the salinity affected area has increased from 8330 square km in 1973 to 10560 square km in 2009 (SRDI, 2010). In the last 3.5 decades, salinity increased around 26 percent in the country, spreading into non-coastal areas as well. About 0.223 million ha (26.7%) new land is affected by various degrees of salinity during the last four decades. The saline soils are mainly found in Khulna, Barisal, Patuakhali, Noakhali, Chittagong, Laxmipur, Feni, Satkhira, Pirajpur, Barguna, Bagerhat, Bhola, Cox's Bazar, Jessore, Magura, Narail, Faridpur, Gopalganj, Jhalakathi districts of the coastal and offshore lands. Several natural processes cause salinity in soil, namely, primary salinization and secondary salinization (resulting from human activities) occurring in irrigated and in rain-fed agriculture.The global issue, soil salinization,affects more than 412 million hectors of the coastal lands in around 100 countries in the world (Jakeman et al., 2016). Nineteen (19) districts comprise the coastal areas of Bangladesh coveringabout 32% of the country and accommodating more than 35 million people (Huq and Rabbani, 2011). Increasing salinity in the coastal region is a crucial issue to be addressed. The people of the coastal region suffer from scarcity of safe drinking water, quality irrigation water and other uses due to increasing soil salinity. It has been observed that all the coastal cultivable lands are not being utilized for crop production, mostly due to soil salinity. Increased soil salinity limits growth of standing crops and affects overall crop production, and also makes the soil unsuitable for many potential crops. Increasing levels of salinity in soil and water are affecting livelihoods in various ways. Water salinity is the main cause of increasing soil salinity which further reduces agricultural productivity and puts a huge pressure on food security (Basar, 2012).

Crop management practices for safe use of saline-contaminated soils and saline water includes cultivation of suitable salt-tolerant crops, seedbed management, and minimizing local accumulation of salts by grading, sustainable soil management, improvement of irrigation efficiency, and soil, water, and salinity monitoring for leaching assessment and drainage requirements (Khan et al., 2008). Salinity causes the existence of special environmental and hydrological situations thatinhibit the normal year round crop production (Fig. 1). There are many effective ways for improving salt-affected land, such as water leaching, chemical remediation and phytoremediation. The salt-affected soil remediation can be done by using chemicals, such as gypsum ($CaSO_4.2H_2O$), calcite ($CaCO_3$), calcium chloride ($CaCl_2.2H_2O$), and organic matter (farmyard manure (FYM), green manure, organic amendment and municipal solid waste) that has been proved to be successful approach.This approach is being implemented worldwide for being efficient, cost-effective and simple (Tejada et al., 2006).The integrated use of chemical and organic fertilizers is also effective for successful crop production and intensification. The physical, chemical and biological properties of soil in salt-affected areas are improved by the application of organic matter, leading to enhanced plant growth and development (Bello et al., 2021). Therefore, the application of organic matter combined with chemical fertilizers for soil remediation is important for sustainable land use and crop productivity.

Crop yields, crop intensities, and productivity levels are lower in saline areas than in plain areas, resulting in lower quality of life compared to other parts of the country, as farmers and agricultural systems in saline areas are not based on high yielding varieties, improved fertilizers and water management andhave not enjoyed the success of agricultural technology (SRDI, 2010). To improve the situation of farmers and farming community in the saline areas,nutrient management practices should be developed for sustainable intensification of cropping.

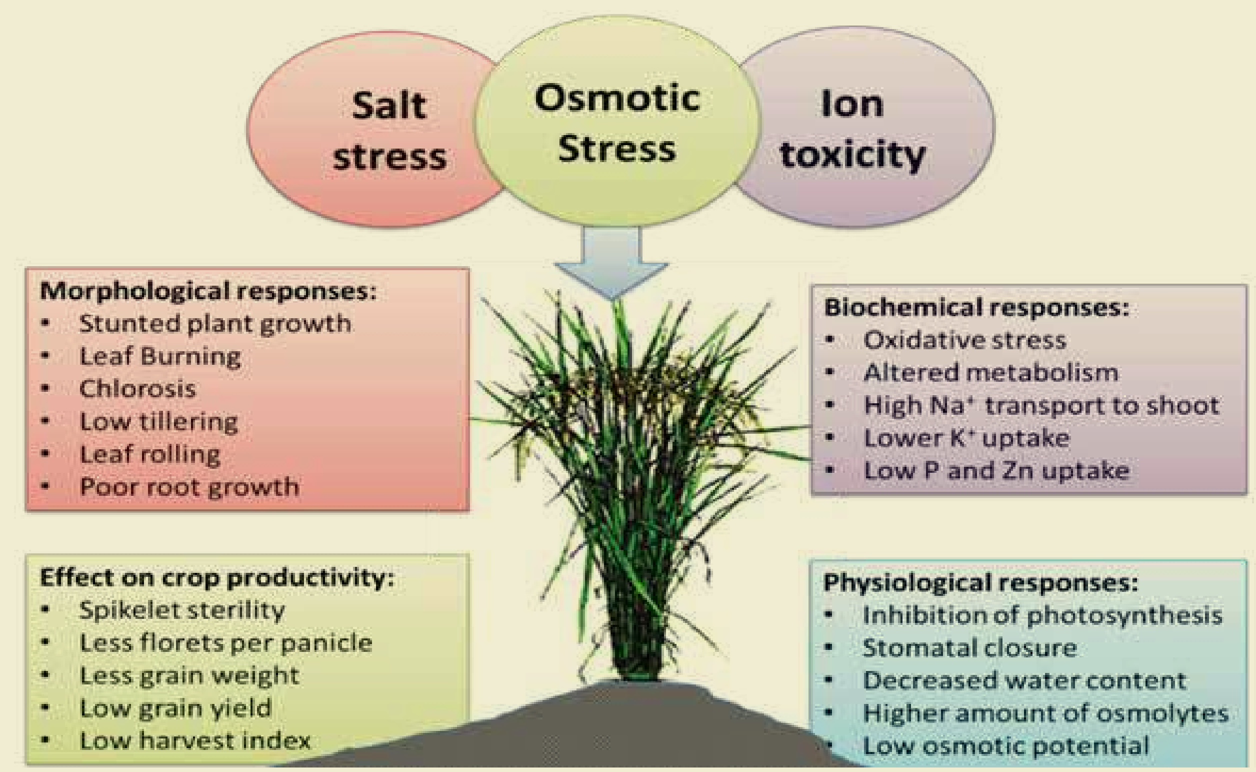

Fig. 1. Major responses of plants to soil salinity. The crops show responses to soil salinity in many ways. These include morphological, physical and biochemical responses that lead to low grain yield.

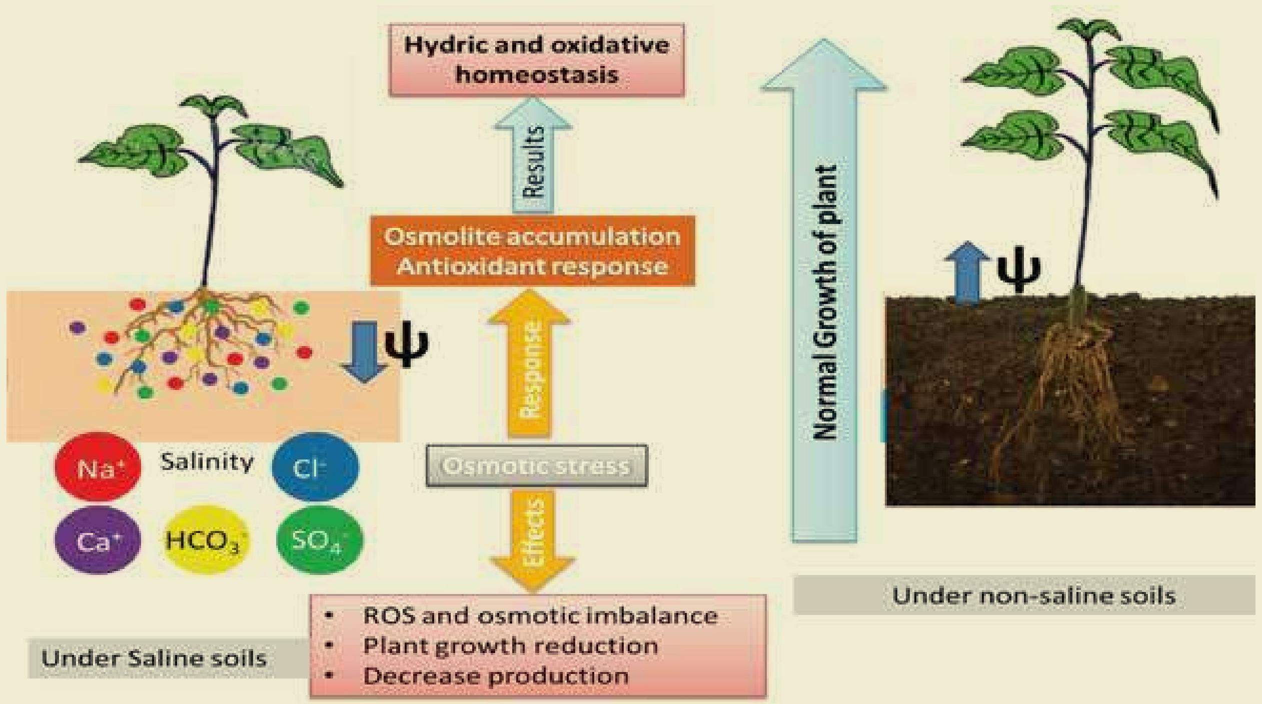

Fig. 2. Comparative growth of plant under saline vs. non-saline soils.The effects of salinity on plants occur mainly in two ways; initially salinity suppresses the plant growth by the osmotic stress including decreased rootcapacity of waterabsorptionand ion toxicity (e.g., nutritionand hormonal imbalance, oxidative stress and increased susceptibility to pathogens) (Gupta and Huang, 2014; TalbiZribi et al. 2018).

Salt-affected soils

Salt affected soils are generally classified on the basis of their pH, electrical conductivity of the saturated extract (ECe), sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) (Qadir et al., 2007; Rengasamy, 2010). Based on these properties, salt-affected soils are thus classified as saline soil with EC ≥ 4 dSm^{-1}, in which higher number of soluble salts are there; saline-sodic soil with EC ≥ 4dSm^{-1} and SAR ≥ 13 having high soluble as well as exchangeable Na; sodic soils having excessive amount of Na at exchange site and soil solution. Due to the combined effects of salinity and sodicity on soil properties and plant growth in saline-sodic soils, these soils are considered to be the most degraded form of salt-affected soil (Rengasamy, 2002).

Causes of salts in soil

Salt accumulation in the soil profile may be caused due to various factors like rain, weathering of rocks, application of soil amendments and soluble fertilizers, saline irrigation water, and capillary rise of saline ground water and seawater (Rengasamy, 2010). On the other hand, generally, the nature of soil parent material, climatic features of a particular area, diversity of soil microorganisms, time, and topography/relief decide the nature and properties of saline soils (Mansour and Salama, 2004).

There are generally two processes of salinization i.e., primary and secondary salinization processes. In primary salinization, salts generally originate from native soils through weathering of rocks (Rengasamy, 2006). While, secondary salinization is a consequence of anthropogenic activities such as poor quality water irrigation without sufficient leaching of salt, thus increasing salt concentration in the root zone (Ghassemi et al., 1995). The formation of coastal saline soils of Bangladesh is affected by the land relief and degree of flooding. The other factors are: i) the nature of the soil, ii) precipitation, iii) tidal action, iv) the effect of the river system and their discharges, v) depth of the groundwater table and salt deposits, and vi) the slope of the ground and the proximity to drainage channels (Rahman, 2012).

Causes of Salinity Intrusion

There are multiple reasons of salinity intrusion in the coastal area of Bangladesh. It includes natural, socioeconomic and political systems. All these systems are interlinked to each other. This section describes how these systems play a role in increasing salinity intrusion in the inland part of the country (Mahmuduzzaman et al., 2014).

1. Natural Processes

The natural systems include geographical location, sedimentation, sea level rise, cyclone, storm surge and tidal surge.

1.1. Critical Geographical Location of the Country

1.2. Sedimentation

1.3. Sea Level Rise

1.4. Cyclone and Storm Surge

1.5. Tidal Flooding

1.6. Back Water Effect

1.7. Changes in Ground Water Flow

2. Socioeconomic Systems

2.1. Unremitting Shrimp Cultivation

2.2. Weak Structure and Poor Maintenance

2.3. Anthropogenic Climate Change Induced Factors

3. Political Systems

3.1. Weak Water Governance Systems at Local Level

3.2. Cross Boundary River Policy

3.3. Lack of Capacity of Local Government

3.4. Structural Intervention in Upstream Neighboring Country (Mahmuduzzaman et al. 2014).

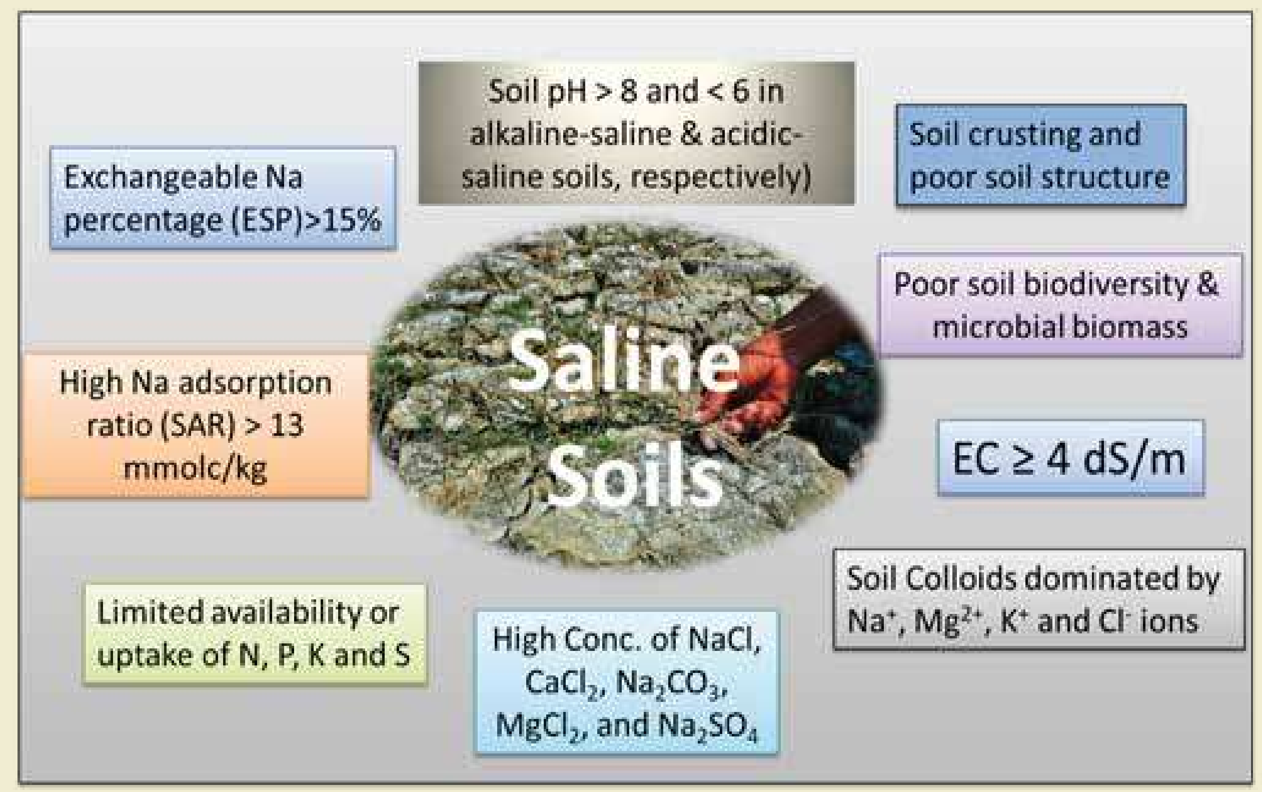

Fig.3.A general summary of the characteristics of salt-affected soils. In the above figure, thegeneral characteristics of saline soils are shown that depicts why saline soils are problem soils and creates problems in growing crops.

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Fertility status of saline soils

In general, the coastal regions of Bangladesh are quite low in soil fertility. A characteristic of saline soil is low nutrient ion activity (macronutrients such as N, P, K, Mg, and Ca, and micronutrients such as Fe, Mn, Zn, and Cu) due to extreme ratios of Na^+/Ca^{2+}, Na^+/K^+, Ca^{2+}/Mg^{2+}, and Cl^-/NO_3^- in the soil solution, which affect plant nutrition uptake and its growth (Grattan and Grieve, 1992; Bidalia et al., 2019). Usually,soil reaction values (pH) range from 6.0-8.5 with the exception of Chittagong and Patuakhali, where the pH values range from 5.0-8.0. Most of the soils are moderate to strongly alkaline, the pH values of the surface soils being lower than those of the subsurface soils. In places with higher pH values, micronutrients' deficiencies are expected. The soils are in general poor in organic matter content with the exception of Paikgachhaupazila of Khulna district, where the topsoil contains high organic matter (7%). The organic matter content of the top soils ranges from less than 1% to 1.5%. The low organic content in soils indicates poor physical condition of the coastal soils. The cation exchange capacity (CEC) of the soils range from 9.4-40.6 m.e.%. The higher CEC values of Khulna and Bagerhat soils are due to finer texture and higher organic matter contents. Soils having CEC below 15.0 m.e.% is considered as of poor status (Singaraval et al., 1996).

The soils contain variable levels of exchangeable bases, but a general feature is the higher Ca and K saturation of the exchange complex compared to Na and Mg in most of the soils. The Na and Mg saturation of the exchange complex is harmful because they destroy the soil physical properties and offset plant nutrition. Magnesium has synergistic effect of plant uptake of Na as well as antagonistic effect on the uptake of Ca and K. The total N contents of the soils are generally low, mostly around 0.1%. The N content is low in saline soils which may be attributed to low organic matter contents of most of the soils. Available P status of the soils ranges from as low as 5 ppm to as high as 35 ppm. Some deficient P soils are also found in Chttagong, Barguna, Satkhira and Patuakhali districts. Widespread Zn and Cu deficiencies have been observed in the coastal regions (Khan et al. 2008).

Since the soil organic matter, and consequently, the biomass and microbial activity, are generally more relevant in the first few centimeters at the surface of the soil, salinization close to the surface can significantly affect a series of microbiologically mediated processes. This is a significant problem, since the microbial processes of the soil control its ecological functions and fertility. Due to salinization, electrical conductivity of the soil increases and the microbial community cannot survive in those soils (Celia and Elisabeth, 2012).

Saline soil management

The principal objective of the recovery of soils affected by salts is to reduce the concentration of soluble salts and of exchangeable sodium in the soil profile, to a level that does not prejudice the development of crops. A decrease in the degree of salinity involves the process of dissolution and consequent removal by percolation water, whereas a decrease in the exchangeable sodium content involves its displacement from the exchange complex by calcium before the leaching process.

Nutrient Management for saline soils

High concentration of soluble and exchangeable ions and low organic matter in salt-affected soil depletes its fertility. Nutritional disorders in plants are the result of competitive uptake, transport, partitioning of major essential nutrients as affected by saline and sodic environment (Chatterjee et al. 2019). Since, saline soils in general are poor in fertility with low organic matter content, it is necessary to apply appropriate fertilizers to boost up crop production. So, proper amendments along with nutrient management practice are highly required to get reasonable crop production and to maintain environmental sustainability. It is very important to apply organic manure and inorganic fertilizers in an integrated way to maintain a steady supply of nutrients and reduce their loss. However, considerations of major soil nutrients for crop production in saline soils are described below:

Nitrogen

Rapid decomposition of organic matter in salt affected soil leads to lower organic carbon and increase N mineralization which in turn makes soils poor in total and available N (Swarup 1998). Increasing salinity level in soil adversely affects urea hydrolysis by lowering urease activity (Singh and Bajwa 1986). Decreased rate of NO_3- uptake by crops is mainly due to antagonistic effect of it with Cl-and SO_4^{2-} ions in these soils and high leaching loss of NO_3- (Choudhary and Yaduvanshi, 2016). Poor plant growth due to inadequate soil reclamation, nutritional imbalances within the plants, excessive ammonia volatilization and denitrification losses of N are found under high soil sodicity or salinity resulting in poor crop response to applied fertilisers (Swarup, 1994). About 32-52% of applied N was lost through NH_3 volatilization under sodic soils (Bhardwaj and Abrol, 1978) and the extent of volatilization loss of NH_3 depends upon pH, calcium carbonate content of the soil as well as alkalinity of floodwater (Bajwa and Singh, 1992).

In saline soils, high concentration of salts inhibits nitrification and results in accumulation of NH_4^+–N (Swarup, 1994) leading to large losses via ammonia volatilization. Nitrate-containing N fertilizers rather than Ammonical nitrogen in split application should therefore be preferred in saline soils. High water stress faced by plants in saline environments further restricts the metabolism of the absorbed N. Also because of high leaching losses of NO_3^- during reclamation of the saline soils, N requirement of crop in saline soils is higher than that in normal soils (Swarup, 1994).Crops grown under saline condition needs 20-25% higher dose of N than recommended one (Rao and Batra, 1983). It is proved that crop response to N fertilizers depends upon the extent of salts remain in soil after reclamation.

Apart from dose of N fertilizers, the method and time of fertilizer application influences NH_4+ -N concentration in soils (Kumar et al., 1995). Therefore, deep placement of fertilizers rather than broadcasting is efficient in sodic soils (Rao, 1987).Application of N fertilizer into three equal splits as basal, 3 and 6 weeks after transplanting or sowing under sodic water irrigated soils maximizes the yield of rice and wheat (Yaduvanshi and Swarup, 2005).

Phosphorus

Salinity-induced P deficiency is major abiotic stress in saline based agro-ecosystems, that negatively affects almost all facets of plant growth and development (e.g., seed germination, vegetation, flowering, fruiting and leaf senescence) as well as plant metabolism (e.g., photosynthesis, respiration, protein synthesis, and lipid metabolism) (Chen et al., 2015; Abdel-Fattah, 2015).

Availability and transformation of soil P greatly varied from salt affected to normal soils. In saline soils availability of P decreases due to precipitation of applied P, higher retention of soluble P, antagonism due to excess of Cl^- and SO_4^{2-} (Grattan and Grieve, 1994). Phosphorus is relatively immobile in saline soils as increasing salinity level restricts root growth that in turn, reduces the root surface area of the crop in contact with soil P (Chhabra et al., 1986). Thus, the availability of P is truly a function of plant root characteristics and the antagonistic behaviour of excess Cl^- on P absorption by roots. In most cases, salinity decreases the bioavailability of P (Sharpley et al., 1992). Moreover, soil environment and crop genotypes play a major role in P uptake (Grattan and Grieve, 1994). Fageria et al. (2011) reported that P uptake in plants reduced with increasing salt concentration in lowland rice where 93% decrease at 15 dS m^{-1} and 19% at 10 dS m^{-1} were observed in genotype CNA 810098 and CNA 810162, respectively. So, P availability in saline and saline-sodic soil can be enhanced by conjunctive application of P fertilizers and organic amendments like crop residues (Mahmood et al., 2013).Under high soil salinity conditions, yield of wheat was significantly enhanced by application of fertilizer P (Swarup, 1995).

Almost 70–90% of applied P fertilizer in agricultural soils is fixed with cations in the form of calcium phosphate, aluminum phosphate, and ferric phosphate; as a result, P is immobilized into an inorganic P pool, and is no longer directly available to plants (Walpola and Yoon, 2012). Even, the immobilized P pool is increased by salinity in cases of saline-soil-based agriculture. Thus, P management and salt stress remediation in saline soil-based agriculture are the main issues in current day research. These problems are generally overcome through some strategies, such as organic amendments (e.g., sewage sludge, farmyard manure), and modified biochar in saline soil (Wu et al. 2019; Wu et al. 2020).

Application of P can also enhance use efficiency of other nutrients. Swarup and Yaduvanshi (2004) observed that application of P in a saline soil

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increased the N use efficiency. During 3 years, the N use efficiency observed between 20 and 25 kg kg^{-1} N ha^{-1} at 50 kgNha^{-1}increasedto 31.6 and 41.1 kg kg^{-1} N by applying 13.1 and 26.2 kg P ha^{-1} along with 50 kg N ha^{-1}. Similar effect of P application was observed at 100 and 150 kg N ha^{-1}. In a rice–wheat rotation, continuous use of fertilizer P, green manure, and FYM to crops significantly enhanced the yield of rice and wheat and improved the available P status of the soil (Swarup and Yaduvanshi, 2004).

Soils irrigated with chloride rich waters respond to higher phosphate application, because the chloride ions reduce availability of soil P to plants. The requirement of the crop for phosphatic fertilizers is, therefore, enhanced and nearly 50% more P than the recommended dose under normal conditions should be added, provided the soil tests low in available P.

Potassium

Potash fertilizer has an added advantage under soil salinity. It lowers down Na uptake by plants and of course increases K uptake. Thus K fertilization protects crops from harmful effects of Na. Potassium deficiency is observed under high soil-Na concentration. So, K fertilizer application is highly recommended (Miransari and Smith, 2007). Deleterious effects of salinity on corn yield do not eliminate due to potassium fertilization despite increased K content in the plant and reduced the Na: K ratio in the plant tissue while increasing salinity reduces K concentration in the plant dry matter (Bar-Tal et al., 1991). Feigenbaum et al. (1990) derived a linear relationship between exchangeable potassium percent (EPP) and potassium adsorption ratio (PAR) in sandy loam soil of Nordiya and silty loam soils of Gilat, Israel regardless of salinity level or SAR value. AvoidingNaCl addition in soil is suggested because it induces none changeable K release to soil solution that resulted in elimination of the effect of K fertilization under salt stress. Depletion of K by plant uptake in salt affected environment can be organically subdued by crop residue incorporation (Li et al., 2014). So, returning straw to the field (Kaur and Benipal, 2006) and application of FYM can improve available K in soil (Habib et al., 2014) to satisfy the vast demand of K inputs when applied with K fertilizers.

On moderately saline soils, the application of potassic fertilizers may increase the crop yields (Dregne and Mojallali, 1969) either by directly supplying K or by improving its balance with respect to Na, Ca and Mg. However, under high salinity conditions it is difficult to exclude Na effectively from the plant by use of K-fertilizers.Swarup and Yaduvanshi(2004) put forward that application of fertilizer K in saline soils benefits crop yields by (i) directly supplying K, (ii) improving tolerance of plants to Na uptake, (iii) improving water use efficiency, and (iv) improving N use efficiency. Swarup (1995) observed that increasing application of K up to 42 kg K ha^{-1} resulted in a significant increase in yield of wheat grown in a saline soil.

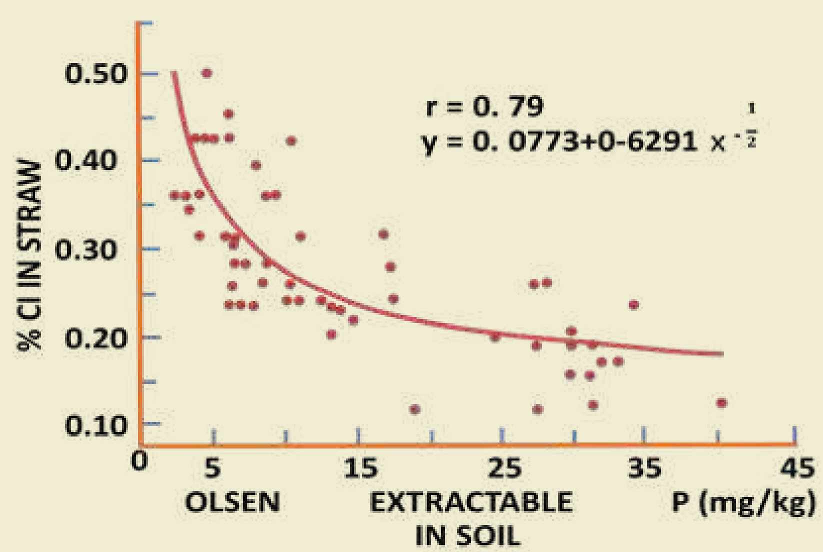
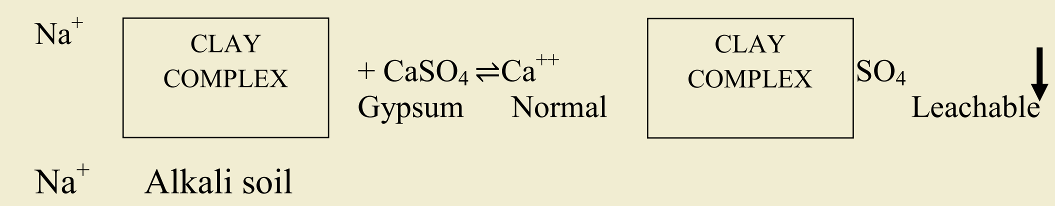


Fig.4. Effects of available soil phosphorus on the chloride content of wheat straw (Singh et al., 1979)

Sulphur

Amendments used in reclamationof salt affected soils

Gypsum: Gypsum (CaSO4.2H20) reacts with sodium carbonate and the adsorbed sodium as follow



$$Na_2CO_3 + CaSO_4 \rightleftharpoons CaCO_3 + Na_2SO_4 \downarrow$$

Sulphur: When sulphur is applied to salt affected soils the fallowing reaction takes places,

$$\underset{\text{Sulphur}}{2S + 2H_2O + 3O_2} \xrightarrow[\text{oxidation}]{\text{biological}} \underset{\text{Sulphuric acid}}{2H_2SC_4}$$

$$\underset{\text{Sodium carbonate}}{Na_2CO_3} + H_2SO_4 \rightleftharpoons CO_2 + H_2O + Na_2SO_4 \downarrow \text{ Leachable}$$

$$\underset{\text{Calcium Carbonate}}{2CaCO_3} + H_2SO_4 \longrightarrow \underset{\text{Calcium Sulphate}}{CaSO_4} + Ca(HCO_3)_2$$

Iron pyrite: When Iron pyrite is applied to alkaline soils the following reactions takes places.

$$FeS_2 + 3^1/_2O_2 + H_2O \rightleftharpoons FeO_4 + H_2SO_4$$

$$FeSO_4 + 2H_2O \rightleftharpoons H_2SO_4 + Fe\,(OH)_2$$

$$H_2SO_4 + CaCO_3 \rightleftharpoons CaSO_4 + H_2O + CO_2$$

$$CaSO_4 + {}^{Na}_{Na}[Clay \rightleftharpoons Ca[Clay + Na_2SO_4 \downarrow \text{ leachable}$$

Lime sulphur: When lime sulphur applied to soils the fallowing reactions takes places,

c) Use of Lime sulphur (by-pdt. of Sugar industry):

$$CaS_5 + 8O_2 + 4H_2O \rightleftharpoons \mathbf{CaSO_4} + 4H_2SO_4$$

$$CacO_3 + H_2SO_4 \rightleftharpoons CaSO_4 + CO_2 + H_2O$$

$$2Na\text{-}[soil] + \mathbf{CaSO_4} \rightleftharpoons Ca\text{-}[soil] + Na_2SO_4$$

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Table 1.The effects and rates of S-containing compounds in the amelioration of salinity stress on crops (Adapted from Bello et al. 2021).

S-Containing Compound	Optimal Application Rate	Crop	Impact on Soil and Crop Productivity	Reference
Elemental S	1120 kg S ha^{-1}	Sugarcane (Saccharum sp. var. CP87-3388)	Increased available soil P and S; Increased leaf area index	Wiedenfeld(2011)
Elemental S	500 kg S ha^{-1}	Pea (Pisumsativum L.)	Increased growth and yield; Increased uptake of N, P and K; Reduced leaf Na+ content	Osman and Rady (2015)
Agricultural sulfur (98% S)	600 kg S ha^{-1}	Rice (Oryza sativa L. cv. Sakha 106)	Decreased soil pH, EC and bulk density; Increased growth and yield	Zayed et al. (2015)
Gypsum	4 t ha^{-1}	Onion (Allium cepa L. cv. Adama red)	Decreased soil EC and ESP; increased exchangeable Ca2+ and onion yield	Kitila et al. (2020)
Gypsum	9.2 t ha^{-1}	Wheat (Triticumaestivum L. cv. Gemmeiza 11)	Increased grain yield and reduced soil and irrigation water salinity	Aboelsoud et al. (2020)

Gypsum and bio-organic amendment

Complementary Use of Gypsum and Bio-Organic Amendments in the Management of saline soils has been successful in many saline areas. Due to the great impact of beneficial microbes and organic materials in soil fertility improvement, their integration with gypsum application has the potential to have a remarkable effect on the amelioration of saline soils. The integrated application of gypsum with compost has been reported to produce the highest yield of onion in a saline-sodic soil by causing a reduction in EC, ESP, pH and SAR (Kitila et al. 2020; Bello et al., 2021).

The inoculation of beneficial microbes in conjunction with gypsum application has been demonstrated to improve the solubility of gypsum for higher efficiency in ameliorating saline soils (Sahin et al., 2011; Bello et al., 2021). It has been reported that the combination of gypsum with *Acidithiobacillusthiooxidans* and *Bradyrhizobium*spp inoculation improved the growth of cowpea by making more nutrients (P and K) available for uptake on a saline-sodicsoil (Stamford et al. 2015). Likewise, a saline-sodic soil ameliorated with gypsum in conjunction with two bacterial (Bacillus megaterium and Bacillus subtilis) and two fungal species (*Alternaria* spp. and *Aspergillus* spp.) was found to have improved soil saturated hydraulic conductivity, which causes easy water movement for plant use (Sahin et al., 2011; Bello et al., 2021).

Potassium and zinc fertilization in saline soils

Salt tolerance is directly associated with potassium contents because of its involvement in osmotic regulation and competition with Sodium. Plant salt tolerance requires not only adaptation to Na^+ toxicity but also the acquisition of abundant K^+ whose uptake by the plant cell is affected by high external Na^+ concentrations (Zhang et al., 2010). Zinc plays an important role in many biochemical functions within plants. Zinc has been shown to improve salinity tolerance in tomato (El-Sherif et al., 1990). Chemical amendments are found to be effective in the amelioration of saline soils. Removal of exchangeable Na necessitates application of K and Zn to remove Na from the soil's exchange sites. There are increasing evidences that application of K and Zn fertilizers reduce the adverse effects of salinity in a variety of crops including rice (Shahriaripour et al., 2010; Kamrani, 2013; Wakeel, 2013).

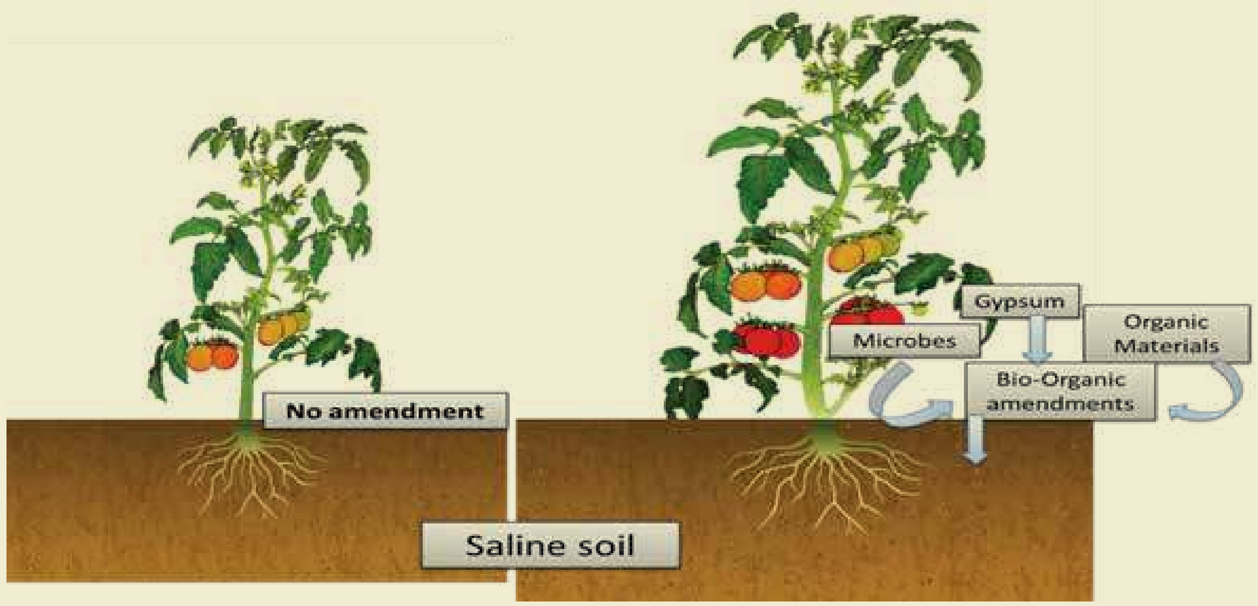

Fig.5.A conceptual diagram showing the potential influence of the integrated use of gypsum and bio-organic amendments on crop production (Adapted from Bello et al. 2021).

Organic amendment for saline soils

As saline soils are deficient of organic matter, organic amendment can be the best management and soil fertility improvement aspect of their management. Besides, organic amendment mitigates soil salinity and improves crop yield in salt affected soils. Walker and Bernal (2008) described the mechanism by which organic amendment helps to improve crop yield in salt affected soils. The application of poultry manure and compost to soil can increase both the CEC and the soluble and exchangeable-K^+, which is a competitor of Na^+ under saline-sodic conditions, thus, limiting the entry of Na^+ into the exchange complex. Dutta et al. (2015) reported that organic amendments (poultry manure, cowdung and green manure) helped to ameliorate salinity stress compared to those without organic amendments in rice. Ahmed et al. (2016) showed that varying levels of sulfur and gypsum significantly improved soil properties and rice-wheat yield than control.

Under saline condition, organic amendments had increased the growth of maize (Fig. 6 & 7). The physico-chemical properties were improved by the organic amendments (reducedsoil EC (from 10.6 dS m^{-1} to 3.4 dS m^{-1}) and pH (from 7.63 to 7.38) compared to control soil ($p \leq 0.05$). The root length was significantly higher in organic amendments treated soil (Khatun et al., 2019) that led to increased crop production.

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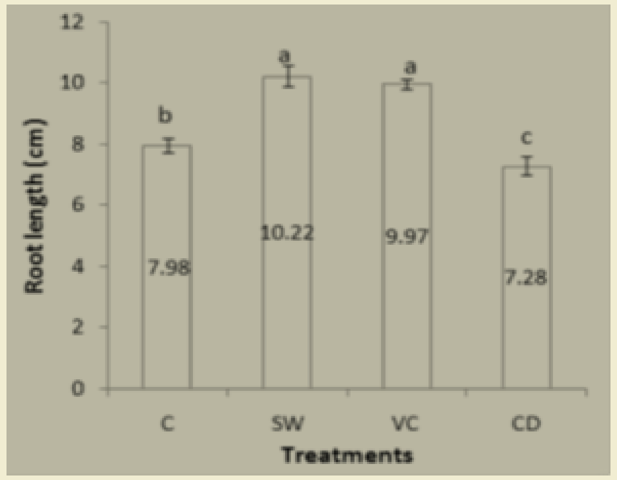

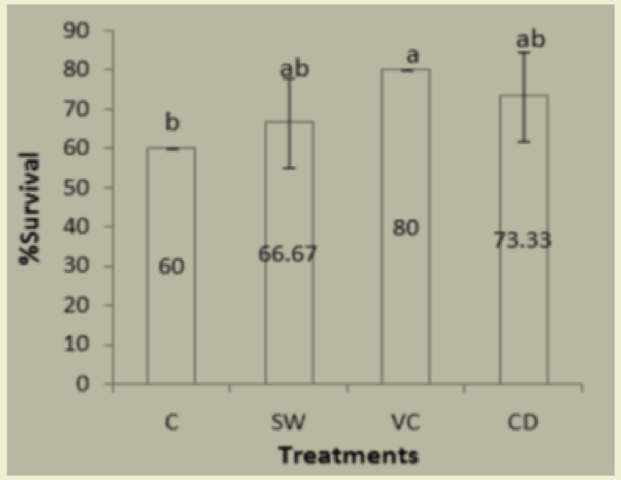

Fig.6. Effect of organic amendments mixed soil on root length (cm) of maize

Fig.7. Effect of organic amendments mixed soil on survival rate of maize

Soil salinity may affect not only plants but also the soil microorganisms responsible for nutrient cycling. It is known that soil salinity is a severe stress to the living components of ecosystems by increasing the osmotic pressure on cells and reducing water availability (Mitran et al., 2017). Soil salinity is a major threat to soil microorganisms, strongly altering soil organic matter turnover and nutrient recycling (Leogrande and Vitti, 2019).

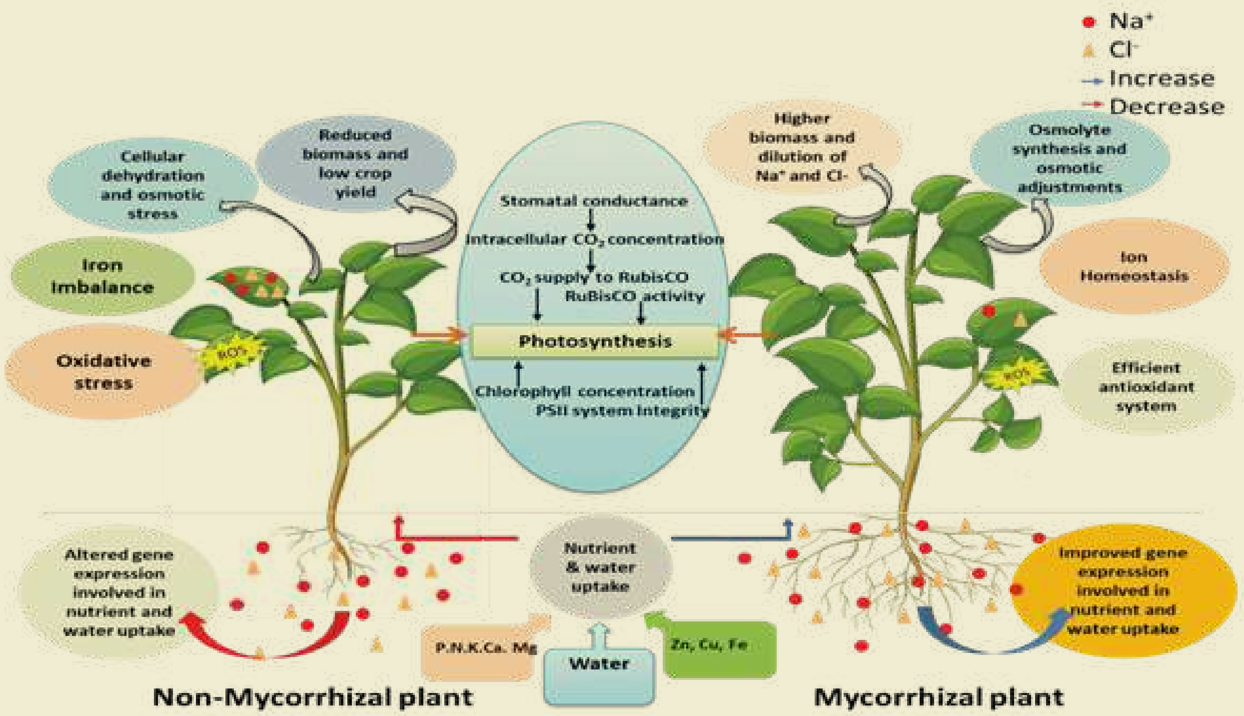

Fig.8. Differential response of non-mycorrhizal and mycorrhizal plants under salt stress. Accumulation of salt in soil creates competition for nutrient uptake and transport. This leads to imbalance of the ionic composition of plant, thereby affecting plant's physiological traits.

One method for decreasing negative salinity effects is the incorporation of organic materials into soil, due to their beneficial effects on soil physical, chemical, and biological properties (Iqbal et al., 2016). The positive biological effects are most likely caused by the positive effect of available carbon (C) derived from the added organic matter to microbial cells allowing their adjustment to osmotic stress by producing osmolytes, which counteract osmotic stress (Wichern et al., 2006). Moreover, crop residues are decomposed by soil microorganisms and thus contribute substantially to nutrient availability in the soil, especially, when external input is low. The decomposition of crop residues and organic amendments is largely determined by the presence of soil microorganisms and optimal conditions for their activity, such as temperature and sufficient oxygen for heterotrophs.

Arbuscular mycorrhizal fungi (AMF)increases the volume of soil explored by plant roots, upregulate several cation transporters, leading to improved nutrient uptake, and also maintains ionic homeostasis. Salinity lowers soil water potential causing cellular dehydration due to decrease in water uptake. Arbuscular mycorrhiza (AM) negates this effect by mediating accumulation of osmolytes and also improves plant's water status by improving root hydraulic conductivity. Salinity induces oxidative stress due to imbalance in ROS (reactive oxygen species) generation and the quenching activities of antioxidants. AMF are known to improve both enzymatic and non-enzymatic antioxidant systems of plants. Photosynthesis is also negatively affected by salinity. AM has a positive effect on photosynthesis under salt stress. Overall, AMF improve the performance of plant under salt stress (Evelin et al., 2019).

Many short-term experiments investigating the effect of elevated salinity on soil microorganisms have been carried out under aerobic conditions. Here plant residues were added as a means to provide available substrate to the soil microorganisms. The added substrates often resulted in alleviation of the negative effects of salinity, when providing easily available energy and nutrient sources for the soil microorganisms (Wichern et al., 2006). When substrates of lower availability to microorganisms were added, the effects of salinity remained more pronounced (Iqbal et al., 2016). Consequently, the question arises, if addition of organic amendments and crop residues are means to reduce the negative effects of soil salinity on the microbial driven mineralization processes in paddy rice soils, where conditions are temporarily anaerobic and thus potentially adding additional stress to part of the microbial community.

Conclusions

Soil salinity affects adverselyboth crop production and ecology of the area. The prevalence of salt at higher levels in the soil root zone undesirably affects crop production by creating imbalance in ions and toxicity in plants. Sustainable agricultural intensification requires increased crop yields and fertilizer application efficiency to ensure food security at country and global levels. As salinity has strong adverse effect in soil and the underlying processes of nutrient cycling, knowing details about nutrient management and dynamics of fertilizers in soil upon application is becoming very essential to ensure increased crop production and favourable ecology. Nutrient management for crop production in the saline soils requires reliable information. The use of integrated organic and inorganic fertilizers can only be more successful than methods aimed at improving the quality of soil or crop management or sustainable intensity in saline areas to improve the practice of existing local farmers. However, more research is needed to understand the dynamics of salinity and fertilizers applied for crop production to decide in time and to modify the management practices.

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Salinity in the South-West Coastal Regions and Its Sustainable Management Strategies for Agricultural Productivity at Farmer's Level: Perspective Bangladesh

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Abstract

The coastal area covers about 20% total area of Bangladesh and embodies above 30% of the total cultivable lands. The negative effects of climate change due to global warming on environment and agro ecosystem is a hazard to the coastal economy. The main reasons for soil salinity in coastal areas are the reduction of freshwater flow, natural calamities and shrimp culture, irrigation by ground water, decreased rainfall and increased temperature. The general, local and peat soil are the major obstacles to agricultural development in saline areas. The salinity tolerance mechanisms, viz. numerous metabolic changes in each plant part are regulated by a set of inherent multigene and prevalent environmental factors. The uptake of Ca2+ under saline conditions might be decreased due to precipitation and an increase in ionic strength that reduces its activity. As a result, integrated mitigation strategies or sustainable management techniques might be relevant to all land areas compared to a single technology that is not fruitful for the reduction of salinity. The south-west coastal region experiences more severe salinity level compared to other coastal regions of Bangladesh due to lower mean sea level (MSL) as well as intensive river-canal network and therefore, this region requires special management practices to enhance sustainable crop productivity and ensuring food security for over increasing population. Before setting up soil salinity adaptation strategy it is a crucial issue to investigate the existing resources (farmer income, freshwater availability and cost-benefit ratio), the purposes of retrieval and the reclamation plan established suiting the specific farmer needs.

Keywords: Coastal area, Farmer's Level, salinity mitigation, Salt stress, Water Quality

Introduction

The coastal area of Bangladesh covers about one-fifth of the country and represents more than 30 percent of the total cultivable lands of Bangladesh (Rasel et al. 2013). Livelihoods in this region are thus largely dependent on agricultural practices; however, dry season agricultural productivity in this region is low compared to the national average, which is considered to be one of the major reasons for high incidence of poverty (Lazar et al. 2015). Soil salinity is the dominant factor behind the low crop productivity, which is further compounded by inappropriate and/or faulty water control structures in some areas. A part of the coastal area, the Sundarbans, is a reserve natural mangrove forest covering about 4,500 km2. The remaining part of the coastal area is used in agriculture. A total of 1.05 million hectares of land out of 2.88 million hectares in the Khulna and Barisal divisions are affected by different degrees of soil salinity within the coastal and offshore lands (Karim et al., 1990; SRDI, 2010). According to the level of salinity, this area was categorized into four categories i.e. S1 (< 4 dSm^{-1}), S2 (4-8 dSm^{-1}), S3 (8-15 dSm^{-1}) and S4 (> 15 dSm^{-1}). Among these categories S1- S3 were used for rice cultivation in the wet season associated with high rainfall. On the other hand, brackish shrimp farming and salt cultivation were adopted in S4 (Islam

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et al., 2008a). The coastal and offshore area of Bangladesh includes tidal, estuaries and river floodplains in the south along the Bay of Bengal. Agricultural land use in these areas is very poor, which is roughly 50% ofthe country's average (Petersen and Shireen, 2001). The spatial pattern of soil salinity is similar to that of river water salinity and groundwater salinity. Large areas of land remain fallow in the dry season (January–May) because of soil salinity, lack of good quality irrigation water, and problems with water control (mostly drainage) (Mondal et al. 2006; SRDI 2010). The coverage of dry season irrigated Borocrop within the study area (29.3 percent) is much lower than the national average of around 63 percent. With poor dry season surface water resources, groundwater is the primary source of irrigation water in many areas. However, shallow aquifers in most of the south-west coastal region are affected by different levels of salinity due to seawater intrusion and interaction with saline surface water.

Climate change due to global warming and its negative consequence on environment and agro-ecosystem is a threat of the coastal economy. The Intergovernmental Panel on Climate Change (IPCC, 2007) predicts an increased frequency of heavy precipitation events, drought, intense tropical cyclones, sea level rise (SLR) and temperature. Most of these factors related to climate change are responsible for creating salinity in the coastal region. Salinity is the common phenomenon of any coastal region and Bangladesh coast is not free from such type of natural hazards. Saline and sodic soils have been recorded in a wide range of environments under many different hydrological and physiographic conditions. Such a wide distribution tells us that 'no single adaptation or mitigation option or technique will be applicable to all land areas'. However, diagnostic based recommendations work satisfactorily for a specific site or location. Prior to setting up soil reclamation plan it is essential to review the available resources (farmer budget, availability and quality of water) and the objectives of reclamation and the reclamation plan established suiting the specific farmer needs (Shabbir et. al., 2018). The exploitation of these soils for agriculture will require an integrated reclamation and management plan based on a comprehensive investigation of soil characteristics, including water monitoring (rainfall, irrigation and soil water-table), a survey of crops and local conditions, including climate, the economic, social, political, and cultural environment, as well as the existing farming systems. Fortunately, several approaches can be combined into an integrated system of soil reclamation and management (Shahid and Alshankiti 2013). First, one needs an integrated system of soil reclamation and management techniques, and these can generally be grouped into four adaptation or mitigation approaches to deal with salt-affected soils. The four approaches are: (i) Hydrological, (ii) Physical, (iii) Chemical, and (iv) Biological, though under unique environmental conditions salt-affected soils may be used for other purposes. The south-west coastal region experiences more severe salinity level compared to other coastal regions of Bangladesh and therefore, this region requires different adaptation policies for more crop productivity and ensuring food security. The objective of this study is to popularize the salinity perception and the salinity management strategy at farmer levels to produce more crops under the salinity intrusion state of coastal region of Bangladesh.

The causes of salinity in Bangladesh soils

The main reasons for soil salinity in coastal areas are-

a) The tidal wave results in continuous freezing of salt in the land or regular flooding of the land by salt water.

b) As the flow of fresh water decreases in the dry or winter season, salt-water intrusion increases to the rivers or channels which flooded the adjoining land or coastal areas.

c) Due to natural calamities like cyclones, storms, tidal surges etc. plain lands are flooded by salt water.

D) Salt water is used for shrimp farming causing of adjoining areas being salted

e) Use of ground water adjacent to shoreline for irrigation due to increase salinity

F) Another cause is decreased rainfall and increased temperature

The salinity of water from various sources in the south-western region

Surface water

In general, almost all the river/canal water in south-western part is extremely saline in dry season and not suitable for irrigation.

a) River and canal water

Most of the river's waters in the coastal districts have excessive salinity during the dry season. Excessive salinity is prevalent in Patharghata Canal, Baleshwar and rivers in Nazirpur upazila of Pirojpur district. The waters of Titikaka river in Mathbaria, Tetulia river in Patuakhali district, Pandobandi river and northern region river of Bhola district have moderate salinity in dry season which is suitable for irrigation. Excessive salinity is present in all river water in the southern part of Bhola district.

b) water in shrimp cultivation field, locally called 'Gher'.

Shrimp farms in the southwest have salinity levels of 10.0 to 35.0 dSm^{-1}. The highest level is in Koyra upazila of Khulna district and the lowest level is in Dumuria upazila. However, salinity of more than dSm^{-1} is present in the water of all Gher.

Groundwater

a) Shallow tube well water

The salinity levels from 0.39 to 19.0 dSm^{-1} were found after analyzing 28 saline and non-saline water samples from six districts of the coastal region. The highest salinity was found in Shyamnagar upazila of Satkhira district which is used for shrimp farming. Salinity was found below 2.0 dSm^{-1} in 83% of tube well and above 20.0 dSm-1 in 17% of tube well water.

b) Deep tube well water

In the south-western region, 24 water samples from saline and alkaline areas under 5 districts were examined and it was found that salinity level of 0.55 to 6.8 dSm^{-1} existed in that area. The highest salinity exists in Paikgachha upazila of Khulna district. About 50% of deep tubewell water contains <2.0 dSm^{-1} and 50% of deep tubewell water contains > 2.0 dSm^{-1}

Obstacles to agricultural development in saline areas

a) General obstacles

Due to the effect of soil salinity, some general and regional constraints are being observed in the south-west regions of Bangladesh. All these barriers are increasing with the increase of salinity. The following are some of the natural, climatic and social problems identified.

1. Salinity of soil and water
2. Naturally slow drainage
3. 1 m depth of soil has salinity all year round
4. Soil nutrient levels are low
5. The depth of water in the soil is higher at the time of transplanting seedlings in Kharif-2
6. Winter durability is short
7. Natural uncertainty
8. Adverse Barga custom and,
9. Inadequacy of communication system etc.

b) Local obstacles

Permanent water retention: Man-made environmental degradation such as water logging is affecting the environment and socio-economic conditions. At present, water accumulation in canals, poor management and development of infrastructure, lack of proper maintenance has led to long-standing water logging in some places which is hindering crop production. For example, 0.02 million hectares of land in Khulna and Jessore districts are affected by this situation. River bed siltation has caused localized water logging in Kobatak river in Keshabpur upazila of Jessore district.

c) Peat soil

The Pit Basin covers an area of 0.09 million hectares in the central and western coastal areas of southern Bangladesh. All these soils have low bearing capacity, are deeply inundated, drainage is delayed and highly acidic.

Criteria of salinity and theirs category

Soil containing excess soluble salts in the root zone to adversely affect the growth and yield of crop plants are called salt-affected soil. A saline soil contains sufficient soluble salts commonly are mixtures of Sodium chloride (table salt), Sodium sulphate, Calcium chloride, Calcium carbonate, Calcium bi-carbonate, Magnesium carbonate, Magnesium Sulphate and so on. In most of the saline soils and water the ionic preponderance decreased in the order of $Na^{+} > Ca^{2+} > Mg^{2+} > K^{+}$ and these are the dominant cations in different saline areas. However, SO4= and Cl- ions are the dominant anions and the ionic preponderance decreased in the order of $SO_4= > Cl^- > HCO_3$- (SRDI, 2010).Soluble CO_3= is found nil or trace in all the pedons. Sodium chloride salt is more toxic than sodium sulphate in most of the cases. Categories salinity into general ranges from non-saline to extremely saline. These values are used for plant selection for saline soil areas (Table 1). The amount and kind of salts determine the evaluation of water for irrigation. With poor water quality, various soil and water problems may arise (Table 2). Special management practices may then be necessary to maintains sustainable crop productivity. Salt concentration of water having ECe of 12 dSm^{-1} can be used for growing salt-tolerant and semi-tolerant crops in coarse-textured soils, provided the annual rainfall is not less than 400 mm. Nevertheless, in fine-textured soils, water with ECe of more than 2 dSm^{-1} often creates salinity problems (SRDI, 2010).

The important parameters that determine water quality are:

i) Total salt concentration: It is measured by the electrical conductivity (EC) of water, expressed as dSm^{-1}. The major cations in water include sodium, magnesium and calcium and the anions include of chloride, sulphate and bicarbonate. Other ions that may be present, but usually in low concentration are carbonate, nitrate, slica or boron.

ii) Sodium hazard: The sodium hazard is denoted by the residual sodium carbonate (RSC) and sodium adsorption ratio (SAR) of the water which are defined by the relation-

RSC= (carbonate+bicarbonate)-(calcium+ magnesium)

SAR= $(sodium)/(calcium+magnesium)/2)^{1/2}$

Where all the concentrations are me/l.

Table 1. Soil classes in relation to their salt concentration

Soil classes	Soil depth	
	0-60 cm(0-2ft)	60-120 cm (2-4 ft)
Non-saline	<2 ds/m	<4 ds/m
Slightly saline	2-4 ds/m	4-8 ds/m
Moderately saline	4-8 ds/m	8-16 ds/m
Very saline	8-16 ds/m	16-24 ds/m
Extremely saline	>16 ds/m	>24 ds/m

Source: FAO-UNESCO, 1973

Table 2. Water quality ratings

Water quality rating	ECw (dSm^{-1})	SAR ($mmolL^{-1}$)1/2	RSC (meL^{-1})
Good quality water	<2.0	<10	nil
Marginal quality water	2.0-4.0	<10	<2.5
Poor quality water	>4.0	<10	nil

Source: CSSRI, 1997.

Irrigation Water Quality and Monsoon Rainfall

Clarke et al. (2015) showed that the accumulation of salts on the agricultural land in the dry season is controlled by the amount and quality of irrigation water applied. An increase in the salinity of sources of dry season irrigation water will lead to increased salt accumulation in soils. Another key factor was the effectiveness of the monsoon rainfall in removing water by leaching/disposal through effective and well-maintained drainage systems. Their analysis showed that irrigating with water at up to four parts per thousand (ppt) can be sustainable, but if the dry season irrigation water quality goes above 5 ppt, the monsoon rainfall is unable to flush out the salt deposits. It was found that agricultural productivity in the Barisal, Patuakhali, and Bhola districts is likely to fall by 25 percent by 2050, with some regions expected to experience dry season crop yield reductions of 50 percent. Regions which are already experiencing severe salinity in Barisal and Khulna divisions are expected to see salinities of greater than 20 ppt by the end of the century, effectively curtailing dry season agriculture (Fig. 1).

Salt stress mechanisms prompt physiochemical changes in rice grain and quality

Salinity has robust effects on plant growth and production and is one of the major factors responsible for crop yield losses of the agricultural soils of the glove. The mechanisms of salinity tolerance in plants are regulated by a set of inherent multigene and prevalent environmental factors, which bring about numerous metabolic changes in each plant part. The stress-induced metabolic changes in the rice plant have been intensively studied, but extensively in plant parts such as stem, leaf, and root. Nevertheless, slight information exists in the literature about such stress-induced architectural and physiological changes in rice grain, a premier staple food of a large proportion of human population (Razzaq et al., 2020). The revelation of salinity-induced changes in rice grain structure would help to understand whether or not a nutritious and healthy staple food is available to human population from rice grown under saline environments. Adverse effects of salinity on plant growth include those of i. soil compactness and hardness upon which plants cannot establish an

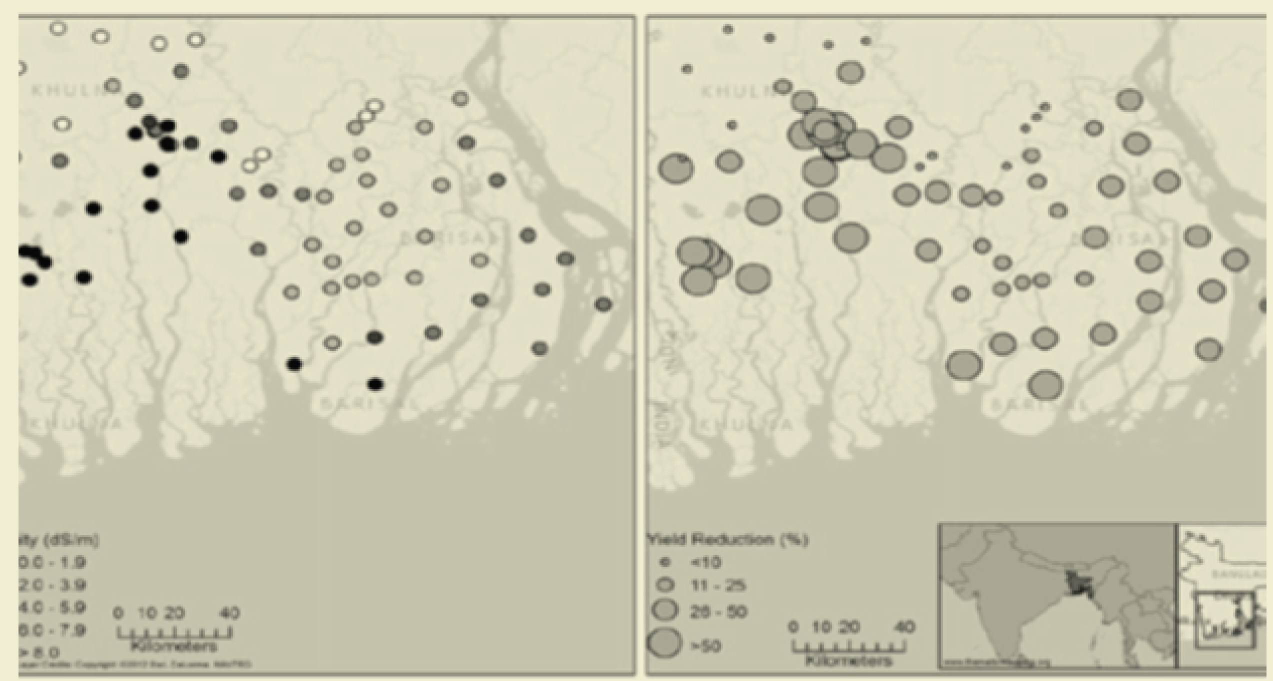

Fig. 1.Projections of future 2050 river water salinities (left) and simulated crop yield reduction due to increased irrigation water salinity (right) (Clarke et al., 2015)

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effective root system (Machado and Serralheiro, 2017), ii. Osmosis stress due to less water availability, iii. Nutritional deficiencies due to decreased uptake of nutrients including nitrogen, phosphorus, potassium, and calcium as salinity clogged the efficiency of transportation of them, and iv. Ion toxicity (Fig. 2). Genetic make-ups were supposed to be responsible for plant tolerances against salinity and a number of stress-tolerant genes are reported to be regulated by salinity stresses (Tuteja et al., 2012). Although different cereal crops differ in their potential to resist different stresses due to their genetic make-ups, their composition and quality are hampered to a great extent under salt stress environments (Flowers and Flowers, 2005).

The current state of soil salinity in coastal areas of Bangladesh and its Physiography

Tidal and estuarine floodplains cover almost 65% and 33%, while floodplains and peat basins are occupied only 2% of the coastal areas (Fig. 3). Tidal floodplains cover a total of 18,65,000 ha or about 65% of the coastal areas, which remain in Satkhira, Khulna, Bagerhat, Pirozpur, Jhalukhati, Barisal, Patuakhali, Chittagong, and Cox's Bazar district. Estuarine floodplains cover about 9,37,000 ha or about 33% of the coastal area and are found in Noakhali, Bhola, and Patuakhali districts as well as the north-western part of Chittagong district (Ahsan and Sattar, 2010). More than 30% of the cultivable land of the country is in the coastal areas. Approximately 0.326, 0.284, 0.179, 0.171 and 0.101 million hectares of coastal land are suffering from very lightly saline, light saline, medium saline, strongly saline and severe saline levels. Patuakhali, Barguna, Barisal, Jhalokati, Pirojpur, Jessore, Narail, Gopalganj and some new lands in the Madaripur district are being affected by different levels of salinity, which is severely depleting the agricultural production capacity. A comparative study on soil salinity has been formed in 1973 (Ahsan and Sattar, 2010). At that time, the amount of saline land in Bangladesh was 833.45 thousand hectares. In 2000, it stood at 1020.75 thousand hectares, and it was slightly increased 1056.28 thousand hectares in 2009. This means that the amount of saline land has been increased gradually from 1973 to 2009 by 222.61 thousand hectares or 26.7% and increased to 35.53 thousand hectares or 3.5% from 2000 to 2009 (Table 3).

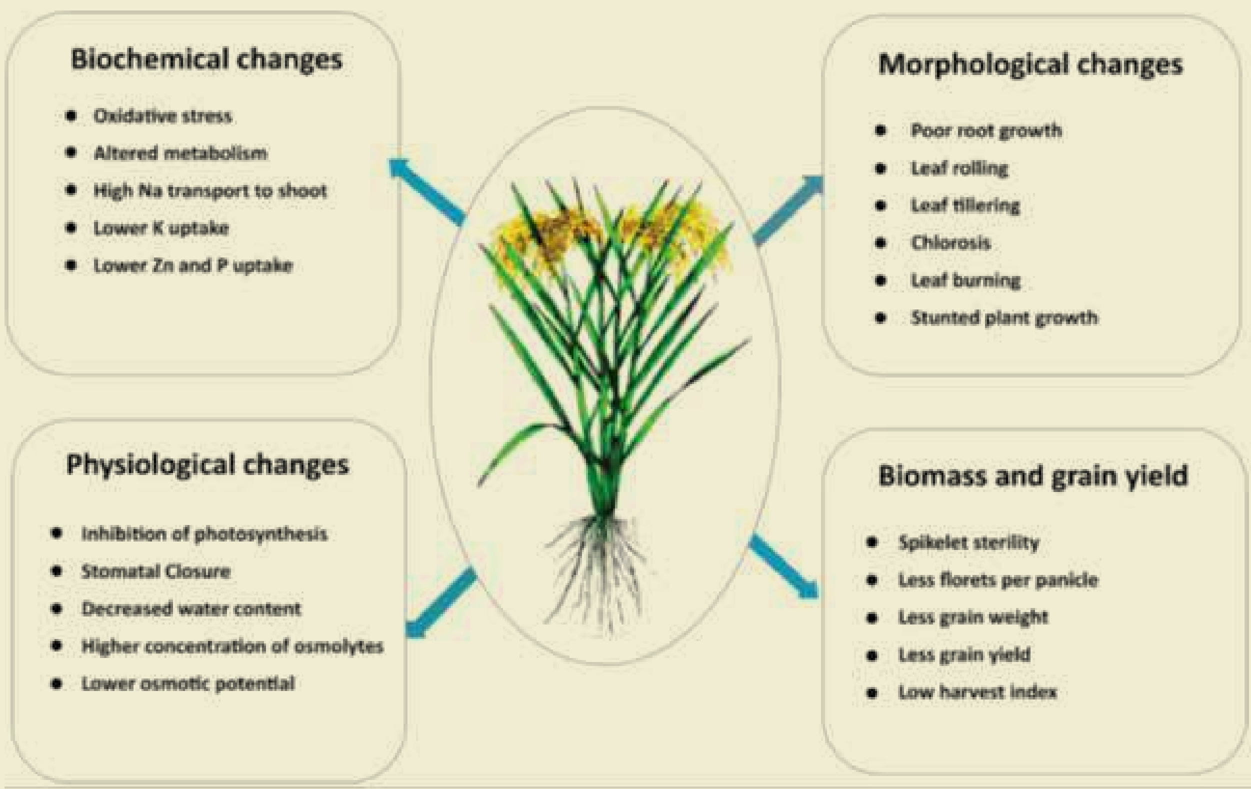

Fig. 2. Adverse effects of salt stress on plant growth.

Presently slight to strong soil salinity problems exist in 20 districts. The distribution of saline area is situated in four of the thirty AEZs of the country [The Ganges Tidal Floodplains (AEZ-13), The New Meghna Estuarine Floodplains (AEZ-18), The Chittagong Coastal Plains (AEZ-23), and The St. Coral Island (AEZ-24)]

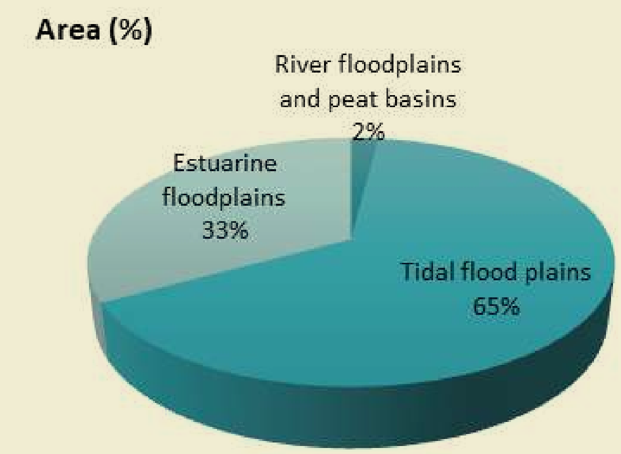

Fig. 3.Distribution of coastal areas of Bangladesh (Source: Ahsan and Sattar, 2010)

Table 3. Increase of soil salinity in coastal areas during 1973 to 2009

1973 (000,ha)	2000 (000,ha)	2009 (000,ha)	Salt affected area increased during last 9 years (2000-2009) (000'ha)	Salt affected area increased during last 36 years (1973-2009) (000'ha)
833.45	1020.75	1056.19	35.44 (3.5%)	222.74 (26.7%)

Source: Ahsan and Sattar (2010)

Fig. 4. Spatial variation of soil salinity in a field at Char Majid.

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Three characteristics of soil salinity are important for agriculture. These are intensity, spatial variations and annual cycle. Soil salinity begins to rise in February, reaches a maximum in March/April and declines with the start of monsoon rain in June/July. Salt tolerant rabi crops are successfully grown in the salinity level of up to 16 dSm^{-1}, provided adequate management practices are adopted. Only transplanted aman rice is grown beyond this salinity level. Considerable variation in the levels of soil salinity can be observed within a distance of a meter or two in a single crop field (Fig. 4) (Sattar and Mutsaers, 2004).

Nutrient management for salinity mitigation:

Calcium (Ca)

A recent review (Cramer, 2002) summarized Na^{+}/Ca^{2+} interactions under salinity stress from a physiological perspective. Because Na^{+} readily displaces Ca2+from its extracellular binding sites, Ca2+availability could be seriously reduced under salinity, especially at low Ca^{2+}: Na^{+} ratios (Crameret al., 1988). Furthermore, the uptake of Ca2+ under saline conditions might be decreased due to precipitation and an increase in ionic strength that reduces its activity. The low Ca^{2+}: Na^{+} ratio in saline media plays a significant role in inhibiting plant growth as well as causing significant changes in morphology and anatomy (Cramer, 1992).Calcium has a very prominent role in the maintenance of cell structure. It activates the plasma membrane enzyme ATPase which pumps back the nutrients lost during cell membrane damage due to Ca deficiency recovers the plant from injury.

Nitrogen (N)

Salinity and N interaction studies were conducted on N-deficient soils (Grieve et al., 2012). Therefore, when the degree of salinity was not severe, the addition of N improved growth and/or yield for cowpea, tomato, clover, and millet and wheat (Soliman *et al.,* 1994). A study on the interactive effect of macronutrients (N, P, K^{+}, Ca^{2+}, Mg^{2+}, and S) and salinity on the growth of hydroponically-grown wheat by Hu et al. (1997) showed that, for a given salinity level, increases in nutrient supply improved plant growth in the deficient treatment only, and not in those treatments with optimal nutrient supply.

Soil salinity management strategies in coastal areas at farmer's level

- Use of salt-tolerant high-yielding crops and varieties. Cultivation of salinity tolerant varieties viz, Dhaincha, Sesame, etc. as a cover crop during aman-fallen cropping pattern will reduce the white layer of salt on the soil due to evaporation in the dry season, which greatly reduces the salinity loss in the subsequent crops.
- During the high tide of the new moon and full moon, the dam should be built 2-3 meters higher than the water level. If a sluice gate is installed at a certain distance from the dam, along with the drainage facility, the salt that accumulates on the land in the month of March-April (Falgun-Chaitra) can be used for washing the land at the beginning of the monsoon season.
- Canals, dead rivers (inside dams), ponds, natural reservoirs can store rainwater during the monsoon season, which can be used for irrigation purposes to cultivate rabi crops in the dry season.
- Drought salinity can be tackled by making high (25-30 cm) strong Isles from the ground to store rainwater.
- During the Rabi season, those soils content salinity levels in-between 2.0-4.0 dS/m, salinity tolerant paddy, and other crops can be cultivated through proper soil and water management.
- When the land is not even or low and high, most of the high lands are salted owing to the capillary rise, and the existing crop dies. For avoiding the capillary rise, water should be kept in the soil at all times so that the crop does not die due to salt. In the case of boro-rice cultivation, the land should be leveled well with a ladder, so that irrigation water can be applied evenly in whole lands.
- Tilling fallow land during the summer season, big cracks will not be able to create; as a result, falling salted crust will stop on the soil through evaporation.
- Soil salinity can be reduced by applying gypsum and potash fertilizers.
- Surface soil salinity can be reduced by providing sub-surface drainage (15-30 m intervals 1.75 m deep). In this case, salt-water leaks and collects into the drain resulting in the top-soil being free from salinity, and all kinds of crops can be cultivated. This method is reasonably effective but initially expensive.
- In Bagerhat, Satkhira, and Khulna regions, salt-tolerant rice varieties like BRRI Dhan 40, 41, 47, 51, 52, 53, 54, 55, and 61 can cultivate in high and medium high land as transplanted aman. Due to waterlogging in low-lying areas, long seedlings are required for transplanting. In seedling conditions rapidly growing and waterlogging tolerant rice variety (BRRI Dhan 44) and improved rice varieties such as Shada-mota, Kalo-mota, Patnai etc. with mixed fish farming is very profitable (Shiragi and Hossain, 2013).

Cultural management approaches

- **Sowing/planting time:** Sowing boro rice seeds in between November and avoiding crop loss due to high salinity levels in April-May, young seedlings should be transplanted in December. In the same way, sowing/planting work should be completed by November in order to get a good yield in winter rabi crops cultivation (Shiragi and Hossain, 2013).
- **Storing of excess rain water for irrigation:** A part of the excess water stored in pond after meeting the requirement of the kharif season can be utilized during dry period for rabi crops.
- **Mulching:** In Rabi and Kharif-1 seasons, tomato, potato, sweet pumpkin, watermelon, onion, garlic, turmeric, pepper, etc. cultivation reduces the evaporation due to mulching and prevents capillary rising of salt to the surface. As a result, salinity hazardous can decrease in saline areas through effective mulching.
- **Soil flashing:** In boro rice cultivation, salinity in rice fields usually increases due to the evaporation of irrigation water, which damages the stalks of rice husks and milking stage. In this case, the damage can be reduced to a great extent by washing occasionally.
- showed their research four-time soil washing also reduced salinity from 4.68 dSm-1 to 0.49 dSm^{-1}
- **Fertilizer management:** The recommended dose of fertilizer depends on the type of crop, the inherent fertility of the land, etc. Therefore, after soil testing applying recommended dose of fertilizer better yield is obtained.
- **Seed sowing by dibbing method:** In Kharif-1, high yielding aus rice should be cultivated by the dibbling method in saline areas. In this case, seeds should be sown between rows 3-4 cm deep without sowing seed directly on the land.
- **Raise and slopping bed:** In this method, a variety of vegetable and spice crops can be planted throughout the year by preparing the bed 1 m wide, 10-15 cm high and the distance between two beds 50 cm especially in saline areas. The soil in between two beds should be set in conjunction with two beds next to it. After seedlings or seed sowing, beds should be thickly covered with mulch using straws (Shiragi and Hossain, 2013).
- **Introduction of "Sharjan technique":** GenerallySharjan technique is practiced in south and south-west of the saline areas of Bangladesh. This facilitates to grow different crops on beds and accumulated water in the furrows during monsoon can be utilized to irrigate the bed crop during winter's months.
- **Pit method:** In the south-western part of the country, Watermelon, pumpkin, cucumber and bitter gourd etc. are being cultivated in the pit. Initially, all the land has to be plowed well, then making pit at a certain distance 30-50 cm radius, 15 days before sowing the seedlings or seeds all the organic and inorganic fertilizers are mixed well with soil 2-3 times after 4-5 days intervals. Finally, all the land should be mulched with hay or straw.
- **Organic amendment application:** For getting optimum yield, organic amendment such as dhayncha, cow-dung, ash, well-decomposed waste and crop residues, etc. is applied in the paddy field at the rate of 5 ton ha^{-1} or chicken manure 1.5 ton ha-1 in thesaline zones.
- **Drip irrigation with mulch or manual irrigation:** ICBA-BARI collaborative project suggested that drip irrigation in raised bed with mulch or manual pump irrigation in raised bed

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with mulch are both effective for saline soil (<12 dS^{-1}) management to cultivate horticultural crops like tomato, watermelon, chili cucumber etc. due to these improved management techniques help reduce soil salinity from 10-12 dS^{-1} to within the limit of crop tolerable limits of 4.5-5.5 dSm^{-1} for economically viable production of high value horticultural crops.

- **Splitting of Fertilizer Application:** Different crops have different salt tolerance levels. When salinity level exceeds the salt tolerance of the crop, yield is affected and begins to decrease. Therefore, split fertilizer applications help to avoid salt damages to the crop and improves germination rate. Applying smaller amounts of fertilizers at shorter intervals reduce salt stress.
- **Following proper cropping pattern:** Where there is availability of suitable water for crop production, crop intensity can be increased by selecting salt-tolerant crop varieties.
- **Pitcher Irrigation method:** One technology developed by Salinity Management and Research Center (SMRC) for pit (madha) crops viz. pumpkin, watermelon, cucumber, bitter gourd etc., it is called 'Pitcher Irrigation Technology'. The amount of salinity around the pit is possible to reduce from 2.0 to 2.5 dSm^{-1} through this irrigation system. Research has been conducted by SMRC in the dry season that shown irrigation by the conventional method in pit where the salinity is found between 8.0 to 12.0 dSm^{-1}. Nevertheless, irrigation by the pitcher method where the salinity can be kept within 5.5 to 6.5 dSm-1 and it is possible to cultivate pit crops with this level of salinity (Fig. 5a).
- **Flying bed method:** It is a modern technology through which it is possible to cultivate vegetables in saline environment throughout the year for getting satisfactory yield. In this method, large plastic drums are cut and the drums are filled by mixing a certain amount of organic matter and soil. In this case, a few holes are made in the bottom of the drum. Then some amount of gravel or stone (khoya) is given under the cut drum. Studies have shown that a mixture of 60% dung or organic matter and 40% soil improves plant growth and yields (Fig. 5b).

Fig. 5. Technology developed by Salinity Management and Research Center a) Pitcher Irrigation method (left) and b) Flying bed method (right)

Conclusions

Due to global warming climate is changing rapidly and showing adverse effects on the environment as well as agro-ecosystems, threatening food security, agricultural production, fisheries, human health, biodiversity, water and other natural resources. Increasing flood density, changing rainfall patterns because of droughts and soil salinity are intensifying. Due to soil salinity, lack of quality irrigation water, and late recession of rainwater, most of the land is fallow during the dry season (January-May). Crop production has become risky, causing an increase in water salinity level and intrusion of saline water in some areas. In these areas crop yield, cropping intensity, production level and living standard of people are different from other parts of the country. Combined adaptation or mitigation opportunity or technique will be applicable to all land areas, but any single technology is not fruitful for sustainable soil management. Before setting up soil salinity mitigation plan it is essential to analysis the available resources (farmer economical status, availability and irrigation water quality), the purposes of recovery and the reclamation plan established suiting the specific farmer needs.

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"লবণাক্ততা ব্যবস্থাপনার মাধ্যমে ফসলের ফলন বৃদ্ধি
একটি সহনশীল ও কার্যকরী মৃত্তিকা ব্যবস্থাপনা পদ্ধতি"

Effects of different fertilizer sources and varieties on rice production in south-western coastal region of Bangladesh

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Abstract

Two field experiments were conducted including two varieties of Boro rice [(BRRI dhan67 (salinity tolerant) and BRRI dhan88 (farmers' choice)] in south-western coastal region of Bangladesh, i.e.Satkhira sadar and Kaliganj upazilla of Satkhira (AEZ 13) during the Boro 2019-2020 season with an objective to develop suitable integrated nutrient management package utilizing local resources, which could help sustaining rice production with maintaining soil fertility. Six treatment combinations laid out in a split plot design, distributing the variety to the main plots and treatments to the sub-plots with 3 replications were tested in both sites: T_1= Farmers' practice, T_2= Urea Deep Placement (UDP) + PKSZn (S from Gypsum), T_3= OCP fertilizer (NPSZn) + Straight fertilizer (remaining S from Gypsum), T_4= NPKSZn [Gypsum as sources of S 100%], T_5= Ash @ 3 t/ha + 100 % NPKSZn fertilizer and T_6= Ash: Manure (1:1 ratio) @ 5 t/ha at + 70 % NPKS fertilizer + 100% Zn. Application of organic amendment either ash or ash with manure might be a good option for salinity management, total nutrient uptake along with higher rice yield in south-western coastal region of Bangladesh.

Introduction

In Bangladesh, about 0.83 million ha of arable land, scattered over 64 *upazillas* in13 coastal districts, are affected by varying degrees of salinity. But, more than 50% land belongs to moderate salinity level (4-8 dS/m), where yields of many crops are restricted (Karim et al, 1990). However, saline belt faces twin problems-lack of quality water for irrigating crops and plant nutrient hunger or toxicities due to ion imbalance. The scarcity of good quality irrigation water in these lands is incapable of supporting double rice crops. Consequently, the organic matter turnover is also very low.

In moderate conditions when salinity is not lethal, nutritional imbalance may be come as a major growth limiting factor for higher production of rice. Occurrence of high Na+Mg saturation of the exchange complex relative to Ca and K in most of the saline soils hinders plant nutrition since Mg has both synergistic effect on plant uptake of Na and antagonistic effect on that of Ca and K. Increasing the amount of K supply in relation to Na and Ca improved salt tolerance of some plants (Sutcliffe, 1962). In contrast, Lal and Singh (1973) reported that the response of fertilization decreased as the level of EC and sodium adsorption ratio (SAR) of water increased. Developing the concept of "balance ionic environment" good crops can possibly be grown in saline situation if favorable environment of Na: K is maintained around root zone by adding K in Na-saturated soil conditions. Thus, the productive potential of a particular crop can be better achieved if the nutrients essential for the physiological and metabolic activities of the plant are made available to them through application of fertilizers or combination of organic and inorganic fertilizers in proper forms and with required amount.

The coastal soils are also poor in organic matter content, ranging 1.0-1.5%, which reveals the poor fertility of these soils (Karim et al, 1990). Addition of organic materials in saline soils should receive priority in managing soil salinity as well as managing soil fertility. However, in saline soil fertilizer showed better response in the presence of FYM. The concept underlying integrated use of organic and inorganic fertilizers is to reduce the inorganic fertilizer requirement to restore organic matter in soil and to maintain soil quality in terms of physical, chemical and biological properties. In this context, an experiment was conducted under two locations of saline coastal soils at Satkhira district in dry season with an objective to develop suitable integrated nutrient management package utilizing local resources, which could help sustaining rice production with maintaining soil fertility.

Materials and Methods

Two field experiments were conducted including two varieties of Boro rice [(BRRI dhan67 (salinity tolerant) and BRRI dhan88 (farmers' choice)] in south-western coastal region of Bangladesh, i.e.Satkhirasadar and Kaliganj upazilla of Satkhira. Six treatment were tested in various combinations: UDP, customized fertilizers, gypsum and organic amendments (ash and cowdung) presented in Table 1. The experiment was laid out in a split plot design, distributing the variety to the main plots and treatments to the sub-plots, with 3 replications. Initial soil properties of both locations are presented in Table 2. Nutrients viz. N, P, K, S & Zn were used at a soil test based recommended rate to all plots as per BARC Fertilizer Recommendation Guide (FRG-2012) and the rates were 120 kg N/ha, 28 kg P/ha, 100 kg K/ha, 18 kg S/ha and 2.6 kg Zn/ha, respectively. Soil amendment (cowdung& ash) were applied 3 days' prier of transplanting. Urea briquettes (UB) were placed at a depth of 10 cm at the center of 4 rice hills 10 days after transplanting (DAT). PU was applied in three equal splits at 7, 35 and 55 DAT, respectively.

Intercultural operations were done as and when required. Weeding was done thrice over the season to keep the plots free from weeds and it was done two days ahead of urea top dressing. Plant protection measures viz. insecticide and fungicide spray were done to keep the crop free from any insect and pathogen attack. The details of operations made during the study are presented in Table 3. The crop was harvested at full maturity of the crops. After harvest, plot-wise crop was bundled separately and was brought to the threshing floor; threshing was done manually. The rice grains were cleaned and weighed. Then, sundry weight of grain was recorded for every plot and the weight in kg $plot^{-1}$ was adjusted at 14% moisture and finally expressed in t ha^{-1}. The sundry weight of straw was also recorded plot-wise and expressed as t ha^{-1}.

Table 1. Treatment Description for Saline Soil Management Trial for Boro 2019-20

Treat	Description
T1	Farmers' practices (FP)
T2*	UDP + PKSZn (S from Gypsum)
T3*	OCP fertilizer (NPSZn) + Straight fertilizer (remaining S from Gypsum)
T4*	NPKSZn [Gypsum as sources of S 100%]
T5*	Ash @ 3 t/ha + 100 % NPKSZn fertilizer
T6*	Ash: Manure (1:1 ratio) @ 2.5 t/ha + 70 % NPKS fertilizer + 100% Zn

**Soil test-based application of N, P, K, S & Zn fertilizers.*

Table 2. Initial soil characteristics of the experimental plots at BRRI farm, Satkhira and Kaliganj, Satkhira

Parameters	BRRI Farm, Satkhira	Farmer's Field, Kaliganj
Texture	Silty loam	Silty loam
EC (1:5)	0.02	0.97
pH (1:2.5)	8.09	8.17
Organic C (%)	1.35	1.40
Total N (%)	0.12	0.13
Available P (mg/kg)	12	14
Available S (mg/kg)	25	30
Available Zn (mg/kg)	0.8	0.9
Na (Cmol/kg)	0.8	1.26
K (Cmol/kg)	0.19	0.20
Ca (Cmol/kg)	2.85	3.20
Mg (Cmol/kg)	2.22	3.0

Table 3. The details of field operation carried out during the period of experimentation

Operations	Shatkhira	Kaligang
First ploughing date	05-Jan-2020	12-Jan-2020
Final ploughing date	16-Jan-2020	27-01-2020
Date of Layout making & Fertilization	17-Jan-2020	27-01-2020
Date of Basal Fertilization	17-Jan-2020	27-Jan-2020
Date of Transplanting	18-Jan-2020	28-Jan-2020
First top dressing	29-Jan-2020	6-Feb-2020
Second top dressing	22-Feb-2020	20-Feb-2020
Third top dressing	10-Mar-2020	11-Mar-2020
Gap feeling	28-Jan-2020	08-02-2020
First weeding	29-Jan-2020	6-Feb-2020
Second weeding	22-Feb-2020	20-Feb-2020
Third weeding	10-Mar-2020	11-Mar-2020
Irrigation & Insecticide application	When required	
Harvesting		
BRRI dhan88	19-Apr-2020	17-Apr-2020
BRRI dhan67	21-Apr-2020	20-Apr-2020

Results and discussion

Effects of fertilizer

Fertilizer treatments had significant effects on tiller m^{-2}, $panicle^{-2}$, grain $panicle^{-1}$, filled & unfilled grain $panicle^{-1}$, grain & straw yield and total nitrogen uptake (TNU), except thousand grain weight (TGW) in BRRI farm, Satkhira and Kaliganj (Table 4-5). In BRRI farm, Satkhira, across the variety, Ash and Manure (1:1) @ 5 t ha^{-1} +70% NPKSZn (T6) significantly increased rice grain yield compared to FP and recommended fertilizer (Table 4). Increased grain yield with ash and

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manure (1:1) @ 5 t ha^{-1} +70% NPKSZn might be associated with an increased number of effective tillers, grain per panicle and filled grain per panicle. Similarly, TNU was statistically higher in ash and manure (1:1) @ 5 t ha^{-1} +70% NPKSZn, ash 3 (t ha^{-1}) + 100% NPKSZn and UDP (T_2) treatment than that of FP and recommended fertilizer (T_4). Higher TNU increment under ash and manure (1:1) @ 5 t ha^{-1} +70% NPKSZn, Ash 3 (t ha^{-1}) + 100% NPKSZn and UDP treatment was due to higher grain and straw yield (Table 4). However, deep placement of urea and Ash 3 (t ha^{-1}) + 100% NPKSZn gave statistically similar yield with ash and manure (1:1) @ 5 t ha^{-1} +70% NPKSZn in BRRI farm, Satkhira (Table 4).

In Kaliganj site, across the variety, ash and manure (1:1) @ 5 t ha^{-1} +70% NPKSZn gave higher yield than those of farmers' practice, OCP fertilizer and recommended fertilizer (Table 5). The larger yield increment was observed in ash and manure (1:1) @ 5 t ha^{-1} +70% NPKSZn treatment, because of higher number of effective tillers, grain per panicle and filled grain per panicle (Table 5). Similarly, ash and manure (1:1) @ 5 t ha^{-1} +70% NPKSZn gave higher TNU than those of FP and recommended fertilizer. However, except the FP and recommended fertilizer (T_4), no significant variation of TNU was observed in all other treatments (Table 5). Higher TNU might be associated with higher grain and straw yield.

Table 4. Effects of fertilizers sources and varieties on yield & yield contributing traits and total N uptake (TNU) in BRRI farm, Satkhira during Boro season 2020

Treatments	Variety	Tiller m^{-2}	Panicle m^{-2}	Grain $panicle^{-1}$	Filled grain $panicle^{-1}$	Unfilled grain $panicle^{-1}$	TGW (g)	Grain yield (tha^{-1})	Straw yield (tha^{-1})	TNU (kg ha^{-1})
T_1	Mean	300b	280b	143b	117b	26b	21.5a	5.23c	5.18b	63.3c
T_2		333ab	320ab	153ab	121ab	32ab	21.0a	5.91ab	6.00a	101.9a
T_3		321ab	310ab	153ab	123ab	30ab	20.7a	5.74b	5.66ab	93.8ab
T_4		303ab	291b	147ab	115b	32ab	20.9a	5.45bc	5.30ab	86.1b
T_5		323ab	313ab	151ab	116b	35a	21.4a	5.95ab	5.75ab	99.2a
T_6		350a	338a	158a	127a	31ab	20.9a	6.34a	6.06a	100.4a
Mean	BRRI dhan67	329a	314a	157a	135a	23b	21.6a	6.07a	6.09a	96.5a
	BRRI dhan88	314a	303a	144a	104b	40a	20.5b	5.47a	5.22b	85.0a
ANOVA (p value)										
Fertilizer (F)		0.0333	0.0050	0.0167	0.0020	0.0268	0.3841	0.0000	0.0114	0.0000
Variety (V)		0.3676	0.3144	0.0668	0.0023	0.0167	0.0322	0.1175	0.0263	0.1522
F × V		0.9527	0.9225	0.8579	0.0046	0.0001	0.3854	0.3411	0.3411	0.3736

Within a column, means followed by same letters are not significantly different at 5% level of probability by Tukeys's honest significant difference (HSD) test.

Effects of variety

The effects of variety on grain $panicle^{-1}$, filled and unfilled grain $panicle^{-1}$, TGW and straw yield was significant in BRRI farm, Satkhira (Table 4), while it had significant effect on TNU and all yield contributing characters, except the tiller production per square meter in Kaliganj site (Table 5). In Satkhira site, no significant variation of grain yield and TNU was observed between BRRI dhan88 and salinity tolerant variety BRRI dhan67. This result indicates that both varieties are suitable in BRRI farm, Satkhira due to less salinity in this site (Table 4). On the other hand, salinity tolerant variety BRRI dhan67 showed significantly higher yield and TNU compared to BRRI dhan88 in Kaliganj site. The larger yield increment of BRRI dhan67 was associated with its salinity tolerant capacity in saline prone area of Kaliganj, Satkhira (Table 5).

Table 5. Effects of fertilizers sources and varieties on yield & yield contributing traits and total N uptake (TNU) in Kaliganj, Satkhira during Boro season 2020

Fertilizer	Variety	Tiller m^{-2}	Panicle m^{-2}	Grain $panicle^{-1}$	Filled grain $panicle^{-1}$	Unfilled grain $panicle^{-1}$	TGW (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	TNU (kg ha^{-1})
T_1	Mean	295b	278c	137b	114ab	23b	21.2a	4.28c	4.29b	50.5c
T_2		318ab	302abc	147ab	118ab	28ab	20.9a	4.78ab	4.88ab	81.5ab
T_3		313ab	286bc	146ab	120ab	27ab	20.7a	4.69bc	4.67ab	76.1ab
T_4		323ab	296abc	140b	111b	29ab	20.8a	4.56bc	4.71ab	72.9b
T_5		328a	304ab	144ab	112b	32a	21.3a	4.89ab	4.88ab	81.4ab
T_6		338a	315a	152a	123a	29ab	20.8a	5.17a	5.06a	82.2a
Mean	BRRI dhan67	324a	306a	152a	131a	21b	21.5a	5.64a	5.49a	87.8a
	BRRI dhan88	314a	288b	137b	102b	35a	20.4b	3.82b	4.02b	60.4b
ANOVA (p value)										
Fertilizer (F)		0.0030	0.0019	0.0117	0.0025	0.0241	0.6192	0.0020	0.0231	0.0000
Variety (V)		0.0862	0.0422	0.0351	0.0053	0.0165	0.0409	0.0003	0.0009	0.0095
F × V		0.9341	0.9765	0.8820	0.0216	0.0005	0.3805	0.5990	0.4150	0.5421

Within a column, means followed by same letters are not significantly different at 5% level of probability by Tukeys's honest significant difference (HSD) test.

Conclusion

Application of organic amendment either ash or ash with manure might be a good option for salinity management, total nutrient uptake along with higher rice yield in south-western coastal region of Bangladesh.

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HALT SALINITY, BOOST SOIL PRODUCTION

Sustainable Land Management concept could be an approach align with the theme

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The IUSS has declared WSD-2021 theme as "Halt soil salinization, Boost soil productivity". Halting soil salinization as such is utopique, however, abating or containing the aggression of soil salinization is rather a feasible action one may undertake. Boosting productivity in the salt affected soils has to be achieved not only by halting salinization process but by adopting in a broader scale to the situation as well.

The salinization of Bangladesh soils is coastal region.Of the 2.85 million hectares of coastal area of Bangladesh about 0.833 million hectares of land was recognized as saline soils (Karim *et. al,* 1990). Three major Agro-ecological regions cover the coastal region. They are the Ganges Tidal Floodplain (AEZ-13, 17,066 sq.km), Young Meghna Estuarine Floodplain (AEZ-18, 9,269 sq km) and Chittagong Coastal plain (AEZ-23, 3,720 sq km).The salinity problem did not receive enough attention in the past, but now much emphasis has been given on this issue.In the 1960s and 1970s 139 polders were erected in coastal regions (CGAIR, 2015) to protect farmers from saline water intrusion and tidal floods. Those are not effective in many areas as anticipated due to lack of maintenance, non-functional sluice gates, regular breaching anda resultant effect of the present global climate change. In the recent past observations, it is noted that due to increasing degree of salinity of some areas and expansion of salt affected area as a cause of further intrusion of saline water, normal crop production has become more restricted causing an enhancement of shrimp and salt production area. In general, soil salinity is believed to be increasing with time and space. The saline area in the country is now estimated to be 1.12 million hectares out of the 1.459 million hectares of cultivated land. Thesalinity is seasonal and varies in place to place due to variation in the fluctuation of ground water. The extent of salinity increases with dryness and falls with the advent of the rainy season. The salinity starts augmenting from the end of November and attains its peak during the months of May-June and then it starts declining. The dominant crop grown in the saline areas is local transplanted Aman rice crop with low yields. The factors involve in the salinization are land relief, degree of flooding, the nature of the soil, precipitation, tidal action, the effect of the river system and their discharges, depth of the groundwater table and salt deposits, the slope of the ground and the proximity to drainage channels (Huq and Shoaib, 2013).Soil reaction values (pH) in coastal regions range from 6.0-8.4. The organic matter content of the soils is also pretty low (1.0-1.5%). Nutrient deficiencies of N and P are quite dominant in saline soils. Micro-nutrients, such as Cu and Zn are widespread. During the monsoon the severity of salt injury is reduced due to dilution of the salt in the root-zone of the standing crop. It was strongly and reasonably felt that mapping of the coastal salinity in a smaller scale using of remote sensing (RS) and GIS tools to characterize and monitor coastal soil resources. In the coastal regions of Bangladesh. It has become imperative to explore the possibilities of increasing the production potential of these (saline) lands for a sustainable future.

One of the strategies or approaches to better use of the salt affected soils could be adoption of Sustainable Land Management (SLM) best practices. It has a central role to minimize land degradation due to salinization by generating multiple co-benefits including climate change mitigation, resilience, improved biodiversity and enhanced production. SLM directly supports to halt/avoid, reduce or reverse salinization process and contribute to restore ecosystem services. It also creates space for investment. Coastal zone management is essential for implementing sustainable development strategy in Bangladesh. Any approach taken thereof, must have interlink with that at the national level, sub-national level and local community level. This is likely to ensure safety, security and sustainability for the coastal communities.

Sustainable Land Management (SLM) best practices could be the best option in abating salinity to boost production in the Coastal regions of Bangladesh:

The definition of 'sustainable development' encompasses a diverse array. The diversity reflects the complexity of relationships involved in defining processes. Environmental characteristics, market forces, social ambitions, development objectives and conservation aims are but some of the examples of the forces and factors that interact to determine sustainability. Definitions of sustainable management therefore, differ because witnesses place differing importance on these various factors.In context of Sub-Sahara, SLM has been defined as "the adoption of land-use systems that through appropriate management practices enable land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources" (Anne Woodfine, 2009). United Nations in 1992 Rio Earth Summit defined SLM as "the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions"(Sanz *et al.,* 2017 and UNCCD, 2017). Recognizing that a clear objective is essential to successful evaluation, the Framework of Evaluating SLM (FESLM) Working Party, in Nairobi (1991), laid a foundation for the following definition of SLM: "Sustainable land management combines technologies, policies and activities aimed at integrating socio-economic principles with environmental concerns so as to cater simultaneously to the following five pillars: (i)Productivity (Maintain or enhance production/services), (ii) Security (Reduce the level of production risk), (iii) Protection (Protect the potential of natural resources and prevent degradation of soil and water quality), (iv) Viability(Be economically viable) and (v) Acceptability (Socially acceptable)". SLM combines technologies, policies and activities aimed at integrating socio-economic principles with environmental concerns so as to simultaneously maintain or enhance production, reduce the level of production risk, protect the potential of natural resources and prevent (buffer against) soil and water degradation, be economically viable, and be socially acceptable (FAO, 1993). This is what exactly needed to halt or reduce salinization in the coastal regions of Bangladesh and keep soil productivity (crops grown on the soil) boosting up. Successful implementation of sustainable land management practices requires accounting for local environmental and socioeconomic conditions. In the context of climate change SLM is typically advanced by involving all relevant stakeholders in identifying land-use pressures and impacts (such as biodiversity decline, soil loss, over-extraction of groundwater, habitat loss, land-use change in agriculture, food production and forestry) as well as preventing, reducing and restoring degraded land. Agricultural practices that include indigenous and local knowledge can contribute to overcoming the combined challenges of climate change, food security, biodiversity conservation, and combating desertification and land degradation. For a certain set of biophysical and socio-economic conditions, the optimum technologies or practices that the farmers and other land users can introduce to prevent degradation or restore degraded land could be obtained from reliable information (FAO, 1993):

- World Overview of Conservation Approaches and Technologies (WOCAT), accepted by UNCCD.
- Technologies and practices for small agricultural producers (TECA)
- Climate-smart agriculture sourcebook
- Sustainable forest management toolbox
- Mountain and watershed management.

A decision support framework is needed to make SLM as an operable tool. It will include design of an operational strategy and action plan for mainstreaming and scaling up/scaling out SLM supported/validated by local and national assessment, integrating SLM into land-use planning to facilitate the implementation and scaling up and/or scaling out of SLM as knowledge-management actions. Mainstreaming SLM means integrating and institutionalizing SLM practices into the prevailing

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thinking and into policy, planning, economic and educational processes. Scaling up SLM refers to increasing the extent to which SLM is accepted as a land management model or practice. Scaling out SLM means replicating and spreading SLM practices in geographical space and expanding the number of people and organizations applying SLM practices. By and large documentation of appropriate SLM practices and approaches is an important step in ensuring the effectiveness of land management and restoration.

SLM conglomerates technologies, policies and approaches /activities that aim to integrate the management of Physical (land, water, biodiversity, and other environmental resources) and Socioeconomic principles with environmental concerns to meet human needs while ensuring the long-term sustainability of ecosystem services (biodiversity, niches, hydrology, carbon sequestration) and livelihoods. This ultimately connects the 2021 WSD theme to come out with technologies, policies and approaches to halt salinization and boost soil productivity.

Farmers of coastal region are adopting SLM with the help of government and non-government organizations to utilize soil and water resources to avoid/halt or reduce soil-water salinity. There are a good number of SLM best practices that have been documented by different professionals/organization in this region. The center of these SLM are to *improve production* (crop, fodder, wood/ fibre, water, energy), prevent (avoid), *reduce land degradation* (soil, water, vegetation), *conserve ecosystem, preserve/improve biodiversity, create beneficial economic impact* (increase income/ employment opportunities), *create beneficial social impact* (reduce conflicts on natural resources, support marginalized groups). *reduce risk of disasters* (tidal surge, embankment breaching), *adapt to climate change/ extremes and its impacts* (resilience to salinity in dry season, storms), *mitigate climate change and its impacts* (through carbon sequestration), etc. All these practices may be grouped into agronomic, structural, vegetative or management measures.Rearranging landscape is necessary to achieve these. In addition to the introduction of salt tolerant and salt adapted plant varieties, SLM best practices could be explored following widely accepted tools. Some of the examples of SLM best practices in coastal area deserve to be scaled up for their wider usage. They are basically focused tohalt or reduce salinization in existing polder environment:

A. Soil and crop management

a. Integrated homestead farming.
b. Modifying landform to grow rice-fish and vegetable.
c. Changing cropping pattern to increase cropping intensity.
d. Growing vegetables with rice and fish in moderate saline area.
e. Transplanted aman and golda *(M. rosenbergii)* shrimp/white fish cultivation.
f. Tower gardening in saline and intermittently shallowly flooded areas in coastal region.
g. Dyke agriculture integrated with aquaculture in waterlogged area in the coast.
h. Ditch and dyke multi-cropping system.
i. Usage of Gher boundary for cropping.
j. Climate resilience vegetable farming at homestead level.

B. Soil and water management

a. Tidal River water Management (TRM).
b. Usage of cut-off river water to increase cropping intensity.
c. Rain water harvesting for year-round fresh water supply.
d. Manage Aquifer Recharge (MAR) for fresh drinking water supply.
e. Raising Community seed bed to facilitate quality seed for Boro rice.

C. Agroforestry and others

a. Vermin compost production by women community.
b. Tree plantation to protect Embankment/Dykes.
c. Crab (Scylla serrata)cultivation.
d. Mele (Bolboschoenusmaritimus)cultivation by less privileged community.
e. Creating green shelter-belt through 'Jhau' (Casuarina equisetifolia) plantation in Coastal area.
f. Agro-forestry in Coastal district of Bangladesh- Assisted Natural Regeneration.
g. Strengthening embankments by redeveloping mangrove.

Conclusions and Recommendations

Greater investments are needed in gathering better knowledge about salt-affected soil management based on scientific evidences. Astrong awareness on management of salt-affected soils and their impact on agriculture and the environment is needed to combat salinization at all levels. Sustainable land management (SLM) best practices are to be identified and documented following standard tool (Preferably WOCAT questionnaires on SLM technology and approaches). Area or location specific SLM best practices could be scaled up based on local or indigenous knowledge with priorities and scale out to adopt in wider landscapes. By and large policy support and implementation are essential to establish an ideal situation of sustainable saline soil management framework. Nevertheless, polder management supported with strong water governance in this context should get the highest priorityto halt salinity in this part of the country and that is what focused in Delta Plan 2100.

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Biosaline Agriculture: Role of Nuclear Techniques

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Introduction

Development of a sustainable agriculture will require the combined use of soil, nutrient, and water management strategies that enhance crop productivity, while at the same time reducing abiotic and biotic stresses. Among the numerous abiotic and biotic stresses that affect plant productivity worldwide, soil water stress (drought) is the most common growth limiting factor in arid and semi-arid regions (Saranga et al.2001), followed closely by salt stress (Pessarakli 1991). To reach a truly sustainable agriculture, new 'climate smart' agricultural practices will need to be developed and adopted by the end users. These climate smart practices include both management strategies and specific technologies, ones which enhance crop productivity, environmental sustainability and wise use (conservation) of agro-ecosystems. The Soil and Water Management & Crop Nutrition (SWMCN) subprogram of the Joint Food and Agriculture Organization (FAO) and International Atomic Energy Agency (IAEA)'s Division of Nuclear Applications in Food and Agriculture, has developed a wide range of nuclear and isotopic techniques to enhance nutrient and water use efficiencies, increase biological N fixation through the capture of atmospheric di-nitrogen (N_2) and carbon (C) storage in salt affected soil.

Over the past several decades, the biosaline agriculture concept has been gaining in understanding. Awareness is growing that global water security can only be achieved, if all parties work together to develop Integrated Water Resource Management (IWRM) practices on a local, national and regional scale. Biosaline agriculture contributes to IWRM by developing the potential of salt-affected lands, saline water and salt-tolerant plants to increase agricultural production improve livelihoods and conserve the environment. Biosaline agriculture contributes to two of the primary objectives of global integrated water resource management. These are the following: 1. To produce more food and create more sustainable livelihoods per unit of water applied (more crops and jobs per drop) and ensure access for all to the food required for healthy and productive lives.

Background Information on Isotopes

A radioactive isotope is an atom with an unstable nucleus which spontaneously emits radiation (alpha or beta particles and/or gamma electromagnetic rays). The non-stability occurs because the ratio of neutrons to protons in a nucleus lies outside the belt of stability (i.e., outside a particular number due to an excess of either protons or neutrons), which varies with each atom. In contrast, a stable isotope is an atom with a stable nucleus (i.e., the ratio of neutrons to protons in the nucleus of an atom is within the belt of stability), and hence, it does not spontaneously emit any radiation (Nguyen et al.2011). Stable isotopes exist in light and heavy forms with heavy isotopes having a higher atomic weight than light isotopes (Table 1).

The quantity of a stable isotope is measured by an Elemental Analyzer coupled to an Isotope Ratio Mass Spectrometer (IRMS). Thus, a sample of soil or biological material is combusted into a gas, which is fed into a mass spectrometer, where the ratio of the stable isotopes of interest is determined. Radioactive isotopes (radioisotopes) are measured by their rate of 'decay', e.g. liquid scintillation counters are used for beta particle emitting radioactive isotopes, gamma spectrometers for gamma ray emitting radioactive isotopes and alpha spectrometers for alpha particle emitting radioactive isotopes. The international unit (SI) of activity decay is the Becquerel (Bq), which is equal to one disintegration per second (dps). The old unit commonly used was called the Curie, which is equivalent to 3.71010dps or 3.71010Bq (Nguyen et al. 2011)

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2. To manage human water use to conserve the quantity and quality of freshwater and terrestrial ecosystems that provides services to humans and all living things. Although technical progress has been made in the use of saline ground and surface water for agricultural production of salt-tolerant plants, the transfer from science to larger scale practice still remains to be promoted and supported by governments in affected countries. Biosaline technology transfer to agriculture has had some success where it has been demonstrated, under farm and local conditions.

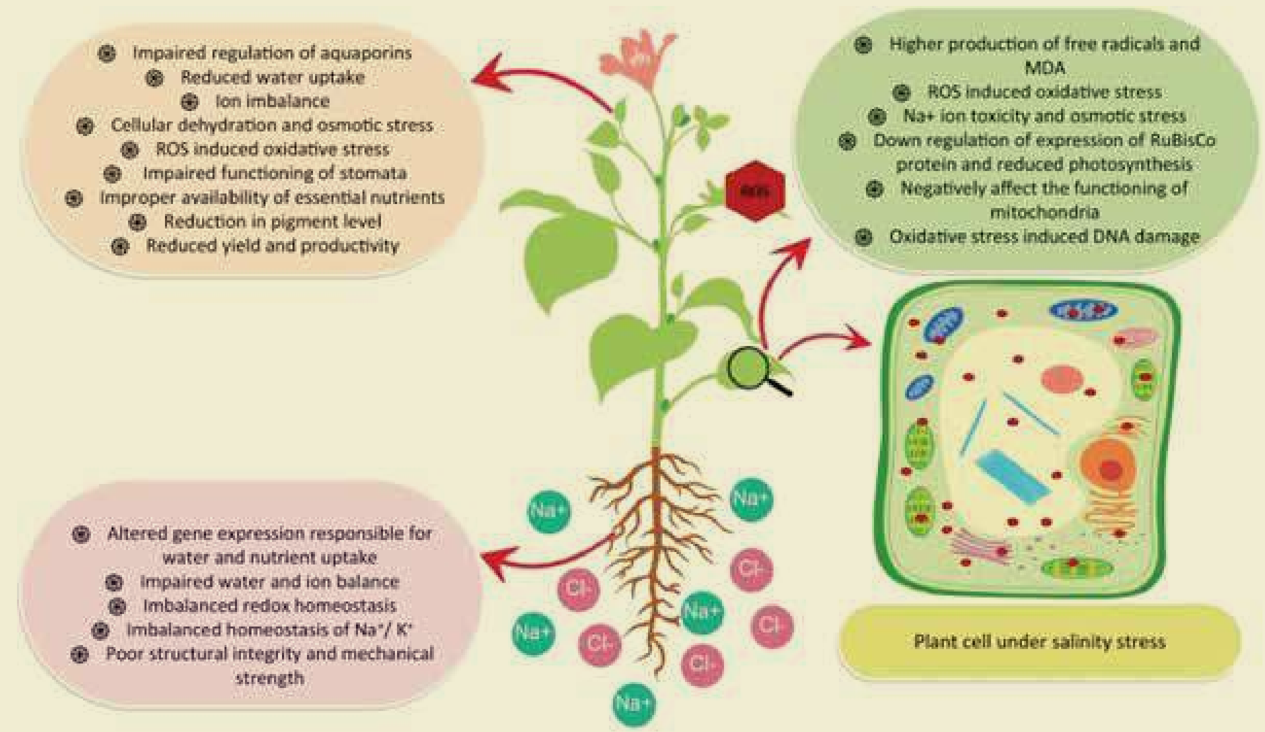

Fig. 1 Plant physiological stress under saline condition

Table 1. Average abundances of stable isotopes (% abundance in brackets) of some of the major elements commonly occurring in agro-ecosystems

Elements	Carbon	Hydrogen	Nitrogen	Oxygen	Sulfur
Heavy isotope	^{13}C (1.108%)	^{2}H (0.0156%)	^{15}N (0.366%)	^{18}O (0.204%) ^{17}O (0.037%)	^{33}S (0.76%) ^{34}S (4.22%)
Light isotope	^{12}C (98.892%)	^{1}H (99.984%)	^{14}N (99.634%)	^{16}O (99.759%)	^{32}S (95.02%)

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Nuclear and Isotopic Techniques in Biosaline Agriculture

The nuclear based techniques are a complement to, not a substitute for, non-nuclear conventional techniques. Nuclear-based techniques, however, do have several advantages over conventional techniques by providing unique, precise and quantitative data on soil nutrient and soil moisture pools and fluxes in the soil-plant-water and atmosphere systems. Isotopic techniques provide useful information in assessing soil-water-nutrient management which can be tailored to specific agro-ecosystems for managing soil salinity. For example, ^{15}N stable isotopic techniques can be used to measure rates of the various N transformation processes in soil-plant-water and atmosphere systems, such as N mineralization-immobilization, nitrification, biological N_2 fixation, N use efficiency, and microbial sources of production of nitrous oxide (N_2O), a greenhouse and ozone depleting gas, in soil. Several nuclear and isotopic techniques are being employed in soil water management studies. The soil moisture neutron probe is ideal in field-scale rooting zone measurement of soil water, providing accurate data on the availability of water for determining crop water use and water use efficiency and for establishing optimal irrigation scheduling under different cropping systems especially under saline conditions.

The use of oxygen-18, hydrogen-2 (deuterium) and other isotopes is an integral part of agricultural water management, allowing the identification of water sources and the tracking of water movement and pathways within agricultural landscapes as influenced by different irrigation technologies, cropping systems and farming practices.

Nitrogen-15 (^{15}N) to Study Fertilizer Use Efficiency

The major constraints under Saline Agriculture are the availability of essential nutrients and water to the plant which are adversely affected by excessive salts in the soil solution. Among the essential plant nutrients, N plays a key role in plant growth and productivity. To take up N from the soil solution, plants compete with a range of N removal processes/losses including immobilization, leaching, and gaseous emissions of N as ammonia (NH_3), nitrous oxide (N_2O), nitric oxide (NO) and molecular nitrogen (N_2) into the atmosphere. Because of these N losses, the N use efficiency (kg of dry matter produced per kg of N applied) or useful use of N by plant is invariably less than 50% of the applied N (Zaman et al.2013a, b, 2014). The extent to which N is removed from soils, or made unavailable to plants by the above biogeochemical processes is of both economic and environmental importance. Under saline conditions, the presence of excessive salts (especially Na+) in the soil solution, coupled with a high soil pH, is likely to further increase the competition between N uptake by the plant and the soil N losses, thereby reducing crop productivity further. Quantifying N use efficiency and the sources of N losses enables researchers to develop 'technology packages' which can enhance N uptake and minimize N losses, thus allowing for sustainable crop productivity under saline conditions.

Biological Nitrogen Fixation (BNF)

Over the past 62 years, world food supplies have become heavily dependent on the use of synthetic N fertilizers predominantly urea, with over half of this N fertilizer being applied to cereal crops. The use of fertilizer N will continue to play a critical role in ensuring world food security. Most of these increases in N fertilizer use will occur in developing countries.

Legume species are common sources of protein-rich food for humans and feed for their livestock, and they also provide fiber, medicines and other products. Grain legumes can be cultivated in a separate crop rotation, or by intercropping with cereals. Certain fast-growing legume species may be included in cropping systems for use as cover crops, or incorporation into the soil as green manures. In order to ensure appreciable biological nitrogen fixation (BNF) inputs into agricultural production systems, legume genotypes can be grown from seeds, or propagated vegetatively. A number of stress conditions, such as salinity, acidity, drought, extreme temperatures and nutrient deficiencies have negative effects on both partners of the symbiosis.

Estimating Legume BNF Using ^{15}N Isotope Techniques

Isotopic methods using the stable ^{15}N isotope, both with enrichment and also at natural abundance levels, provide the most sensitive measures of total N_2 fixation over the growing cycle of legume crops. These methods capable of distinguishing atmospheric N_2 from other sources of N present in the soil only. Of the two main stable isotopes of N, the light isotope ^{14}N, is by far the most abundant (99.6337%). The heavy stable isotope ^{15}N, has an abundance of 0.3663atom %. If the ^{15}N concentrations within each of the two main sources of N (atmospheric N_2 and soil N) differ appreciably, then it is possible to calculate the proportion of the total N that accumulates within the legume tissues that is derived from atmospheric N_2 fixation.

When the aim is the assessment of the N input by N_2 fixing plants through BNF, three parameters are required: the content of N in plant material, the dry matter yield of the N_2 fixing plant and the percentage of N in the N_2 fixing plant derived from the atmosphere (%Ndfa). The %Ndfa depends on the interaction between plant growth and efficiency of microsymbiont strain depending on the soil physical and chemical properties, (e.g., water and nutrient availability). The two most important isotopic techniques for this purpose are the ^{15}N isotope dilution and ^{15}N natural abundance technique (Boddey et al.2000; Urquiaga et al.2012; Collino et al.2015).

Natural Abundance of ^{15}N Technique

This technique depends on the slight natural enrichment of ^{15}N in the soil, relative to atmospheric N_2. The slight increase of ^{15}N in soil is a consequence of the non-identical behavior of the light and heavy isotopes involved in various reactions in the soil environment. The ^{15}N isotopic fractionation, also called the mass discriminatory effect (Xing et al.1997), is a result of complex and prolonged interaction of biological, chemical and physical processes in soils, which results in fractionation between ^{15}N and ^{14}N. There is a tendency of the reaction products, such as the gaseous N forms produced by denitrification, to become relatively enriched in the lighter isotope ^{14}N, while the remaining N compounds, which can be stabilized in soil organic matter over time, tend to be enriched in the heavier isotope ^{15}N (Xing et al.1997). It is important to consider that this small 15N enrichment occurs in a longtime scale, and is closely associated to soil organic matter retention and long-term dynamics (Ledgard et al.1984).

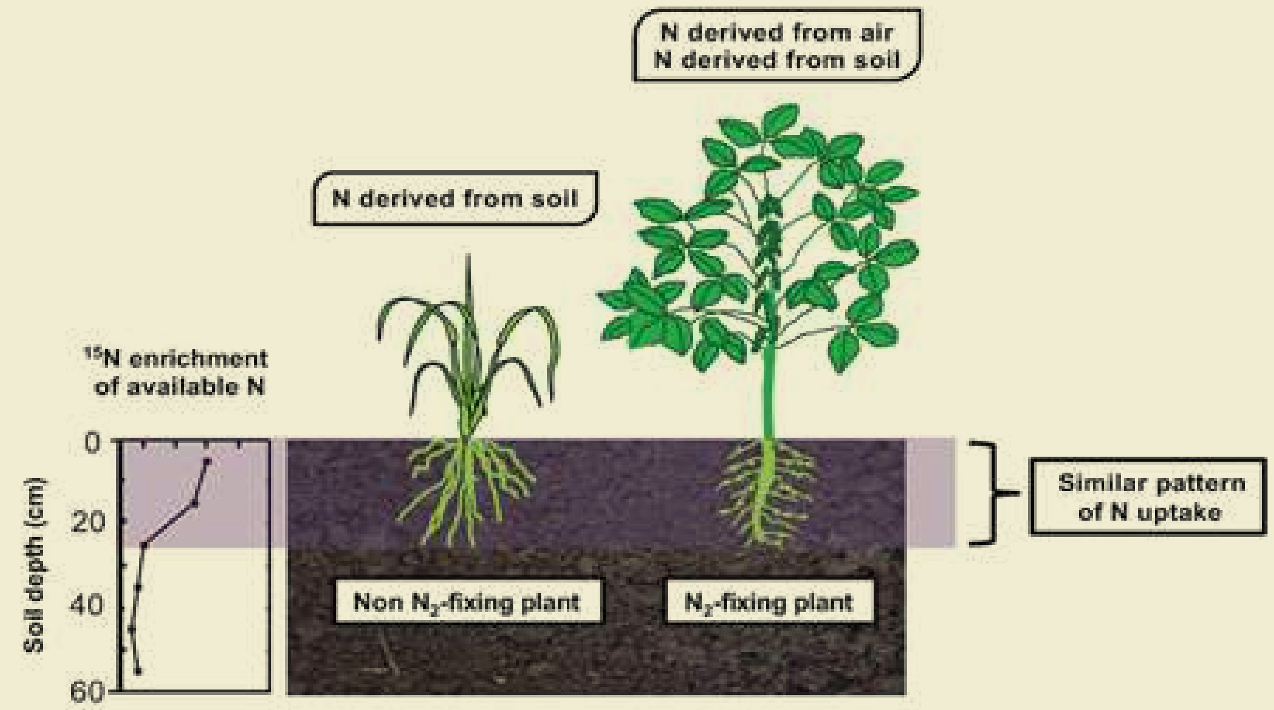

Fig. 2 Illustration of the 15N isotope dilution technique for the BNF quantification

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Water Stable Isotope Technique to Determine Evapo-transpiration Partitioning

In agriculture, evapotranspiration (ET), or the flux of water from a vegetated surface via both evaporation (E) and transpiration (T) by plants, is an important component of the water budget. Water loss via transpiration can be considered 'good' water use, while water loss via evaporation can be considered 'wasted' water use. Transpiration occurs through stomatal pores, the pores which are also used by the plants for uptake of atmospheric CO_2 in photosynthesis, and subsequent biosynthesis of carbon compounds, a process which ultimately leads to biomass gain. Stomata are tightly controlled by plant physiological signals to optimize carbon gain per unit of water lost. The use of the stable isotopes ^{18}O and ^{2}H as signatures in water and water vapor can help scientists to differentiate between water losses through direct soil evaporation versus transpiration from the plant leaves. Water use efficiency (WUE) of a plant species or crop type is related both to the plant's genetics, as well as acclimation by the plant to the irrigation regime. The recent advancement of laser-based water vapor isotope analyzers, various calculation models have been developed to correlate the real-time, spatial, and temporal isotopic measurements with evaporation and transpiration fluxes (FET and FT).

Isotopic research at BINA

Nuclear techniques have been successfully used in Bangladesh agriculture in the development of many technologies that are environment-friendly and contributing to the national economy. The Bangladesh Institute of Nuclear Agriculture (BINA) has its nuclear research work from the beginning of its activities. A number of its released varieties and nuclear technologies have been developed by the BINA. Sixteen crop varieties have been developed using ionizing radiations either directly or by crossing with the irradiated mutant line that included three varieties of rice, two varieties of jute, one variety each of chickpea, mungbean and blackgram and four varieties each of mustard and tomato.

Studies with ^{15}N isotope showed that nearly 70% of applied N is lost if applied in the soil surface and only 35-40% of it is utilized by rice crop. Use of ^{32}P indicated that phosphorus use efficiency of crops is enhanced if applied in the soil surface and hoed in before planting of seeds. Rubidium-86 tracer studies indicated that the annually flooded floodplain soils do not need immediate application of potash fertilizer. Irrigation scheduling and water requirement of HYV rice, wheat, chickpea, lentil and mustard have been made. Using ^{15}N-isotope dilution technique seven high biological nitrogen fixation potential (Ndfa) rhizobial inoculants have been developed for seven leguminous crops.

The neutron moisture and the neutron probeis used to measure the quantity of water present in soil. Different isotopes are used for measuring nutrient use efficiency in abiotic stress condition like saline and drought. The ^{15}N is common isotope which is used for the nitrogen dynamic within the soil and biological nitrogen fixation. The cesium-137 (^{137}Cs) is used for erosion deposition measurement in surface soil especially in hills areas by Gamma spectrometer is widely used at Soil Science division of BINA.

Application of other Isotopes

As mentioned in earlier sections of this chapter, nuclear and isotopic techniques have a wide range of applications in the soil-water-plant interaction studies, covering the fields such as plant ecology, physiology, biochemistry, nutrition, microbiology, protection against insect pests, and soil fertility, chemistry, physics, and hydrology, etc. Few common examples of the applications of isotopic and nuclear techniques in agricultural research are listed below.

- ^{32}P fertilizer use efficiency, root activity, DNA probes in molecular biology
- ^{35}S in soil and fertilizer studies
- ^{65}Zn in plant uptake and use efficiency
- ^{13}C, ^{14}C in soil organic matter dynamics, root activity, photosynthesis, pesticide residues, and water use efficiency, etc.
- ^{22}Na, ^{36}Cl, ^{40}K in ion uptake and mechanism of salt tolerance in plants
- ^{137}Cs in soil erosion studies
- ^{60}Co for sterile insects in integrated pest management (IPM)
- $^{198}Gold$ for detection of termite colonies in agricultural fields

The nuclear and isotopic techniques are the supporting tools, and not substitute, to the conventional techniques for understanding the biological processes and mechanisms of ecosystem functioning. Therefore, a careful evaluation is required with regard to: i) the need for using an isotopic/nuclear technique, and ii) the choice of the appropriate isotopic/nuclear considering the research objective, facilities and expertise available, risks involved in safe handling and disposal of hazardous materials, and the financial considerations. In this context, the stable isotopes are the ever preferred choice in soil-water-plant-atmosphere studies.

Conclusion

Salinity is reluctant to agricultural crop production due to the unavailability of plant nutrients elements as well as water stress. Nuclear-based techniques, however, do have several advantages over conventional techniques by providing unique, precise and quantitative data on soil nutrient and soil moisture pools and fluxes in the soil-plant-water and atmosphere systems which can be tailored to specific agro-ecosystems for managing soil salinity. The ^{15}N stable isotopic techniques can be used to measure rates of the various N transformation processes in soil-plant-water and atmosphere systems, such as N mineralization- immobilization, nitrification, biological N_2 fixation, N use efficiency, and microbial sources of production of nitrous oxide (N_2O), a greenhouse and ozone depleting gas, in soil. Within the saline soil, water management is an integral part that can be assessed accurately and identification of water source, its movement in different irrigation technologies by the use of oxygen-18, hydrogen-2 (deuterium). Nuclear techniques have been successfully used in Bangladesh agriculture in the development of many technologies that are environment-friendly and contributing to the national economy.

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Climate Change Accelerated Soil Salinization and It's Sustainable Management

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World Soil Day is held annually on 5 December as a means to focus attention on the importance of healthy soil and to advocate for the sustainable management of soil resources. World Soil Day 2021 and its campaign "Halt soil salinization, boost soil productivity" aims to raise awareness of the importance of maintaining healthy ecosystems and human well-being by addressing the growing challenges in soil management, fighting soil salinization, increasing soil awareness and encouraging international organizations, governments, NGOs, communities, and individuals around the world to commit to proactively improving soil health.

Naturally, saline soils host valuable ecosystems, including a range of rare plants that are adapted to extreme conditions. However, salt-affected soils may develop quickly in response to human activities. Soils may thus become affected by salinity and sodicity due to inappropriate management or through saline water intrusion from sea, river, or groundwater and undergo a rapid decline of health, losing their capacity for biomass production, natural filtration, carbon sequestration, and other necessary ecosystem functions.

Changes in climate patterns are dramatically influencing some agricultural areas. Arid, semi-arid, and coastal agricultural areas are especially vulnerable to climate change impacts on soil salinity. Inventorying and monitoring of climate change impacts on salinity is crucial to evaluate the extent of the problem, recognize trends, and formulate irrigation and crop management strategies that will maintain the agricultural productivity of these areas. Trends in salinization due to climate change indicate that the infrastructure and protocols to monitor soil salinity from field to regional to national to global scales are needed. The main expected impacts of global warming will be represented by sea-level rise, higher and more variable temperatures, changes in precipitation patterns (lower and more erratic rainfall), and higher frequency of extreme events (Cyclone, storm surge, etc.).[1]

Agriculture is directly linked to climate change. Crop yield, water use, biodiversity and soil health are directly affected by changes in the climate. Changes in the frequency and intensity of rainfall, temperature, and other extreme weather events will impact agricultural productivity, with the net effect of climate change on world agriculture most likely negative. One notable soil property that is seldom mentioned by scientists when speaking about the impacts of climate change is soil salinity. This may be due to the fact that salinity is among the most spatially complex and temporally dynamic soil properties, with a coefficient of variation generally over 80-90%[2] or it may be due to the fact that, unlike many other soil properties, it can be easily managed by the addition of water to leach salts.

As long as the water source is plentiful and sufficiently good in quality and adequate drainage occurs, then salinity is generally not regarded as a problem of concern. However, if droughts become more frequent as climatologists predict, then salinity will likely become an issue of concern. Soil salinity is a worldwide concern in arid and semi-arid agricultural areas. Salt-affected soils are estimated to comprise 23% of the cultivated land.[3] In actuality, however, there are no directly measured global inventories of soil salinity. All known global inventories of soil salinity, and with only one exception, all known regional-scale inventories are gross approximations based on qualitative and not quantitative data.[4] Soils are spatially heterogeneous. This is particularly true for soil salinity, which is a dynamic soil chemical property exhibiting complex spatial patterns that vary over time.

These complex spatio-temporal patterns make inventorying and monitoring salinity at field scale or larger spatial extents especially challenging. Techniques that provide rapid, reliable, and detailed spatio-temporal geo-referenced measurements of salinity at multiple scales are crucial for inventorying, monitoring, and managing soil salinity impacted by changes in climate patterns as well as by anthropogenic salinization processes associated with irrigated agriculture.[5]

Soil salinity is one of the major and widespread challenges in the recent era that hinders global food security and environmental sustainability. Worsening the situation, the harmful impacts of climate change accelerate the development of soil salinity, potentially spreading the problem in the near future to currently unaffected regions. Mitigation approaches such as application of amendments, cultivation of tolerant genotypes, suitable irrigation, drainage and land-use strategies, conservation agriculture, phytoremediation and bioremediation techniques have successfully tackled the soil salinity issue and offered associated benefits of soil carbon sequestration and conservation and recycling of natural resources. These management practices further improve the socio-economic conditions of the rural farming community in salt-affected areas. We also discuss emerging reclamation strategies such as saline aquaculture integrated with sub-surface drainage, tolerant microorganisms integrated with tolerant plant genotypes, integrated agro-farming systems that warrant future research attention to restore agricultural sustainability and global food security under climate change scenarios.[60]

Climate change is one of the significant threats to water and food security. Like many parts of the world, the coastal zones of Bangladesh are at risk of sea-level rise and its probable consequences such as salt-water intrusion. Soil salinity is a significant threat to agriculture production. Soil salinity is increasing in coastal Bangladesh at an alarming rate. Soil salinity monitoring is essential for these affected areas for copping up with climate change. Bangladesh is one of the most vulnerable countries to sea-level rise due to climate change. Soil salinity is one of the potential threats to the coastal ecosystem and agriculture which might hinder the country's future food security.

The remote sensing result shows that soil salinity increases significantly in most of the parts of the coastal area of Bangladesh in 25 years period. The percentage of very high saline soil is increased from less than 1% in 1990 to 33% in 2015 which is very alarming for the agriculture growth in this area.[7]

Although climate-related increases in salinity from saltwater intrusion in coastal areas have been highlighted as a serious problem, systematic studies of spatiotemporal impacts are scarce in Bangladesh. Climate change poses a major soil salinization risk for coastal Bangladesh. Soil experts indicate that across the coastal region, median changes by 2050 in the annual, dry season, and wet season soil salinity will be 39.2, 13.1, and 36.6 %, respectively. Many areas will have significantly greater increases. For example, many areas in Barisal, Chittagong, and Khulna Districts will have very large increases in soil salinity during the coming decades. The results have sobering implications for HYV rice production in coastal Bangladesh. Many Upazilas have already suffered significant losses, which will be compounded by further salinity increases in the coming decades. This inexorable process will continue as long as the sea continues to rise and salinity increases in coastal rivers. No prospect for near-term relief is apparent, since rising global greenhouse gas emissions continue to propel rapid climate change and melting of the polar ice caps.

The potential impacts of climate change on coastal regions include progressive inundation from sea-level rise, heightened storm damage, loss of wetlands, and increased salinity from saltwater intrusion. Worldwide, about 600 million people currently inhabit low-elevation coastal zones that will be affected by progressive salinization.[8] Recent research suggests that the sea level may rise by one meter or more in the twenty-first century, which would increase the vulnerable population to about one billion by 2050.[9, 10, 11,12,13,14]

While most research has focused on inundation and losses from heightened storm surges, increased salinity from saltwater intrusion may actually pose the greatest threat to livelihoods and public health through its impacts on agriculture, aquaculture, infrastructure, coastal ecosystems, and the availability of freshwater for household and

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commercial use. Understanding the physical and economic effects of salinity diffusion and planning for appropriate adaptation will be critical for long-term development and poverty alleviation in countries with vulnerable coastal regions.[15]

Bangladesh provides an excellent setting for the investigation of these issues because it is one of the countries most threatened by sea-level rise and saltwater intrusion. In Bangladesh, about 30% of the cultivable land is in coastal areas where salinity is affected by tidal flooding during the wet season, direct inundation by storm surges, and movement of saline ground and surface water during the dry season.[16, 17] In consequence, the potential impact of salinity has become a major concern for the Government of Bangladesh and the affiliated research institutions. Recently, the Bangladesh Climate Change Resilience Fund (BCCRF) Management Committee has highlighted salinity intrusion in coastal Bangladesh as a critical issue for adaptation to climate change. In its National Adaptation Programs of Action, the Government of Bangladesh has assigned particularly high priority to projects related to adaptation to increased salinity. The temporal and geographic pattern of appropriate adaptive investments will depend critically on the expected intensity and diffusion rate of salinization in different locations.

Researchers simulated salinity change in rivers and estuaries using hydraulic engineering models and compared the results with actual measures.[17, 18, 19] In the most comprehensive study to date, Dasgupta et al.[16] extended recent salinity trends in coastal rivers to 2050 with a projection model that links the spread and intensity of salinity to changes in sea level, temperature, rainfall and altered riverine flows from the Himalayas. While the Dasgupta[16] study provides new estimates of future river salinity for alternative scenarios of climate change, no comparable assessment of soil salinity has been undertaken until now. This research attempts to fill the gap by predicting soil salinity in coastal Bangladesh through 2050.

The present analysis was conducted in two stages. In the first stage, changes in soil salinity in coastal Bangladesh for the period 2001–2009 were assessed using salinity information recorded at 41 soil monitoring stations by the Soil Research Development Institute (SRDI). Using these data, a spatial econometric model was estimated linking soil salinity with the salinity of nearby rivers, land elevation, temperature, and rainfall. In the second stage, future soil salinity for 69 coastal sub-districts was projected from climate-induced changes in river salinity and projections of rainfall and temperature based on the time trends for 20 Bangladesh Meteorological Department weather stations in the coastal region. The findings indicate that climate change poses a major soil salinization risk for coastal Bangladesh.[20]

As a country with a large coastline, the adverse impacts of saltwater intrusion are significant in Bangladesh. Salinity mainly affects land and water in the coastal areas. With the consequence of climate change, it gradually extends towards inland water and soil. This scenario of gradual salinity intrusion into the coastal areas of Bangladesh is very threatening to the primary production system, coastal biodiversity and human health, said researchers in Bangladesh.

The total amount of salinity affected land in Bangladesh was 83.3 million hectares in 1973, which had been increased up to 102 million hectares in 2000 and the amount has risen to 105.6 million hectares in 2009 and continuing to increase, according to the country's Soil Resources Development Institute (SRDI). In the last 35 years, salinity increased around 26 percent in the country, spreading into non-coastal areas as well. Salinity which is rising in the coastal areas, is casting a huge impact on the ecosystem. Production of various crops has declined due to excessive salinity in soil.

Studies conducted by the World Bank, Institute of Water Modelling and World Fish, Bangladesh between 2012 and 2016 have quantified the effects of increasing salinity in river waters in coastal Bangladesh, including the areas in and around the Sundarbans – the world's largest mangrove forest that straddles the coast of Bangladesh and India. The broad categories of climate change effects that hit the coastal areas of Bangladesh are changes in temperature and rainfall pattern, sea-level rise, change in frequency and intensity of cyclones, storm surge, changes in river and soil salinity.

Another recent study conducted by the World Bank indicates that climate change will cause significant changes in river salinity in the southwest coastal region during the dry season (October to May) by 2050, will likely lead to shortages of drinking and irrigation water and cause changes in aquatic ecosystems. Salinity increase may induce a shift in the Sundarbans mangrove forest from Sundari (the single most dominant and important species, with the highest market value) to Gewa and Guran. Estimates from the research indicate that Bagerhat, Barguna, Barisal, Bhola, Khulna, Jhalakati, Pirojpur, and Satkhira districts will be affected most adversely.This study also identifies soil salinization in coastal Bangladesh as a major risk from climate change. In the coming decades, soil salinity will significantly increase in many areas of Barisal, Chottogram and Khulna division. It projects a median increase of 26 percent in salinity by 2050, with increases over 55 percent in the most affected areas.[21]

Soil salinity is one of the major and widespread challenges in the recent era that hinders global food security and environmental sustainability. Worsening the situation, the harmful impacts of climate change accelerate the development of soil salinity, potentially spreading the problem in the near future to currently unaffected regions. Mitigation approaches such as application of amendments, cultivation of tolerant genotypes, suitable irrigation, drainage and land use strategies, conservation agriculture, phytoremediation, and bioremediation techniques have successfully tackled the soil salinity issue, and offered associated benefits of soil carbon sequestration, and conservation and recycling of natural resources.

These management practices further improve the socio-economic conditions of the rural farming community in salt-affected areas. The emerging reclamation strategies such as saline aquaculture integrated with sub-surface drainage, tolerant microorganisms integrated with tolerant plant genotypes, integrated agro-farming systems warrant future research attention to restore agricultural sustainability and global food security under climate change scenarios.[22]

Soil salinity is one of the impacts of climate change in coastal agricultural land, as rises in sea levels have increased salinity from 1 to 33% over 25 consecutive years.[23] Sea level rise is associated with the increase in global warming and occurs due to the melting of glaciers and ice sheets as well as the thermal expansion of sea water[24] demonstrated a comprehensive understanding of the possible effects of sea-level rise with the aid of a hydrodynamic model. Sea level rise includes flooding and salinization and has implications for water resources. Rising sea levels increase the salinity of both surface water and groundwater through saltwater intrusion.

Salinity is more evident in semi-arid, coastal agriculture lands, and particularly in arid regions of the world.[25, 26, 27] Changes in weather patterns have resulted in the frequency of recurrent drought or rain falling above the average value for more than a decade.[28] The upward movement of water in areas with shallow water tables and coastal areas with seawater intrusion resulted in root zone salinity. Changes in precipitation and temperature have a greater influence on soil salinity. In one study conducted by,[29] it has been reported that the long-term effects of increased temperatures and decreased precipitation for 30 years showed a positive correlation with increased soil salinity in the arid landscape due to less over leaching of salt in the soil as determined by Landsat sensor data including Thematic Mapper (TM), Thematic Mapper Plus (ETM+), and Operational Land Imager (OLI). In coastal agricultural lands, the salinity has increased from 1 to 33% in the last 25 years.[23]

On a global level, more than 831 M ha of agricultural land is salt-affected;[30] salinity affected 397 M ha, while sodicity affected up to 434 M ha land.[31, 32] Out of the total cultivated and irrigated agricultural land, 50% is affected by high salinity on a global level.[33, 34] Irrigation with saline water, low precipitation, and high evapotranspiration are key factors that cause salinization at a rate of 10% annually to agricultural lands. At this rate more than 50% of arable land would be salinized by 2050.[35]

Expansion of salt-affected arable lands has emerged as a major threat to world food security. About 6% of the cultivated area is destroyed by soil salinization with the continued addition of 1–2% every year around the globe, causing significant yield losses of staple grain crops like maize, rice, and wheat.[36] High rates of evapotranspiration result in the accumulation of salt on the soil surface.[37, 38] Most of the underground

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water used for crops in such conditions become brackish and contains a high content of soluble salt ions, such as Na+ and Cl−, and lower quantities of K^+, Ca^{2+}, and NO^{-3}.[36, 39] The presence of these ions results in hyper ionic salt stress, which induces metabolic impairment and oxidative stress through the generation of reactive oxygen species (ROS), thus adversely impacting the yield of crops.[40, 41, 42]

Management Strategies to Cope with Soil Salinity under Changing ClimatePhysical Methods

Some physical methods to reclaim salt-affected soil include scraping, deep plowing, deep tillage, subsoiling, sanding, horizon mixing, profile inversion, flushing, and leaching. Scraping is used by farmers to mechanically remove salt from the soil surface; however, it is a temporary measure to improve plant growth, and the ultimate disposal of salt remains a major problem. Flushing is used to desalinate soil with surface salt crusts. This method can flush small amounts of salt but has little practical significance. The most common method to reclaim saline soil involves leaching, in which good quality water is supplied to surface soil to leach salt levels.43, 44 The leached salt is then removed with an adequate drainage system.

Chemical Methods
Reclamation by Inorganic Amendment

Saline sodic soil can be reclaimed by the application of Ca^{2+}-containing chemicals which replace Na^+ at soil exchangeable sites, followed by leaching with a good quality water supply.[45]Application of gypsum in soil with low concentrations of carbonate has been extensively studied.[46, 47]

It is commonly used to supply Ca^{2+}. However, for soil containing high carbonate content, sulphuric acid is recommended,[46] which increases soil Ca^{2+} levels by dissolving $CaCO_3$ in soils.[48, 49] The use of inorganic amendments is costly and labor-intensive and is an unhealthy practice for beneficial microbes.

Reclamation by Organic Amendment

The physicochemical and biological properties of soil can be improved by the application of organic matter amendment, as they accelerate salt leaching and improve aggregate stability and water holding capacity,[50] thus enabling better plant growth in salt-affected soils. These are cheap and easily organic amendments which contain soil nutrients, organic matter, and enhance both cation exchange capacity and soluble exchangeable K^+, which compete with Na^+ in saline-sodic soil, and limit its entry at exchangeable sites.[50] Examples of organic amendments include farmyard manure, poultry manure, municipal solid waste compost, and olive mill waste compost[51, 52, 53] Applications of organic amendments have significant effects in an area with low rainfall but cause secondary salinization in other areas where rainfall is abundant.[54]

Biological Methods
Phyto-Reclamation

Phyto-reclamation is an environment-friendly approach to reclaim saline and saline-sodic soils.[55, 56] In this method, salt-tolerant plant species are used to reclaim saline soil. A significant improvement in soil organic matter and water holding capacity and decreased insoluble salts and exchangeable Na^+ have been recorded.[57, 58] Salt-affected soil contains Ca in the form of calcite which is insoluble and unable to displace Na^+ from cation exchange complexes. However, the higher partial pressure of CO^2 and enhanced production of carbonic acid in the root zone could assist in the solubilization of calcite which provides soluble Ca^{2+} for exchanging Na^+.[59]Root exudates of salt-tolerant plant species contain H+ which enhances Na+ uptake and its subsequent removal from the field. Examples of alophytesinclude *Atriplex* spp., *Aegicerascorniculatum, Bruguieragymnorrhiza, Chenopodium album, Plantago media, Rhizophora mucronata, Suaeda australis, and Salsola vermiculata.*[59,60] Phytoremediation has certain limitations in sustainable agricultural productivity, as it changes the microbial community, and takes several growing seasons to remediate polluted soil.

Plant Growth-Promoting Rhizobacteria for Reclamation of Saline Soils

The use of PGPR to reclaim saline soil is a far better approach than chemical and organic fertilizers because of its environment-friendly and persistent nature, with PGPR proliferating slowly and gradually in inoculated soil and ensuring their survival for decades. For this purpose, PGPR should be isolated from their native stress habitat,61 and reinoculated into affected fields in order to improve the soil physicochemical properties to reclaim it and in turn improve the growth and yield of crops.[62, 63] A collective approach to exploit the potential of PGPR to alleviate salinity and sodicity has recently received the attention of modern agriculturalists.[64] In the current climate change scenario, the exploitation of PGPR could be an eco-friendly strategy to promote organic farming.[65]

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Alleviation of Salt Stress through Plant Growth Promoting Rhizobacteria (PGPR) by modulating Proline Biosynthesis in Rice Plants

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Abstract

Recently salinization issue causes a serious warning to environmental resources and human health in many countries. Arround 1.5 billion hectars of cultivated lands are present in the world. It is reported that all most 5% of that cultivated land (77 million) and 6% of total surface land is affected by salinity. Agricultural crops and their productivity severely affected by salt stress. Many physiological mechanisms within the plants are regulated when exposing to salt stress. This salinity tolerance measurement has a great demand to asses this regulatory variations, growth, and survival parameters. Microorganisms that colonize in the roots of rhizosphere or rhizoplane could play a significant role in this respect. Rhizobacteria those have some unique properties such as salt tolerance, nutrient uptake ability, synthesis of compatible solutes, production of plant growth promoting hormones, bio-control potential, and their interaction with crop plants is known as plant growth promotion rhizobacteria (PGPR). Proline is one of the essential compatible solutes for both plant and bacteria to respond to osmotic balance and ionic toxicity. Internal proline biosynthesis occurs on cytosol and mitochondria of a cell and modulate their functions. It can also influence the procreation or demise the cell and provoke specific gene expression to alleviate salt stress. Rhizobacteria having plant growth promotion capability can be the suitable carrier of bio-inoculant to promote growth and productivity through different mechanisms in addition with the accumulation of compatible solutes like proline as osmoregulators.

Keywords: Salinity, Microbial Inoculants, Osmoregulators, Proline, ornithine-delta-aminotransferase (OAT)

Introduction

Soil salinization has been affecting agriculture at a greater rate in the recent years. The rise in sea level due to global climate change and the extensive use of chemical fertilizers are the major driving forces of salinization of lands [1]. It has been estimated that around 45 million ha of agricultural lands is affected by salinity [2], an estimated global crop production loss of US$ 27.3 billion [3]. The high concentration of Na+ and Cl- in soil has a detrimental effect on plant physiology, as it restricts nutrient uptake by plants [4]. The higher uptake of Na+ by plants causes K+ deficiency, disruption in ion homeostasis and dehydration of plant cells [5]. These lead to the reduction in total biomass of plants and eventually in marketable yield.

Plants produce a wide range of low molecular weight compounds which protect cellular damage against elevated concentration of reactive oxygen species (ROS) [6]. They are also known to play an important role in maintaining the osmotic balance in plants under salt stress [7]. Proline is such compatible solutes which belong to the class of amino acid and play important roles in the maintenance of osmotic balance and alleviation of oxidative stress [8]. Proline accumulation is generally observed in the cytosolic compartment of the plant cells and it plays a significant role in stabilization of cellular membranes, balancing cytosolic acidity, decreasing lipid peroxidation and protection of cellular structures by scavenging ROS [9].

The use of bacterial inoculation on plants for stress alleviation and plant growth promotion has been regarded as an economically feasible and sustainable approach for salt stress amelioration [10]. Plant growth promoting bacteria (PGPB) can enhance plant growth and alleviate salt stress by increasing total plant biomass [11] by enhancing nutrient uptake [12], upregulating ROS scavenging enzymes [13], reducing stress ethylene levels by 1-aminocyclopropane-1- carboxylate (ACC) deaminase activity [14], fixing atmospheric nitrogen [15] and colonizing root architecture [16]. Brevibacterium linens RS16 is known to be a potential PGPB [12]. It has been shown that [12], the inoculation of B. linens RS16 reduced stress ethylene levels in red pepper seedlings under salt stress conditions. Similarly, the inoculation of B. linens RS16 on rice cultivars regulated the stress volatile compound levels under salt stress conditions [17].

Rice (Oryza sativa L.) is regarded as one of the major food crops across the world and is cultivated from warm temperate to tropical regions. Rice plants are generally susceptible to salt stress, which leads to reduction in growth, grain yield and development [18]. It has been hypothesized that salt stress would affect the growth and development of the salt-sensitive rice genotype (IR29) more adversely compared to the moderately salt-tolerant cultivar (FL478) due to inherent genotypic differences. The better tolerance of the moderately salt-tolerant cultivar (FL478) will be due to the higher accumulation of proline to the salt-sensitive cultivar (IR29). However, the inoculation of Brevibacterium linens RS16 had alleviate salt stress effects and enhance plant growth of both the genotype, but the increase in growth and development of the salt-sensitive genotype (IR29) will be more profound compared to the moderately salt-tolerant genotype. The increase in growth of plants will be due to the higher accumulation of proline after bacterial inoculation.

The effect of bacterial inoculation on total proline accumulation in plants after imposing salt stress and its correlation with total dry weight of plants

Proline accumulation in the whole plant was also estimated on the basis of total dry weight. Although plant species can differ considerably in the amount of proline that accumulates upon salt stress, there is no clear relationship between the ability to accumulate proline on salt stress tolerance [19]. It has been reported that high accumulation of proline under salt stress increased higher green leaf area in rice plant [21]. In addition, an increased proline accumulation in the whole plant and total soluble sugar in the PGPR-treated wheat plants significantly contributed to their osmotolerance[22]. Proline accumulation was found to be higher in the roots and leaves of the salt-tolerant cultivar Giza 182 compared to the salt-susceptible variety Sakha 105 [8]. In this case, proline accumulation in the whole plant was higher in the moderately salt-tolerant cultivar (FL478) compared to the salt-sensitive cultivar (IR29) when exposed to 50 mM and 150 mM of salt stress at 10 days. This finding is in agreement with the recent results was reported [8] (Table 1 &2).

On the other hand, inoculation of B. linens RS16 significantly increased the proline accumulation of the whole plant in the salt-sensitive cultivar (IR29) compared to the non-inoculated control plants. But, the moderately salt-tolerant cultivar (FL478) had shown higher accumulation of proline compared to the salt-sensitive counterpart. There were no significant changes of proline accumulation in the moderately salt-tolerant cultivar (FL478) with or without inoculation. These results indicated that bacterial inoculation was more effective in the salt-sensitive cultivar (IR29) than the moderately salt-tolerant cultivar (FL478). This might be due to the fact that bacterial inoculation had significantly increased the total dry weight of the salt-sensitive cultivar (IR29). Similarly, it has been reported that, the increase in proline accumulation in maize plants was positively correlated to plant dry weight [23]. Another study was also reported that [20], maize plant biomass was negatively correlated (R^2=0.84*** to 0.88***) with Na^+ accumulation, but positively correlated (R^2=0.59* to 0.58*) with K^+ concentration when plants were inoculated with plant growth promoting rhizobacteria. These reports also corroborate with the results in this study with a positive correlation between proline accumulation and plant biomass. Hence, the increase in total proline accumulation by the B. linens RS16 inoculation had resulted in overall increase in plant growth under salt stress conditions for both the rice cultivars. Further, the correlation between total dry weight and proline accumulationin the salt-sensitive cultivar (IR29) and the moderately salt-tolerant cultivar (FL478) also revealed significant positive correlation, but in the case of the salt-sensitive cultivar (IR29), it was highly correlated (0.61***). These results indicated that inoculation of B. linens RS16 had increased total dry weight significantly with the increased amount of

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Table 1. Effects of inoculation by *B. linens* RS16 on growth parameters of the salt-sensitive cultivar (IR29).

Variety	Day after salt treatment	Inoculation	Salt concentration (mM)	Root Length (cm)	Shoot Length (cm)	Total Length (cm)	Plant Dry Weight (mg)
IR29	3 day	Mock	0	13.62 ± 0.86 a	28.16 ± 0.71 a	41.78 ± 1.02 b	85.61 ± 2.81 b
		RS16	0	17.55 ± 1.35 a	29.17 ± 0.09 a	46.72 ± 1.28 a	112.37 ± 7.02 a
		Mock	50	13.03 ± 1.15 b	24.38 ± 0.19 b	37.41 ± 1.14 b	76.14 ± 6.59 a
		RS16	50	16.68 ± 0.27 a	27.50 ± 0.89 a	44.18 ± 0.82 a	90.58 ± 6.79 a
		Mock	150	11.23 ± 0.19 a	16.58 ± 1.42 a	27.82 ± 1.41 a	48.21 ± 4.93 a
		RS16	150	12.40 ± 0.78 a	18.86 ± 0.33 a	31.26 ± 0.83 a	59.98 ± 4.13 a
	10 day	Mock	0	16.73 ± 1.10 a	30.85 ± 0.67 b	47.58 ± 1.77 a	108.24 ± 0.73 b
		RS16	0	19.52 ± 2.27 a	35.80 ± 0.88 a	55.32 ± 2.82 a	144.28 ± 0.14 a
		Mock	50	14.61 ± 1.75 a	25.35 ± 0.37 b	39.96 ± 1.94 b	80.27 ± 1.06 b
		RS16	50	16.94 ± 1.08 a	31.70 ± 0.97 a	48.64 ± 0.14 a	134.34 ± 0.68 a
		Mock	150	12.67 ± 1.00 a	21.45 ± 0.14 b	34.12 ± 0.91 b	55.08 ± 3.09 b
		RS16	150	12.78 ± 0.30 a	27.08 ± 1.19 a	39.86 ± 1.13 a	92.40 ± 4.11 a

For each number in a column, values (mean ± SE, number of replications=3) represented by the same lower-case letters are not significantly different at P<0.05

Table 2. Effects of inoculation by *B. linens* RS16 on growth parameters of the moderately salt-tolerant cultivar (Fl478).

Variety	Day after salt treatment	Inoculation	Salt concentration (mM)	Root Length (cm)	Shoot Length (cm)	Total Length (cm)	Total Dry Weight (mg)
FL478	3 day	Mock	0	14.77 ± 0.83 a	30.48 ± 0.29 a	45.24 ± 1.12 a	125.06 ± 1.45 a
		RS16	0	15.56 ± 1.92 a	31.29 ± 0.29 a	46.85 ± 2.09 a	132.70 ± 7.05 a
		Mock	50	16.53 ± 0.27 a	28.98 ± 0.84 a	45.51 ± 1.04 a	107.03 ± 6.23 a
		RS16	50	17.22 ± 1.25 a	29.43 ± 0.36 a	46.65 ± 1.35 a	115.53 ± 3.39 a
		Mock	150	12.59 ± 1.22 a	23.38 ± 1.63 a	35.97 ± 0.42 b	67.78 ± 8.05 a
		RS16	150	14.24 ± 0.58 a	24.85 ± 1.03 a	39.09 ± 0.49 a	73.88 ± 2.49 a
	10 day	Mock	0	16.31 ± 0.35 a	38.37 ± 1.01 a	54.68 ± 0.74 a	160.06 ± 5.83 b
		RS16	0	17.54 ± 0.99 a	38.83 ± 0.84 a	56.38 ± 0.28 a	178.86 ± 0.82 a
		Mock	50	16.10 ± 0.95 a	36.84 ± 1.27 a	52.94 ± 1.78 a	145.05 ± 9.17 a
		RS16	50	16.18 ± 0.15 a	38.43 ± 0.55 a	54.62 ± 0.69 a	166.60 ± 5.66 a
		Mock	150	15.14 ± 0.78 a	34.58 ± 1.05 a	49.73 ± 0.43 a	101.11 ± 1.48 b
		RS16	150	15.23 ± 0.53 a	36.38 ± 1.03 a	51.60 ± 1.45 a	121.12 ± 3.02 a

For each number in a column, values (mean ± SE, number of replications=3) represented by the same lower-case letters are not significantly different at *P*<0.05

proline accumulation in the salt-sensitive cultivar (IR29) compared to the moderately salt-tolerant cultivar (FL478) to alleviate salt stress.

In agreement with these results, increased amount of proline has been reported in soybean plants grown under saline conditions upon inoculation with PGPR strains that alleviated salt stress and improved growth [24]. Root colonization with PGPRs in the wheat plant [25] with Azospirillum as a PGPR in plant [26] could also accumulate higher amount of proline as an osmoprotectant. These results indicated a more effective salt stress mitigation by B. linens RS16 in the salt-sensitive cultivar (IR29) compared to the moderately salt-tolerant cultivar (FL478) at 3 and 10 days under salt stress conditions (Fig.1).

Conclusions

The elevated levels of salt stress resulted in a significant decrease in growth of both the rice cultivars, but greater effect in plant growth reduction was observed in the salt-sensitive cultivar (IR29). The moderately salt-tolerant cultivar had accumulated significantly higher amount of proline compared to the salt-sensitive cultivar under salt stress conditions. However, the inoculation of B. linens RS16 had significantly increased the total accumulation of proline in the salt-sensitive cultivar, whereas, the indigenous accumulation of these compatible solute was relatively higher in the moderately salt-tolerant cultivar. Hence, the inoculation effect has pronounced effect on the solute accumulation in salt sensitive cultivar and implies the enhancement of salt tolerance leading to increase in plant growth under salt stress conditions.

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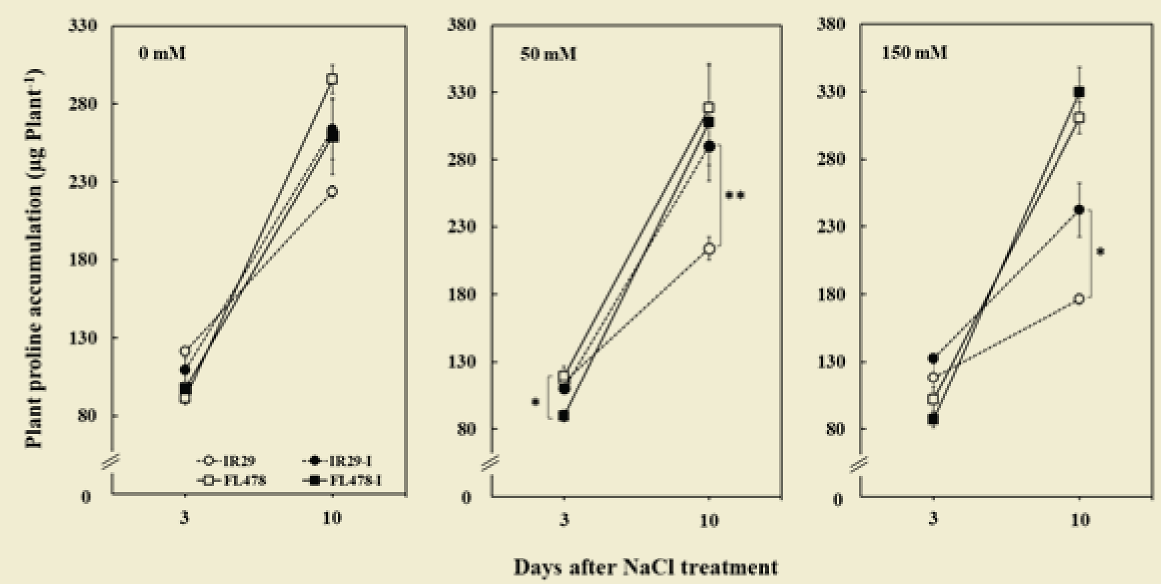

*Fig. 1. The total proline accumulation (µg) of the salt-sensitive cultivar (IR29) and the moderately salt-tolerant cultivar (FL478) at 3 and 10 under 0, 50 and 150 mM salt stress. ** is significant at p< 0.01; * is significant at p<0.05. IR29-I and FL478-I denotes IR29 and FL478 ltivars inoculated with B. linens RS16.*

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Causes and effect of salinity on ecosystem and its mitigation-adaptation to halt salinization for improving crop productivity

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Summary

A major challenge towards Bangladesh agriculture involves the production of 2-3% more food per annum for an additional 72 million people by 2050. On the other hand, the salt-affected area is increasing day by day. To increase crop production in saline soil mitigation (irrigation, drainage, protective shrimp culture and other management practices) and adaptation (salt-tolerant varieties, shifting planting time etc.) processes can miracle desalinize the saline soil to improve crop productivity. Integrated application of chemical, organic materials, and microbes can also desalinize the salt level of the soil. Rice straw and cow dung @ 3.0 t ha^{-1} along with gypsum (6.0 t ha^{-1}) and gypsum alone produced 45, 56, and 19% higher grain yield of rice than control means recommended dose of chemical fertilizer, respectively. Sweet water accessibility (channel from upstream river, watershed, low water requirement technologies/crops, and both salt and water producing industry) is needed for irrigation purposes in the dry season. If we want to get benefits from saline soil, we have to pay more for crop production in saline soil. The salt-tolerant crop is the most important inexpensive adaptation option to solve the salinity problem for the dry season. In conclusion, the mitigation-adaptation hybrid process is the best approach to desalinize the saline soil and increase crop production for ensuring food security and environmental protection of Bangladesh.

1. Introduction

Bangladesh is primarily an agro-based country. Agriculture sector of the country is suffering from various problems due to wide range and greater complexity of lands and climatic conditions. Among the problems, salinity is an extreme and frequent event in the south-west region of Bangladesh and the effect of salinity on agriculture is significant in Bangladesh. The coastal area of Bangladesh covers about 20% of the country and over 30% of the net cultivable area. Out of 2.85 million hectares of coastal and off-shore area, about 1.06 million hectare of arable land is affected by varying degrees of soil salinity (Haque, 2006). Recently, salinity both in terms of severity and extent has increased much due to the intrusion of saline sea water because of the diversion of the Ganges water in the dry season. A comparative study of the salt affected area between 1973 to 2009 (Fig. 1) showed that about 0.833 million hectares of saline soils were assessed in 1973 and in the year 2009 it was about 1.056 million hectares and about 0.223 million ha (26.7%) new land is affected by various degrees of salinity during the last four decades (Fig. 1). It was also found that newly six districts were saline affected from 1973 to 2009 and the salt affected area is increasing day by day. It is one of the most brutal environmental stresses that crops suffer on an account of high osmotic stress, nutritional disorders and toxicities, poor soil physical conditions and reduced crop productivity in Bangladesh. A major challenge towards Bangladesh agriculture involves the production of 2-3% more food per annum for an additional 72 million people by 2050 (FAO, 2009). Yet the total cultivable land is declining, at a rate of more than 1% per annum due to the construction of industry, factory, house, road, and highway. At present, farmers produce 3-4 crops per year excluding problem soils of Bangladesh as a result; further the increase of cropping intensity is not possible in those areas.

The present review is launched to enhance the crop productivity by effective desalinizing practices as well as improvement of salt tolerant crop varieties for the saline areas of Bangladesh. If we can successfully hunt the effective technologies for the 30% of net cultivable arable land of Bangladesh as saline by soil and crop improvement which can ensure food security for ever growing population of Bangladesh.

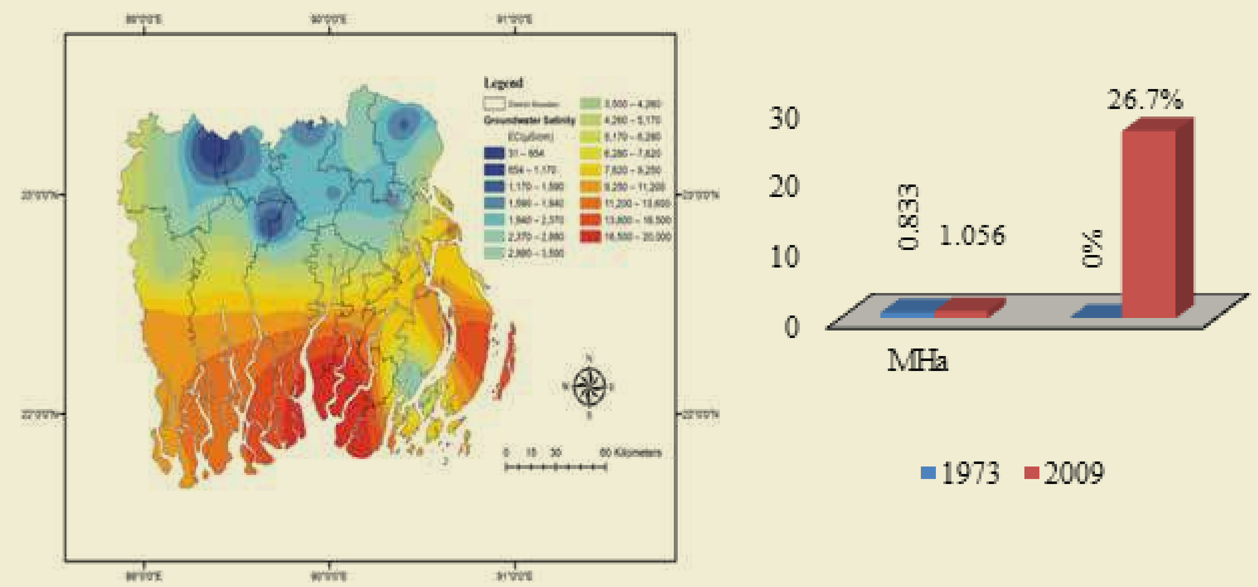

Fig. 1. Salt affected areas and its increasing trend from 1973 to 2009 in coastal areas of Bangladesh

2. Causes of soil salinization

Soil salinization occurs when soluble salts are retained in the earth. It ensues either naturally or improper anthropogenic activities, particularly farming practices. Besides, some earth is initially saline due to low salt dissolution and removal. Causes of soil salinization are as follows:

- earth can't flush of excessive salts due to dry climate and low precipitation;
- salt is added on the ground surface by high evaporation rate;
- poor drainage or waterlogged soil can't wash excessive salts because of the lack of water transportation;
- irrigation with salt-rich water amplifies salt content in the earth;
- removal of deep-rooted vegetation as well as a raised water table as a consequence of salinization;
- groundwater receives salinization compounds from geological deposits;
- sea salts seep into lower lands due to sea-level rise;
- blowing salty air masses to the nearby territories by breezes in the coastal areas;
- seawater submergence followed by salt evaporation;
- excess nitrification accelerates soil salinization due to inappropriate application of fertilizers.

3. Adverse effects of salinization

Salinization is the process which accumulation of excessive salts in the soil. The list of the soluble salts is the compounds of sodium, potassium, calcium, magnesium, sulfates, chlorides, carbohydrates, and bicarbonates. The salient feature of soil salinity effect on plant growth is tampering with water absorption. Notwithstanding, the sufficient soil moisture in the soil, crops wade and die due to the inability to take up enough water. Soil salinization affects multiple aspects of ecology and human life. It affects crop production, the risk of floods and soil erosion, and decreasing biodiversity.

3.1 Agricultural production

Water saturation in plants relies on the level of salts in groundwater and the plant itself. Water is absorbed in

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plants by the process of osmosis, and it fluxes from lower salt-concentrated areas to higher concentrated ones. When the salt concentration is too high, that means the soil's osmotic potential is essentially negative. Plants suffer from osmotic stress because they fail to take up water, even when it is present in the soil. This process is similar to drought stress due to a lack of moisture in the ground. As a result, vegetation dies. Salt-affected soils tamper with nitrogen uptake too, which slows plant development and causes a yield loss. Another effect of saline soil on agriculture is ionic stress due to harmful ions in soil salts, e.g., chloride or sodium. Apart from their toxic impacts, positively charged ions impede the acquisition of other positively charged ions vital for crop growth (particularly potassium and calcium). The result is the same with osmotic stress due to salinization – vegetation dies.

3.2 Water quality

Salinization problem is not only accumulating in the earth but penetrating to initially freshwater bodies as well, leading to their salinization. It deteriorates drinking and irrigation water as well as adds to further salinization of dry lands. The impact of multifold:

- contaminates the farmlands;
- abandon river species of their natural habitats;
- destroy the taste of drinking water for humans and domestic animals;
- reduces access to freshwater for grazing cattle.

3.3 Biodiversity

Salt tolerant species and halophytes can survive in saline soil, but other non-tolerant species do not suitable in strongly saline soil. Ecosystem varieties are reduced and threaten their normal conditions to exist due to salinization. Fauna is reduced through the reduction of flora diversity and shortening food chains and areas of habitats by salinization.

3.4 Surface changes due to salinization

Surface change is happened due to salinization which are as follows:

- damp areas and waterlogging;
- ground whitening at early stages and salt crystal form at late ones;
- water level increases in furrows;
- bare soil is formed where plants fail to grow due to salinization;
- deterioration of roads, buildings etc.;
- white or dark circles form around water bodies.

4. Stop the salinization for increasing crop productivity

There are two major important strategies such as mitigation and adaptation to reduce salinity and increase crop productivity. These are in brief discussion which is as follows:

4.1 Mitigation strategies

Mitigation processes are discussed in (Fig. 2). The Ganges River is the major source of water for dry season irrigation, navigation, fisheries and reducing salinity intrusion as well as maintaining ecosystem of south-western region in Bangladesh. Significant changes have occurred in the hydrological flow of Ganges River during pre-Farakka (1935-1975) and post-Farakka (1976-2015) periods. During post-Farakka period, monthly maximum, average and minimum discharges have been significantly reduced 23, 43 and 65% in February-May, December-May and February-April, respectively from the post water sharing treaty period (1997-2015). Due to long term significant reduction of the Ganges flow at Farakka, south-western region of Bangladesh has been suffering from environmental degradation. So, it is an important issue to negotiate between Bangladesh and India through the Joint River Commission for maximum discharge of water in the dry season, which can help to control the salinization process in the southwestern part of Bangladesh. Salt affected soils are generally two types such as saline and sodic soils, and 3rd is saline-sodic soil, the intermediate between saline and sodic soil. Sodic soil is also known as alkaline soil. Polders can inhibit the inundation of surface soil by sea water during high tide and ingress of sea water through rivers. Scrapping is needed when salinity is more and visible on the surface. For horticultural crops, saline resistant rootstock is chosen for new planting. A good mulch reduces surface evaporation, maintain moisture near the soil surface and lessens the build-up of soil salinity.

Regular monitoring the saline level of soil is important factor to control salinity in soil. Excessive soluble salts are present in the root zone are the problem for plant growth. Irrigation and drainage are effective methods to reduce the salinity of root zone soil. Salinity can reduce from the root zone through irrigation water because of good soil aggregation, percolation, and infiltration capacity. Before going to irrigation practice for the reclamation of saline soil, we have to consider three points which are as follows: i) quality of irrigation water, controlled leaching water, and quantity of irrigation water. The effective application of these three ways helps to sustain soil

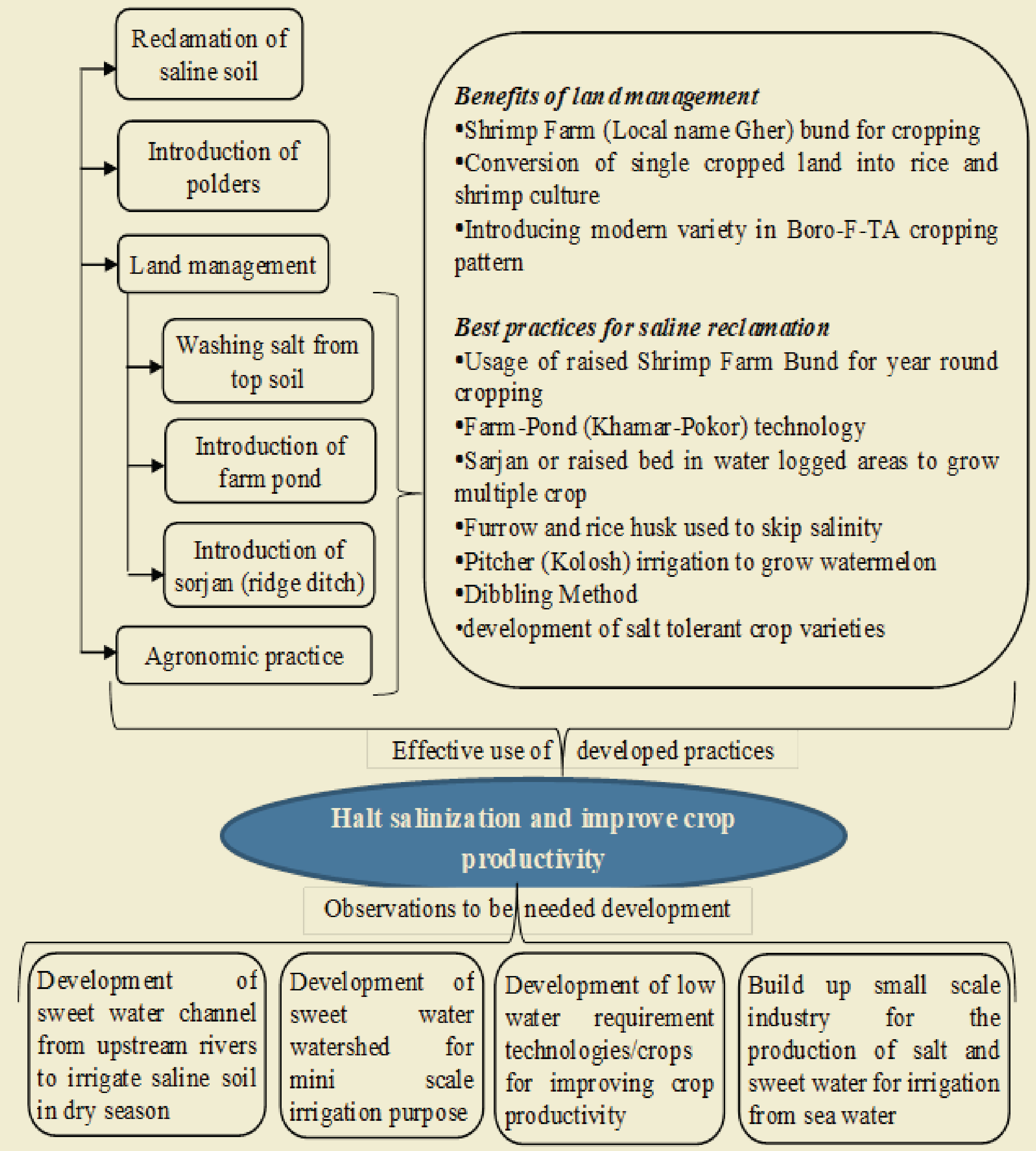

Fig. 2. Flow diagram of developed practices and proposed observations on desalinization and crop productivity

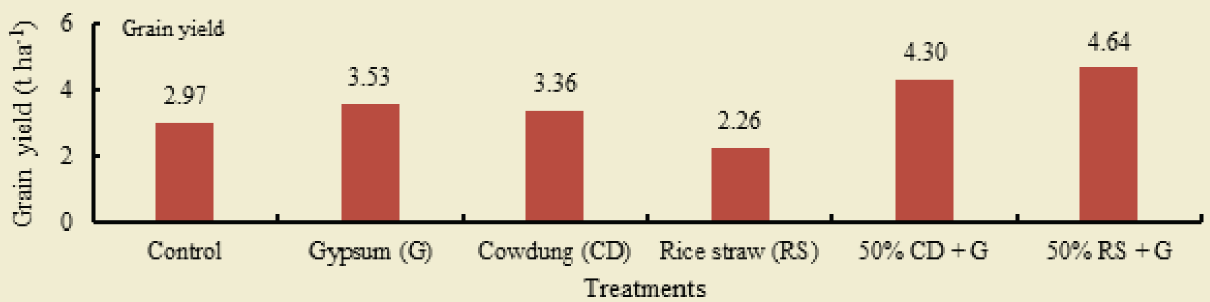

Fig. 3. Effect of organic and inorganic amendments on rice yield (adapted from Hossain and Sarker, 2015)

moisture and sufficient plant nutrients by leaching excessive salts from the root zone of the crop. Effective drainage and a high water table create good conditions for inhibiting salinization in the root growth of crops. In this regard, irrigation depth 30-40 cm is good for the desalinization of saline soil. Soluble salt leaching is poor in sodic soil due to very low infiltration and percolation capacity. This leaching problem can be overcome by tillage, leveling, and the application of amendments. Sodic soil is amended by gypsum $[Ca(SO_4)_2, 2H_2O]$ and after leaching by irrigation water. Reclamation of saline soil depends on the amount and nature of the salts or ions present in the soil. The minimum leaching requirement (MLR) is MLR = ECWA ÷ [(7.5 × ECWY%) ÷ ECWA], where ECWA is the electrical conductivity (EC) of available irrigation water and ECWY salinity level of the irrigation water that results in a specific percentage yield loss. Lentil crop is survived and performed significant yield due to inoculation of Rhizobium strain (Hossain, 2018). Several strategies can be considered to mitigate or reduce soil salinity. The possibilities include the development of freshwater channels from upstream rivers, watersheds for sweet water, low water requirement technologies, and salt with freshwater producing industry to stop salinization and increase crop productivity.

Rice and cow dung @ 3.0 t ha^{-1} along with gypsum (6.0 t ha^{-1}) and gypsum alone produced 45, 56, and 19% higher grain yield than control means recommended dose of chemical fertilizer, respectively (Hossain and Sarker, 2015) (Fig. 3).

4.2 Adaptation strategies

Crops reduce the salinity by removal of excess soluble salts and reducing evapotranspiration as vegetation in saline soil. Decomposed crop residues adsorb cations on their exchangeable sites to reduce the soil salinity. The salt-tolerant crop is the most important option to solve the salinity problem for the dry season. Salt tolerant varieties can successfully detoxify ion toxicity, reduce osmotic stress, increase nutrient (N, Ca, K, P, Fe, Zn) availability, and reduce oxidative stress at germination, vegetative growth, and reproductive stages of the plant. The scientists of Bangladesh release salt-tolerant rice varieties which can tolerate a salinity of up to 8 dS/m. Traditional varieties of most crops can stand salinity up to 0.7dS/m only. The latest

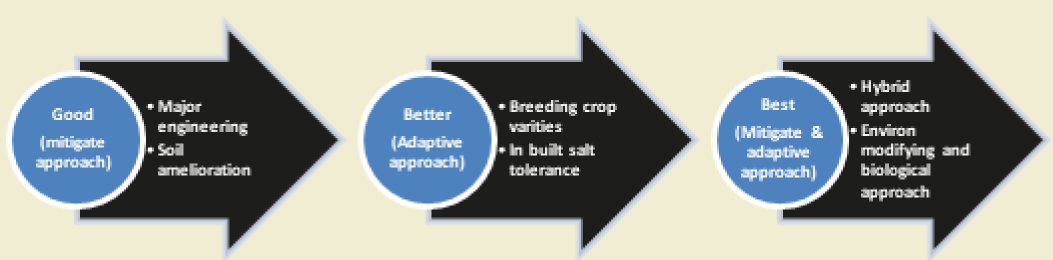

Fig. 4. Comparative performance of mitigation, adaptation, and mitigation–adaptation approaches for saline soil management and crop production

advancements in the field of genomic, transcriptomic, proteomic, and metabolomic techniques, plant biologists are focusing on the development of a complete profile of genes, proteins, and metabolites responsible for different mechanisms of salinity tolerance in different plant species (Hanin et al., 2016). Rice is a transplanted crop that can alleviate the salt stresses at the seedling stage by the aged seedlings plantation. Shifting crop cultivation time is another approach to escape salinity problems during crop production.

For saline soil management, mitigation and adaptation are effective for desalinization and crop production (Fig. 4). The mitigation process involves the major engineering and soil amelioration process, which needs a lot of resources that are often out of the reach of small and marginal farmers. On the other hand, the adaptation processes breeding crop varieties with in-built salt tolerance is the most promising, less resource-consuming/economical, and socially acceptable approach. So, the ability of plants to tolerate the salt stress up to an extent is of paramount importance to manage the resources optimally and this is the reason to develop tailored crops with higher salt tolerance suited to salt stress environments. The third approach is the hybrid approach of environment modifying and biological approaches. It is a highly productive, less

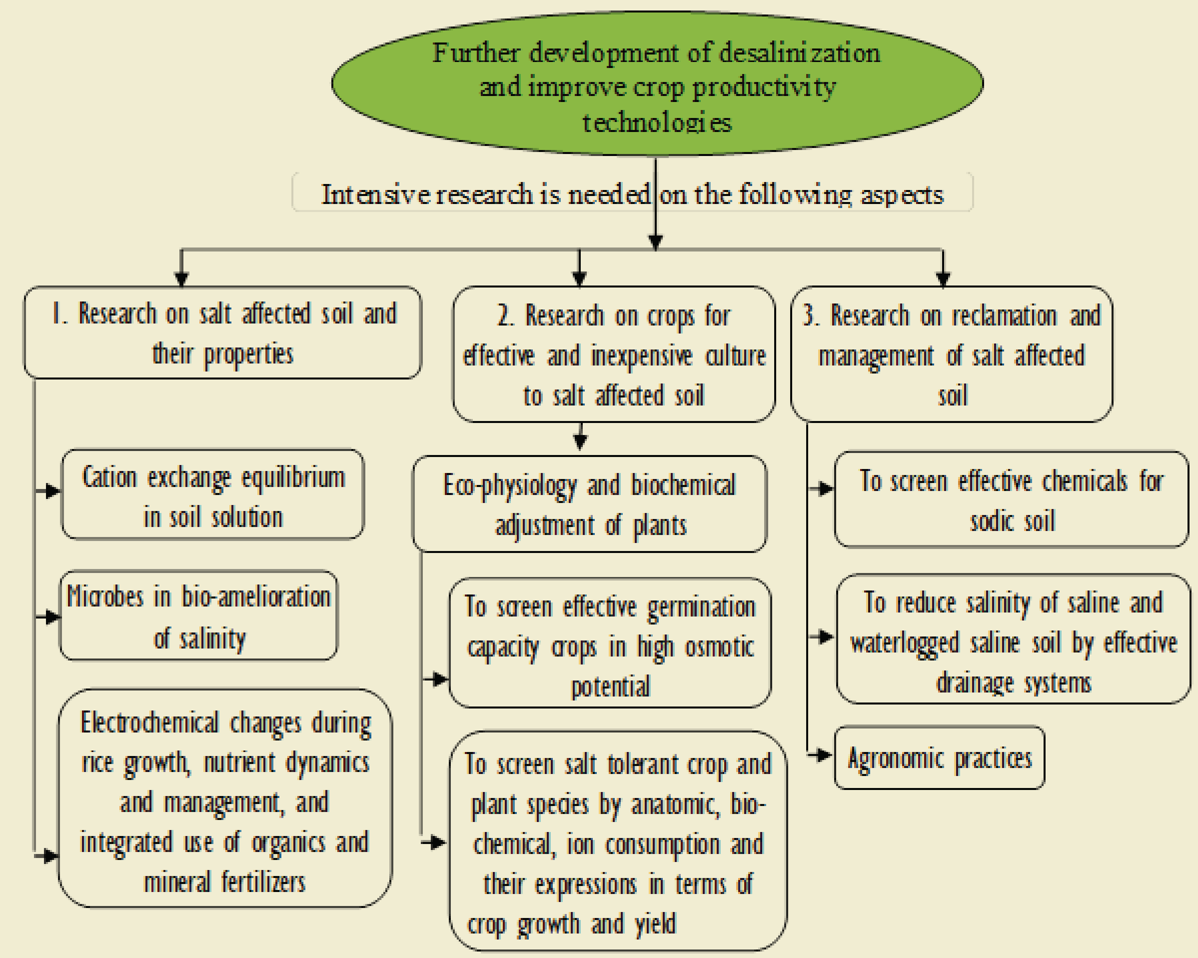

Fig. 5. Research activities are needed to reduce soil salinity and improve crop productivity

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resource-consuming, and economically viable approach. Nowadays, major soil reclamation programs involve both biological and hybrid approaches to combat the salt problem.

5. Future research and extension issues in salt affected soils

Further research and extension are needed to break through to reduce the salinization of soil for increasing crop productivity which is as follows (Fig. 5):

- development of short duration with high yielding aman rice variety;
- development of low water requirement technologies and crops varieties;
- development of intensive vegetation on roadside and ail of arable land to reduce evapotranspirtation from soil;
- to encourage protective pond system shrimp cultivation instead of open water bodys;
- hands-on field demonstrations, trainings to the farmers, women, youths, farm labourers and subsequent collaboration with governmental line departments helped in rapid spread of the technology;
- technology should be developed by combined use of gypsum, calcium chloride, press mud, acids, acid-formers, fly ash for reducing salinity level of soil.
- to study intercellular and intracellular molecular interactions involved in salinity stress response.
- development of salinity-tolerant plants to candidate genes associated with salinity tolerance are identified and widely utilized through genetic engineering.
- isotope-oriented research is needed to identify the insight causes of salinization, the effect of salinity on crops, and mitigation-adaptation measures to improve crop production.

5. Conclusion

Mitigation, adaptation and mitigation-adaptation hybrid processes desalinize the saline soil to increase crop production for ensuring food security and environmental protection of Bangladesh.

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Saline Soil: Challenges for Agriculture in 21st Century

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Introduction

Salts are a naturally occurring substance in both soil and water. Increases in soil salinity, or salinization, can occur for a number of reasons including flooding from seawater, saltwater intrusion through the soil, recurring cycles of irrigation and use of fertilizers. Unfortunately, this phenomenon can have detrimental effects on farming as many crops do not thrive in such saline conditions. As salinization is on the rise across the globe, the amount of land suitable for agriculture continues to decrease. Farmers are more and more unable to use their lands, which can lead to food insecurity as well as economic challenges.

The deltaic country with an areas of 14,7570 km^2 is Bangladesh of which almost 29,000 km^2 or about 20% of the country is under coastal region and the coastal areas cover more than 30% of the cultivable lands of the country. About 53% of the coastal areas are affected by salinity. Agricultural land use in these areas is very poor, which is much lower than country's averagecropping intensity. Salinity causes unfavorable environment and hydrological situation that restrict the normal crop production throughout the year. The factors which contributesignificantly to the development of saline soil are, tidal flooding during wet season (June-October), direct inundation by saline water, and upward or lateral movement of saline ground water during dry season (November-May). The severity of salinity problem in Bangladesh increases with the desiccation of the soil. It affects crops depending on degree of salinity at the critical stages of growth, which reduces yield and in severe cases total yield is lost.

Soil reaction values (pH) in coastal regions range from 6.0-8.4. The organic matter content of the soils is also pretty low (1.0-1.5%). Nutrient deficiencies of N and P are quite dominant in saline soils. Micronutrients, such as Cu and Zn are widespread. During the wet monsoon the severity of salt injury is reduced due to dilution of the salt in the root-zone of the standing crop. The dominant crop grown in the saline areas is local transplanted Aman rice crop with low yields. Salinity problem received very little attention in the past. It has become imperative to explore the possibilities of increasing potential of these (saline) lands for increased production of crops.

Traditional farming techniques use fresh water for irrigation, but as fresh water is a limited resource, it is becoming even more important to adapt and find alternatives. With saline agriculture, food is produced in salt-affected soil and brackish water is used for irrigation. There happens to be as much brackish water in the world as there is fresh water. So, if all of the world's brackish water would be used for irrigation it could effectively double the amount of available water for agriculture, helping to reduce water stress in many areas. And with millions of hectares of degraded soils around the world, there is great potential for saline agriculture.

Population growth and agriculture challenges in the 21st century

The United Nations (2008) predicted a population increase up to 8.01 thousand million people in 2025. This represents a duplication of human population in approximately 50 years. So, agriculture strategies for feeding all people represent one of the most important challenges in the 21st century. Therefore, there is enormous demographic and economic pressure to rise, within the next 40 years, leading to an increase of the crop production by about 50% years in a sustainable manner to fulfil the world food necessities (N. Borlaug, 2007 &Guillon et al. 2012). Some other facts are aggravating this demand, namely,

(a) Increase of land occupation for bio-fuel supply that deviates arable soils from food crops [3],

(b) Challenges posed by increasing occasional episodes of extreme environmental conditions and even natural disasters often associated with the

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generally called "climate change events",

(c) Excesses in soil pressure posed by post-green revolution practices;

(d) Raise of soil degradation and/or the increase of saline soils is growing dramatically, reducing the area of arable land.

Agriculture improvement and adjustment to the 21st challenges also needs to take into consideration the type of land and water available (FAO, 1992 & Khan et. al. 2001). It is estimated that the agricultural production increase will need around 202 × 10^6 ha of arable soil in developing countries, but only approximately 93 × 10^6 ha seem available([Khan et. al. 2001 & E. P. Glenn 1992). These data support the need to develop strategies of sustainable agriculture contrarily to what it should be expected if real sustainable agriculture practices dominated. Millions of ha of agricultural land are lost every year, mostly during the last 50–60 years of agricultural development (due to, e.g., unsustainable irrigation practices, excessive use of fertilizers, soil contamination, urban pressure, climate changes).

Fortunately, it is increasing the number of countries that subscribe the principles inherent of sustainable development and address the Millennium Development Goals, so pressure to use sustainable strategies is rising (e.g., soil and water conservation), despite the increasing pressure for food supply and urbanization.

Insufficient freshwater, salt contamination and soil degradation

Despite it may be considered as having an ubiquitous distribution in all the continents of the world, most of the arid and semiarid regions are located in developing countries (Rasouli et. al. 2012). Many countries possess crop production practices with unconventional water resources irrigation, and the use of brackish water deserves particular attention. Salinity is one of the most widespread soil degradation processes on the Earth. Soil salinisation affects an estimated 1 to 3 million hectares in Europe, mainly in the Mediterranean countries. It is regarded as a major cause of desertification and therefore is a serious form of soil degradation being salinisation and sodification among the major degradation processes endangering the potential use of European soils. The decrease of water availability is found in these developing regions of burgeoning population pressure, and limits the area of arable land and crop production for these people. As stated by Galvani (Galvani, et al. 2007), when it comes to extreme environments, such as arid and semiarid areas, pressure must be put in major adjustments in alternative agriculture (Qadir and Oster, 2004).

Soil and water availability in saline soil

An innovative strategy for enhancing land and water availability is the use of salted soils and water, in a strategy designated as saline agriculture. This strategy is not new, as for example, the use of seawater for crop production in coastal deserts has already been suggested in the last three decades (Glenn, 1997)

Profitable and improved agricultural practices using saline land and saline irrigation water with the purpose to achieve better production through a sustainable and integrated use of genetic resources (plants, animals, fish, insects, and microorganisms) avoiding expensive soil recovery measures (Aslam et. al. 2009) can be described as saline agriculture.

The saline water that may be used in halophyte crop irrigation can be, for example, seawater, salt-contaminated phreatic sheets, brackish water, drainage water from other plantations irrigation, drainage water from humanized areas, or even water derived from aquaculture waste (Porto, et al. 2006). It was suggested that around half of the irrigation systems are susceptible to salt contamination or water logging, probably due to low quality of used water, leaching, and rising water tables. It is therefore clear that, facing the human population pressure, the technological advances, and the increase of salinized soils and reduction of arable land usable by conventional agriculture, the use of these salinized soils in alternative agriculture may be regarded as a strategy to cope with food demand (Shekhawat, et. al. 2006).

Saline Agriculture: An Opportunity for Saline Soils Use

Soil salinization has numerous origins, namely, natural causes provoked by, for example, the microscopic salt particles carried by the wind to inland from the oceans, or, as discussed above, some anthropic causes (secondary salinization) (Yensen, et al. 2006), among which irrigation water quality is one of the most important. The use of salinized land through drainage/irrigation without using high-quality water, but instead also some salinized water, may be, therefore, the solution but demands exploration of the potential of halophytes as new emerging crops and changing mankind habits to incorporate this new crops in daily diet (Qadir and Oster 2004).

The selection of tolerant plants with promising yields and characteristics that make them interesting as crops in saline agriculture: (a) screen of literature for their natural habitats, and so forth; (b) after selecting the species, determining the salinity threshold (Munns 2002).

(1) high yield potential; (2) the irrigation needs must not exceed the conventional crops and be harmless to the soil; (3) the products from halophyte crops must be able to replace the conventional crop products; (4) high-salinity agriculture must be applicable to the existing agricultural infrastructure (Glenn, et al. 1999).

Holophyte crops

The potentiality of using halophytes in saline agriculture has been explored in the last decades. The use of halophytes in commercial cultures/ exploitation, though still limited, is already being applied for some species. Also, the project "Greening Eritrea" from the Seawater Foundation represents an example of how to convert a decertified region into a useful soil.

Halophytes can be improved into new, salt-resistant crops, or used as a source of genes to be introduced into conventional crop species that in general have their economical production decreased as soil salt levels increase. Fuels such as biodiesel can be produced from biomass ranging from cow manure to wood chips. The advantage of developing biofuel from halophytes as opposed to other types of biomass is that saltwater plants are not dependent on fresh water, which is in increasingly short supply, and can instead be irrigated using plentiful seawater supplies.

Environmental and economic impact of saline agriculture.

Vegetation over saline soils tends to decrease salt concentration in the top soil due to increased infiltration and reduced capillary rise of water. This approach can allow farmers to get instant economic returns by growing field crops and also immediate economic benefits from saline wasteland with the help of trees. Such planting is preferred to various expensive engineering methods since it is cheaper and lasting. The environmental impact assessment (EIA) needs equally to concentrate on means in which positive impacts can be enhanced and negative impacts mitigated (FAO, 1992).

Yamaguchi and Blumwald (2005) consider the "identification of key genetic determinants of stress tolerance" a precondition to the knowledge expansion on salt tolerant crops. These same authors consider two different genetic approaches, first the exploitation of natural genetic variations through marker-assisted breeding and second the generation of transgenic plants, a very popular subject that is being currently addressed by researchers. In fact, the use and improvement of conventional and molecular breeding (as well as molecular genetic modification GM) are subjects of research to adapt our existing food crops to increasing temperatures, decreased water availability in some places and flooding in others, rising salinity [64], and changing pathogen and insect threats (Gregory et al. 2009). An environmental and important good of such research is to increase the efficiency of crops nitrogen uptake and use, due to nitrogenous compounds in fertilizers being the main contributors to waterway eutrophication and greenhouse gas emissions (Fedoroff, 2010).

Salinity in Bangladesh

This study identifies soil salinization in coastal Bangladesh as a major risk from climate change. In the coming decades, soil salinity will significantly increase in many areas of Barisal, Chittagong and Khulna districts. The study assesses changes in soil salinity in coastal Bangladesh from 2001-2009, using salinity information recorded at 41 soil monitoring stations by the Soil Resource and Development Institute (Fig.1). It projects a median increase of 26%

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in salinity by 2050, with increases over 55% in the most affected areas.

Bangladesh is one of the countries that are most vulnerable to climate change and sea-level rise. Although climate related increases in salinity from saltwater intrusion in coastal areas have been highlighted as a serious problem, systematic studies of spatiotemporal impacts are scarce in Bangladesh. The climate change poses a major soil salinization risk for coastal Bangladesh and will have median changes by 2050 in annual, dry season, and wet season soil salinity will be 39.2, 13.1, and 36.6 %, respectively. Many areas will have significantly greater increases, like in Barisal, Chittagong, and Khulna Districts will have very large increases in soil salinity during the coming decades. Many upazilas have already suffered significant losses, which will be compounded by further salinity increases in the coming decades. This inexorable process will continue as long as the sea continues to rise and salinity increases in coastal rivers. No prospect for near-term relief is apparent, since rising global greenhouse gas emissions continue to propel rapid climate change and melting of the polar ice caps.

Strategy for management of coastal saline soils:

Provision of sluice gate on the embankment: Establish of protective embankment for saline water inclusion in the crop field. There should be provision of sluice gate in the embankment system to remove excess water and also to prevent ingress of saline water during high tidal.

Leveling of land: Slight variations are generally observed in the micro-relief lead to salt accumulation in the raised spots. Land should be properly leveled to prevent accumulation of water in the low-lying patches with shallow ground water tables and to facilitate uniform drainage of excess water. It will help to apply irrigation water uniformly in the field in rabi season, facilitate uniform germination of seeds and better growth of crops.

Storing of excess rainwater for irrigation: A part of the excess water stored in pond after meeting the requirements of the kharif season can be utilized during the dry period for rabi crops.

Selection of kharif rice variety: Even though the coastal area is relatively flat, there exist elevation differences in areas, where depths of standing water

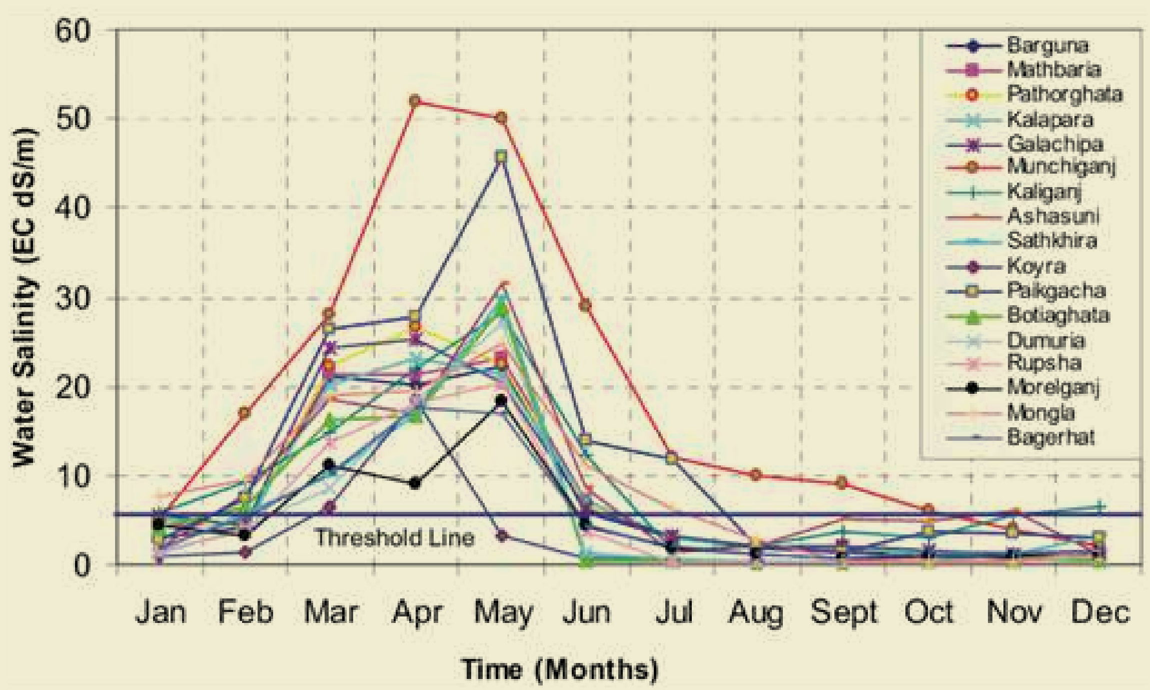

Fig. 1. Monthly salinity intrusions in the coastal small towns in Bangladesh (2010)

ranges from 15-90 cm. Selection of rice varieties (Binadhan-8, 10 and BRRI dhan 23, 30, 40 and 41), available in the country on the basis of standing water and extent of salinity in the field can overcome the situation to a great extent.

Introduction of crop in rabi (winter) season: Cropping intensity can be increased in about 0.596 million hectares of very slight and slightly saline areas by adopting proper soil and water management practices with the introduction of salt tolerant crop varieties.

Keeping land covered in winter and summer months: Ground water is saline and present at a shallow depth (about 1.0 meter). Keeping lands fallow leads to high salinity in soil due to evaporation of excessive soil moisture. Therefore, it is recommended to avoid fallowing of lands during rabi season. Salt tolerant crops should be chosen and grown.

Fertilization of crops: Since, soils in general are poor in fertility with low organic matter content, it is necessary to apply appropriate fertilizers to boost up crop production. Potash fertilizer has an added advantage under soil salinity. It lowers down Na uptake by plants and of course increases K uptake. Thus, K fertilization protects crops from harmful effects of Na.

Provision of sub-surface drainage: In many parts of the coastal area, salinity is very high. To grow crops successfully in those areas, it is necessary to bring down the salinity by leaching the salts. It is also necessary to lower down the water table and maintain it blow the critical depth to prevent salt effect on crops grown. A proper sub-surface drainage has to be installed to keep the ground water at least one meter below the soil surface. This technology is effective but somewhat expensive.

The 4R's of Nutrient Stewardship

The 4R's of nutrient stewardship, or nutrient management, are commonly referred to when talking about proper nutrient application. The 4R's stand for right source, right rate, right time, and right place and serve to guide farmers to the management practices that help keep nutrients on and in the field. Implementation of the 4R's helps to align the economic, environmental, and social components of nutrient management. The Nutrient Stewardship 4R Pocket Guide helps to explain what the components are of each of the 4R's.

The first R is Right source. In order to determine the right source, the following should be taken into account about the fer4tilizer being used as commercial or manure depending on the nutrient status of the soil. The Right Rate describe about the specific demand of the crops based on individual field fertility, appropriate distribution, yield target and considering the law of diminishing returns. The third R is Right Time that expresses the plan for fertilizer nutrients to be available during crop demand, consider the weather and seasonal conditions and with short-term planning of nutrient applications and includes mitigation of potential odors, mainly with manure. Lastly, the Right Place determine the place fertilizer in the root zone, where crops can successfully access the nutrients, crop being grown, soil type, slope, distance to surface waters, soil characteristics (can differ throughout the field) like nutrient supply capacity and the vulnerability to nutrient loss, phosphorus or P-Index and potentially incorporate GPS and variable rate seeding data.

Nuclear and Isotopic Techniques in saline soil

Nuclear and isotopic techniques (also called nuclear-based techniques) are a complement to, not a substitute for, non-nuclear conventional techniques. Isotopic techniques provide useful information in assessing soil-water-nutrient management which can be tailored to specific agro-ecosystems for managing soil salinity. The soil moisture neutron probe is ideal in field-scale rooting zone measurement of soil water, providing accurate data on the availability of water for determining crop water use and water use efficiency. Under saline conditions, the presence of excessive salts (especially Na+) in the soil solution, coupled with a high soil pH, is likely to further increase the competition between N uptake by the plant and the soil N losses, thereby reducing crop productivity further. Quantifying N use efficiency and the sources of N losses enables researchers to develop ‘technology packages’ which can enhance N uptake and minimize N losses, thus allowing for sustainable crop productivity under saline conditions.

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Conclusion

The demand of nutrient is increasing by the prosperous society and the decreasing availability of arable land and freshwater leads to the problem of agriculture sustainable development. With these perspectives, saline agriculture is coming up as an emerging role. Among the stresses in plant agriculture worldwide, the increase of soil salinity is considered the major stress. Therefore, salt-tolerant plants provide a sensible alternative for many developing countries. These plants have the capacity to grow using land and water unsuitable for conventional crops producing food, fuel, fodder, fibber, resin, essential oils, and pharmaceutical products. Without a comprehensive and long-term strategy adaptable to the prevailing economic, climatic, social, as well as edaphic and hydrogeological conditions, it is not considered possible to meet the future challenges of irrigated agriculture using poor-quality water.

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Bangladesh Soil Club: The caravan of hope for the young dreamers of Bangladesh

Md. Mamun Hossain, President, Bangladesh Soil Club
Shomir Kumar Halder, General Secretary, Bangladesh Soil Club

Bangladesh Soil Club is an organization of young dreamers studying soil science which was established in 2018 through some dreamers and is now emerging in the 4th year. It is an organization that seeks to keep the students of soil and ecology alive by discussing various contemporary issues of soil and environment in terms of realities.

To keep them alive, Bangladesh Soil Club regularly organizes various meetings, seminars, training workshops etc. at different times. To develop the latent talents of soil science students, the organization is organizing various national competitions such as Article Contest, Art Contest, Pencil Sketch and Writing for many more useful events.

Following this, Bangladesh Soil Club approved their 12 chapter committees at the beginning of 2021 and organized an in-house training program with the committee members after renewing the old members and recruiting new members. It is held in two steps. Mr. Md. Moniruzzaman Majumder, Founder President and Permanent Adviser of Bangladesh Soil Club was the trainer in the first phase. In this phase training was given to the Central Committee of Bangladesh Soil Club and in the second phase, the presidents, vice-presidents, general secretaries, joint general secretaries and organizational secretaries of different chapter committees received training. Shomir Kumar Halder, General Secretary of Bangladesh Soil Club was the coach in the third phase. At this stage the training was received by the finance secretary and executive members 1, 2 and 3 of the various chapter committees.

Soil is part of the environment, so on the occasion of World Environment Day, the Soil Club organized a discussion meeting with the members of the Central Committee. The present President of Bangladesh Soil Club Md. Mamun Hossain and General Secretary Shomir Kumar Halder were also present in the discussion. Our lives are inextricably linked with the soil. If the soil is healthy, the country will be healthy, the people of the country will be healthy.

And in order to create awareness among all, Bangladesh Soil Club organized an article contest on "Soil Health Management" in September. More than 50 articles from different universities of the country were submitted in the contest and out of them, three articles were selected on the basis of a thorough evaluation of the selected constituencies and the 1st, 2nd and 3rd place was determined.

A webinar on basic research was organized in November to keep students studying soil science free from frustration and to provide ideas about careers as well as to motivate students in research.

Mr. AFM Manzurul Haque, Principal Scientific Officer of SRDI and a member of the advisory board of

Bangladesh Soil Club, provided career discussion and guideline in the webinar and Mr. Dr. Md. Enayet Hossain, ChapterModerator of University of Dhaka Chapter of Bangladesh Soil Club enlightened with knowledge of research methodology in basic research arena of soil science.

Bangladesh Soil Club as before; The National Soil Olympiad was organized in November by the joint venture of Soil Science Society of Bangladesh (SSSB). Held in two stages, the first stage of the Olympiad is held in person in each chapter under the direct supervision of a respected moderator and chapter committee.

For the first time, Soil Science Society of Bangladesh provided question papers to keep the selection process transparent. At the end of the 1st stage selection, three students from each chapter physically participate in the final examination. The three are selected and rewarded through a final examination.

Also, Bangladesh Soil Club based on the theme of World Soil Day 2021; A seminar will be held at Dhaka University on December 11-12, a joint venture of Bangladesh Soil Science Society.

Bangladesh Soil Club is committed to uniting the students studying soil science and at the same time is working relentlessly to create awareness among all and will continue to do so in the near future.

Bangladesh Soil Club is constantly making the students of different universities of Bangladesh interested in various aspects including technical training of soil science students and they are also working diligently for the development of soil in Bangladesh. Bangladesh Soil Club is always striving for the implementation of the Sustainable Development Goals, even if it is very small.

Bangladesh Soil Club will work in the future to make school level students aware about soil and how to make the general public aware about the prevention of soil contamination because if today's children are our hope for the future, then we can make today's children aware of soil. So, in the future, our soil will be good, if the soil is good, our dream Bangladesh will be built.

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SOIL CARE AWARD 2021

ACADEMICIAN

Life Sketch of Professor Dr. A.R.M. Solaiman

Professor Dr. A. R. M. Solaiman was born in 1955 in a village named Gobrikuraof SreebardiUpazila under Sherpur district. He passed SSC examination from Nandina M.H.K. Pilot High School in 1971 and HSC examination from Nandina College in 1973. He obtained B.Sc. Ag. (Hons) degree in 1977 and M.Sc. Ag.(Soil Science) degree in 1978 from Bangladesh Agricultural University (BAU), Mymensingh and secured 1st class in both degrees. Professor Solaiman obtained PhD degree in Soil Microbiology from the Queen's University of Belfast, UK in 1988under the auspices of Commonwealth Scholarship. He did post-doctoral research on Arsenic Toxicity in Soil during 2005-2006inthe University of Aberdeen, UK under Commonwealth Fellowship Program. He also enjoyed Rhine-Waal University (Germany) Fellowship for pursuing research on Microbial Aspects of Soil-Plant System as Visiting Scholar during September to December, 2015.

Professor Solaiman started his carrier as Scientific Officer in Bangladesh Institute of Nuclear Agriculture (BINA) in 1980 where he served as Principal Scientific Officer from1990-1996. He started his new carrier as Associate Professor in the Department of Soil Science of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) from April, 1996. During his academic carrier he served as Research Supervisor/Major Professor for 15 PhD and 30 MS students and also served as Co-supervisor/Member of Advisory Committee for 34 PhD and 50 MS students. His total number of research publication in the national and international journals/proceedings is more than 150. In his glorious academic carrier, he enjoyed many responsibilities like Dean, Faculty of Graduate Studies; Director (International Affairs); Director (Research); Head of the Department of Soil Science; Head of the Department and Biotechnology; Library Chief; Syndicate Member; Member of Academic Council; Member of Trusty Board of the Welfare Fund of Teachers, Officers and Staffs of BSMRAU. Professor Solaiman achieved Grade-1 in May, 2013 and he ended his academic carrier of BSMRAU in April, 2020. He has been appointed as Pro-Vice Chancellor of Mawlana Bhashani Science and Technology University (MBSTU) in April, 2021. In addition to Pro-Vice Chancellor is also serving as the Vice-Chancellor (Additional duties) of MBSTU.

He has travelled across the continents to present his research findings in many international seminars/conferences/workshops. By keeping himself always engaged in education, research and overall development of the country, he is fulfilling his responsibilities with unwavering devotion, honesty and discipline to build the "Sonar Bangla" as it was a dream of our Father of the Nation, Bangabandhu Sheikh Mujibur Rahman.

Professor Solaiman has been serving as the President of the Bangladesh Society of Microbiologists since January, 2020. He is the Senior Vice President of the Executive Committee of Bangladesh Association of Commonwealth Scholars and Fellows since 2019. He is also serving as the Executive Committee Member of Soil Science Society of Bangladesh. Professor Solaiman is the life member of Bangladesh Society of Microbiologists; Bangladesh Association for the Advancement of Science; Soil Science Society of Bangladesh; Bangladesh Botanical Society; Bangladesh Association for the Scientists and Scientific Profession; Plant Breeding & Genetics Society of Bangladesh; Bangladesh Association of Commonwealth Scholars and Fellows; Krishibid Institution and Asiatic Society of Bangladesh. He is a good academician, reputed scientist and man of high personality.

SOIL CARE AWARD 2021
SCIENTIST
Life Sketch of Golam Mohammad Panaullah

Golam Mohammad Panaullah an eminent soil scientist was born in Dinajpur district in 1949. G.M. Panaullah completed B.Sc. (Hons.) and M.Sc. in Soil Science from the University of Dhaka where he secured 1st class. He did his PhD from the University of California, Riverside, USA/University of the Philippines at Los Banos (UPLB)/ International Rice Research Institute (IRRI) in 1984. He started his glorifying career as a Scientific Officer and served in different higher positions. He occupied the position Director (Research), Bangladesh Rice Research Institute (BRRI), Director (Agriculture), Bangladesh Jute Research Institute (BJRI). He worked as Project Coordinator, Arsenic in Bangladesh Agriculture, USAID-Food security Project, International Maize and Wheat Improvement Center (CIMMYT), Cornell University, USA and Texas A&M University, USA and USAID-project on Arsenic in Agriculture and Food, Cornell University, USA, Technical Coordinator, USDA-Food for Progress Project in Bangladesh, Cornell University, USA, Member, Board of Management Bangladesh Agricultural Research Institute, Ministry of Agriculture, GOB, Adjunct Faculty, Dept. of Soil Science, Bangabandhu Sheikh Mujibur Rahman Agriculture University (BSMARU), Affiliate Faculty, Bangladesh Agricultural University (BAU), Supervision of graduate thesis research at BAU, BSMRAU, DU and Sher-e-Bangla Agricultural University (SAU).

Mr. Panaullah has about 47 years of experience in research, research management, policy making and agricultural R&D. He served as research fellow of IRRI (1978-84), Principal Investigator of a national project on the characterization and utilization of the coastal saline soils of Bangladesh implemented by the Bangladesh Agricultural Research Institute (BARI), BRRI, Dhaka University and coordinated by the Bangladesh Agricultural Research Council (BARC); "Integrated Soil Fertility and Fertilizer Management" during 1996-2001; Chairman of the National Sub-Committee for the Standardization and Quality Control of Fertilizer and Allied Products in Bangladesh (Bangladesh Standards and Testing Institute) from1996-2000; Member of the National Technical Sub-Committee for Fertilizers (BARC) from 1996-2000. He also worked as a member of different technical committee/board /task force/ editorial board at national and international level; visiting scientist at Melbourne University, Australia. He has 111 publications as thesis paper, journal papers, technical reports, conference/symposia papers in national and international impact factor journal. G.M. Panaullah is a legend soil scientist and researcher.

SOIL CARE AWARD 2021
FARMER
Life Sketch of Mist. Nadira Sultana

Mist. Nadira Sultana was born in 21st October 1976 in a village named Kayetkhaly of Jashore Sadar Upazila of Jashore District. She got married while she was the student of class nine to an army member. After getting married she continued her studies and passed BA. In the meantime she became a mother of three children. She was passing fine time with her husband. Due to eye problems her husband's job in army was ended. Sadly almost all of the pension's benefit of her husband was fraudulent by Unipay-2u and Destiny 2000 Ltd. When her husband lost his way after finishing all the hard earned money she took the helm of the world with her strong hand. She received training from "World fish" and "Youth Development Training Center Jashore" for fish farming. Initially she started fish farming on 50 acres of land and she succeeded in fish farming. She was also succeeded and benefited a lot by cultivating "Summer Tomatoes" on 50 acres of land with the assistance of Upazila Agriculture Extension office, Jashore Sadar. After getting the benefit from summer tomato, she started to cultivate watermelons on the same land. At present she cultivated Baromasi watermelon three times in a year on two bigas of land including fish fry production and earning handsome amount of money. Mst. Nadira Sultana is one of the claimants of using and popularizing "Vermi compost and quick compost" as organic fertilizer in ponds and lands. She herself produces all these eco-friendly agricultural inputs. Now she is economically sound condition and the cloud of uncertainty removed from her school going children.

For her outstanding contribution and success she was awarded the 'Abu Khaled Trust' award in 2018 for setting an example of fruit, vegetable and fish pollen production. Mst. Nadira Sultana was also awarded by Upazila and District Agriculture Extension Department for her noteworthy contribution in agriculture.

WORLD SOIL DAY 2021

World Soil Day Prize 2021
PRINCIPAL SCIENTIFIC OFFICER
Life Sketch of
G. M. Mostafizur Rahman

G. M. Mostafizur Rahman, Principal Scientific Officer, Soil Resource Development Institute (SRDI) was born in 1977 at Uksha, a very remote village of Kaligonj Upazila under Satkhira district. He started his primary education at Uksha Govt. Primary School. He passed SSC from Dhuliapur Adarsha Vidyalaya in 1993 and HSC from Kaligonj College in 1995. He completed B.Sc. Ag (Hons) degree in 2000 from Khulna University securing 1st class and M. S. in Agronomy in 2005 from the same university where he stood 1st class first.

Mr. Rahman started his carrier as the lecturer of science Department at Khulna Public College. In 2005 he joined as a member of civil service (BCS Agriculture) at Soil Resource Development Institute (SRDI) under the ministry of Agriculture. He actively performed Semi-detailed Soil Survey of 29 Upazilas and about 175 Unions. Besides, he actively participated Salinity Survey in 2009, 2012, 2013 and 2021. He prepared 19 Upazila Land and Soil Utilization Guide (Upazila Nirdeshika) and 290 Union Land, Soil and Fertilizer Recommendation Guide (Union Sahayika). He also completed detailed soil survey on Cotton suitability area of two upazilas and prepared report. Mr Rahman also wrote detailed soil survey report of Khatali mouza under Khulna district funded by NUMAN project. He analyzed around 400 different types of fertilizer sample. He broadcast about 60 Radio-Talk on Agricultural topics especially modern agricultural technologies and soil, water & fertilizer management practices through Bangladesh Betar, Khulna.

He has 7 publications in peer reviewed journals. He is the life member of krishibid Institution Bangladesh (KIB). He is a religious, good academician, reputed scientist and man of high personality.

World Soil Day Prize 2021
UPAZILA AGRICULTURE OFFICER
Life Sketch of
Md. Mosaddek Hossain

Md. Mosaddek Hossain, Upazila Agriculture Officer, Dumuria, Khulna, was born in 1982 in Putuny, a remote village of Kalaroa Upazila under Satkhira district. He started his primary education at Karalkata Govt. Primary School. He passed SSC examination from K.H.K Kazirhat High School in 1998 and HSC examination from Kalaroa Govt. College in 2001.He obtained B.Sc. Ag (Hons) degree in 2006 and did Master's in Agronomy in 2013 from Khulna University (KU), Khulna. He joined DAE, Bangladesh in 2010 as agriculture extension officer under 28th BCS in Lohagara, Narail. After a year he transferred in saline prone Upazila Tala, Satkhira and still working in the saline zone and now Upazila agriculture officer, Dumuria, Khulna. He is working in the saline prone areas for 10 years. He has adopted many saline tolerant technologies like inner canal method (Integrated rice fish and vegetables production round the year), mini pond irrigation system, zero tillage potato, maize, sunflower and mustard production, maize production using dibbling and transplanting, mulching, sarjon and semi sarjon method, saline tolerant crop like water melon, mask melon, sweet gourd, bitter gourd, ladies finger, jujube, saline tolerant rice varieties in the saline prone area and contribute to increase the cropping intensity and productivity in the saline coastal areas. He has awarded a challenge found from the Prime Minister Office by adopting mini pond irrigation system in the saline prone areas. He has also get rat killing award in 2020 and 2021. He has got 20 days fellowship in Thailand 2018 under Thailand International cooperation Agency (TICA) and did a short course on Promoting livelihood and food security through diversified farming practices using integrated system and participatory approaches of Thailand. He also visited in Indonesia in 2019 under NATP-2, DAE projects and did a short course on advanced agrl. Technology & Ext. Services. He has opened a YouTube channel named Math krishi in 2019 and made 179 contents regarding saline tolerant crops and technologies and telecasted in the channel. Now he has about 17000 subscribers. He has made about 150 entrepreneurs in different Upazilas in Bangladesh. He is very popular to the farmers, a religious, good extension worker and man of high personality.

World Soil Day Prize 2021

SUB ASSISTANT AGRICULTURE OFFICER

Life Sketch of Sardar Abdul Mannan

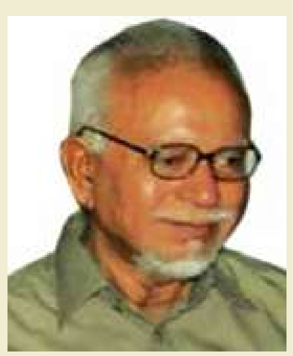
Sardar Abdul Mannan was born in the village named Ula of Dumuria Upazila under Khulna district in 8th February in1989. He passed S.S.C examination from Sahas Noyakathi Secondary School in 1981 under Jashore Board and H.S.C examination from Dumuria College in 1986 under the same board. He obtained Agricultural Diploma from Agricultural Training Institute (ATI) Rahmatpur, Barishal in 1988. Mr. Mannan started his carrier as Sub Assistant Agriculture Officer (SAAO) in 17 January, 1989 in the Department of Agriculture Extension (DAE). Still he is serving in the same position. His contribution in the field of Agriculture Extension is excellent. For his outstanding performance he was awarded Bangabandhu National Agriculture Award in 2017. He also awarded Swarak award ('Swarak award' at regional level in the National Rat Extermination Campaign in 2018 and in the same year he was awarded the 'Swarak of Honour' from Bangladesh Human Rights Protection Commission at international level. Mr. Mannan's performance in the field of agriculture extension is encouraging for the other agriculture extension personnel.

SOIL CARE AWARD 2017

Professor Dr. Aminul Islam

Academician

S.M. Saheed



Scientist

Mrs. Kabija Begum

Farmer

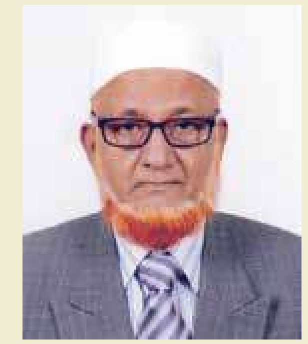
WORLD SOIL DAY 2021

SOIL CARE AWARD 2018

Professor Dr. M. Jahiruddin

Academician

Dr. M. Idris Ali



Scientist

Marzina Begum

Farmer

SOIL CARE AWARD 2019

Mohammad Sultan Hussain

Academician

Dr. Nurul Islam Bhuiyan

Scientist

Md. Abdul Ahad (Shahin)

Farmer

SOIL CARE AWARD 2020

Dr. Zahurul Karim

Scientist

Prof. Dr. M. Rafiqul Islam

Academician

Md. Motiur Rohman

Farmer

recap

Inauguration of World Soil Day 2020 by Dr. Muhammad Abdur Razzaque MP Honorable Minister, Ministry of Agriculture at Hotel Pan Pacific Sonargaon

Inauguration of *Virtual Soil Museum Software* and Unwrapping of the Book *Land Degradation in Bangladesh*: World Soil Day 2020

Speech by the Special Guest S. M. Rezaul Karim MP, Honorable Minister, Ministry of Fisheries and Livestock: World Soil Day 2020

Showcase Visiting by S. M. Rezaul Karim MP, Honorable Minister, Ministry of Fisheries and Livestock and
Md. Mesbahul Islam, Secretary, Ministry of Agriculture, Senior Secretary, Ministry of Agriculture: World Soil Day 2020

Guests and awardee of Soil Care Award 2020

Audience: World Soil Day 2020

WORLD SOIL DAY 2019

Seminar on WSD 2019 observed in Dhaka

An eminant academician received the Soil Care Award, 2019

Wraping off the suvenir on WSD, 2019

Rally on WSD 2019 observed in Dhaka

WORLD SOIL DAY 2018

Rally on WSD 2018 observation at Dhaka

Guests and awardee of Soil Care Award 2018