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SOIL RESOURCE DEVELOPMENT INSTITUTE

MINISTRY OF AGRICULTURE

Executive Summary

During 2017-18 fiscal year “Upazila Nirdeshika Updating Survey” was carried out at 50 Upazilas where remarkable changes in land use were observed in each Upazila (sub-district). Changes in land types were also foundin some cases. It is observed that vegetable cultivation is gaining popularity among the farmers. In this year 30 Upazila Nirdeshika and 90 Union Sahayika (guides) were published. In addition, Technology Transfer activities like fertilizer recommendation cards (FRC) distribution, establishment of demonstration plots through collaboration of static laboratories, mobile soil testing laboratories (MSTL) and district offices resulted substantial yield increase in comparison to unattended farmers plots. In 2017-18, soil analytical service through MSTL was provided to 112 Upazila of the country and provided 5,600 farmers with FRC. MSTL activities needs to be extended to Union level to provide services at grass root level.

Changes in soil fertility due to land use and management practices were observed in monitoring sites. In general, soils are deficient in organic matter and nitrogen. Changes in Phosphorus, Potassium, Calcium, Magnesium, Manganese, Sulfur and Boron were erratic. There is also, evidence of lower pH value in many Upazilas.

In Khulna region, soil salinity in shrimp cultivation area gradually increased from 1990. This salinization may be due to the effect of saline water flooding for long period, slow permeability, presence of highly saline ground water at shallower depth (<1.0m) almost throughout the year and lack of flashing facility after shrimp harvest etc. Water salinity of western side river is more than that of the eastern side. Water salinity of the same stream is less in upper stream and higher in the downstream. Most of the river water remains saline throughout the year and not suitable for irrigation. Few of the river water remain non-saline from the month of August to October.

Soil and water salinity is the major constraint for land use development in Barisal region like other coastal areas of the country. Salinity build up in soil and water of this area is due to the influence of sea water. It is quite natural and a common feature of coastal environment. We cannot prevent this process rather we have to adapt to it. So, management of salinity is the only option for agricultural development here. Monitoring activities need to be widened and strengthened to generate database for setting future strategies to encounter the upcoming challenge of sea level rise.

In Chittagong region, salinity commences with the beginning of dryness of soil (usually, November to December) and reached its peak during the month of February to April and starts to decline with the advance of rainfall and the minimum EC:dS/m reaches during July to September. The variability of soil salinity is fully regulated by rainfall, its intensity, duration, and drainage condition. From the results it is found that the EC value is decreasing over the years.
In the coastal areas, lands, which are not yet protected by embankment but flooded regularly, should be protected. Increasing shrimp cultivation may increase the salinity and hamper the crop production in neighboring areas, so it should be cultivated in a planned way. For the cultivation

of rabi crops drainage system should be well. Use of chemical fertilizers based on soil analysis and drainage improvement are needed to increase the cropping intensity and achieve higher yields. Use of salt tolerant varieties should be increased. Re-excavation of small khals (creeks)as rain water reservoirs is needed to use as irrigation water source. Land should not be kept fallow. It should be covered by any crop or straw within suitable cropping system. Bare lands should be ploughed to reduce the evaporation.

Some innovative technologies for slopping hill soil management were generated by Soil Conservation and Watershed Management Centre (SCWMC), Meghla, Bandarban of which Quesungual Slash and Mulch Agroforestry (QSMAS), Bench Terrace for year round crop production, Gabion Check Dam for gully erosion control, Jute Geo-Textile for rehabilitating degraded land, establishment of Hedge Rows in farmer's field etc. for soil erosion control and organic matter conservation were most important ones.

Some innovative technologies for saline soil management was generated by Salinity Management and Research Centre (SMRC), Batiaghata, Khulna of which Pitcher Irrigation with split application of fertilizers in soluble form, Double Mulching and Raised Bed for vegetable cultivation were proved worthy. These techniques can be disseminated to other saline areas.

During 2017-18, static laboratories conducted soil analysis for both physical and chemical parameters, plant and water analysis for chemical parameters and fertilizer samples analysis under different programs. In static laboratories (Central and Regional Labs), a total of 25,842 samples (21,045 soil samples, 261 water samples, 87 plant samples and 4,449 fertilizer samples) were analyzed.

Activities of Field Offices

Program 1. Updating Upazila Land and Soil Resource Utilization Guide (Upazila Nirdeshika) through Semi-detailed Soil Survey

(a) Introduction: Upazila Land and Soil Resource Utilization Guide (Upazilla Nirdeshika) is being used as a tool for agricultural development activities at Upazila level. Beginning from 1986 all the 459 Upazilla Nirdeshika publication was completed by June 2002. With passing of time changes in edaphic properties, land use and fertility status of soil are being observed along with physical changes due to population growth, rapid industrialization and urbanization, deforestation, unplanned construction of roads, culverts, dams, blocking of upstream flow of rivers, indiscriminate use of chemical pesticides & fertilizers, global warming etc. These changed scenarios need to be incorporated in the Nirdeshika. That is why it becomes imperative to update the existing Upazilla Nirdeshika to enrich the database and make the Nirdeshika more useful to the field level users with the following objectives.

(b) Objectives

- To update the land, soil and land use database for local and regional level agricultural development planning.
- To update the soil fertility database.
- To accommodate the changes due to infrastructure developments (roads, homestead, embankments etc.).
- To make it user friendly and include executive summary of the whole text for the decision makers.

(c) Methodology

Base Materials: Existing Upazila Soil and Landform Map (1:50,000), aerial photographs of approximate scale of 1:25,000 of 1:30,000, topographic maps (1:50,000), DLR maps (1: 63,360) are used as field base maps.

Methods: Based on interpretation of recent aerial photos a photo interpretative Soil and Landform Map is prepared with the help of existing one. The map consists of legend depicting soil mapping unit(s), land type, Mrittika Dal (Soil group).

A planned ground truthing is made by checking catena wise soil, mapping unit boundary following regular traverse and grid as needed in semi-detailed survey.

Soils are examined as often as necessary along traverse lines. For each 200 hectares of land, one soil sample is collected on the basis of land type and Mrittika Dal. The sampling intensity is increased as and when necessary, according to the complexity of Mrittika Dal.

Composite soil samples are collected from adjacent to or possibly nearer point of previous sampling sites with GPS reading so as to compare the changes of nutrient status due to intensive cultivation of modern varieties of different crops with imbalanced application of chemical fertilizers and climate changes.

Mini pits are described by digging shallow pits (where necessary) along each traverse. Soil samples are taken in correlation boxes (if necessary) from Mrittika Dal for correlation.

During soil sample collection, information on inundation depth, cropping pattern, constraints for agricultural development etc. are collected from field observation and farmers interview.

Collected composite soil samples are analyzed in the laboratory and updated Upazila Nirdeshika is prepared incorporating land, soil resource and fertility data.

Table 1: Progress of Upazila Nirdeshika Updating

District	Field Survey		Map finalization		Draft Report Preparation		Final Report Preparation	
	Target	Achievement	Target	Achievement	Target	Achievement	Target	Achievement
Regional Office, Rajshahi								
Rajshahi	Naldunga	Naldunga	Naldunga	Naldunga	Dhamoirhat	Dhamoirhat	Godagari	Godagari
	Gomostapur	Gomostapur	Gomostapur	Gomostapur	Badalgachi	Badalgachi	Chapainawabganj Sadar	Chapainawabganj Sadar
	Porsha	Porsha	Porsha	Porsha	-	-	Durgapur	Durgapur
Dinajpur	Fulbari	Fulbari	Fulbari	Fulbari	Khansama	Khansama	Birganj	Birganj
	Pirganj	Pirganj	Pirganj	Pirganj	Chirirbandar	Chirirbandar	Kaharol	Kaharol
	Debiganj	Debiganj	Debiganj	Debiganj	-	-	-	-
Bogura	Shajahanpur	Shajahanpur	Shajahanpur	Shajahanpur	Nandigram	Nandigram	Naogaon Sadar	Naogaon Sadar
	Panchbibi	Panchbibi	Panchbibi	Panchbibi	Shariakandi	Shariakandi	Gabtoli	Gabtoli
	-	-	-	-	-	-	Dhunat	Dhunat
Rangpur	Jaldhaka	Jaldhaka	Jaldhaka	Jaldhaka	Gaibandha Sadar	Gaibandha Sadar	Fulbari	Fulbari
	Nageshwari	Nageshwari	Nageshwari	Nageshwari	Rajibpur	Rajibpur	Kurigram Sadar	Kurigram Sadar
	Lalmonirhat	Lalmonirhat	Lalmonirhat	Lalmonirhat	-	-	-	-
Pabna	Raiganj	Raiganj	Raiganj	Raiganj	Belkuchi	Belkuchi	Lalpur	Lalpur
	Kazipur	Kazipur	Kazipur	Kazipur	-	-	-	-
Chattogram Regional Office, Cumilla								
Cumilla	Homna	Homna	Sadar Dakshin	Sadar Dakshin	Sadar Dakshin	Sadar Dakshin	Burichong	Burichong
	Bancharampur	Bancharampur	Kachua	Kachua	Kachua	Kachua	Chandpur Sadar	Chandpur Sadar
	-	-	Shahrasti	Shahrasti	Shahrasti	Shahrasti	Bijoynagar	Bijoynagar
Noakhali	Noakhali Sadar	Noakhali Sadar	-	-	-	-	Sonagazi	Sonagazi
Chattogram	Lohagara	Lohagara	Satkania	Satkania	Satkania	Satkania	Anwara	Anwara
	-	-	Ukhiya	Ukhiya	Ukhiya	Ukhiya	Pekua	Pekua
	-	-	-	-	-	-	Kutubdia	Kutubdia
Rangamati	Rajasthali	Rajasthali	Ramgarh	Ramgarh	Ramgarh	Ramgarh	Kaptai	Kaptai
	-	-	-	-	-	-	Naniarchar	Naniarchar
Regional Office, Sylhet								
Sylhet	Dakkhin Sunamganj	Dakkhin Sunamganj	-	-	-	-	Chatok	Chatok
Moulvibazar	Kamalganj	Kamalganj	-	-	-	-	Bahubal	Bahubal
	Nobiganj	Nobiganj	-	-	-	-	-	-
Regional Office, Dhaka								
Dhaka	Kaliganj	Kaliganj	Kaliganj	Kaliganj	Dhamrai	Dhamrai	Tongibari	Tongibari
	Shirajdekhan	Shirajdekhan	Shirajdekhan	Shirajdekhan	Kaliakoir	Kaliakoir	-	-
	Nowabganj	Nowabganj	Nowabganj	Nowabganj	Rupganj	Rupganj	-	-
Tangail	Shibaloy	Shibaloy	Shibaloy	Shibaloy	Nagarpur	Nagarpur	Sribordi	Sribordi
	Gopalpur	Gopalpur	Gopalpur	Gopalpur	Shibganj	Shibganj	Dhunot	Dhunot
	-	-	-	-	Kalihati	Kalihati	Dhanbari	Dhanbari
	-	-	-	-	Islampur	Islampur	Bhuapur	Bhuapur
Faridpur	Kalkini	Kalkini	Kalkini	Kalkini	Kashiani	Kashiani	Muladi	Muladi
	Kotalipara	Kotalipara	Kotalipara	Kotalipara	Bhanga	Bhanga	Kalukhali	Kalukhali
	Naria	Naria	Naria	Naria	-	-	-	-

Jamalpur	Madan	Madan	Madan	Madan	Dewanganj	Dewanganj	-	-
	-	-	-	-	Nagarpur	Nagarpur	-	-
Mymensingh	Bajitpur	Bajitpur	Bajitpur	Bajitpur	Atpara	Atpara	Tarakanda	Tarakanda
	Kotiadi	Kotiadi	Kotiadi	Kotiadi	Gaforgaon	Gaforgaon	Fulbaria	Fulbaria
	Bhaluka	Bhaluka	Bhaluka	Bhaluka	Kuliarchan	Kuliarchan	Fulpur	Fulpur
	-	-	-	-	Mithamoin	Mithamoin	Hossainpur	Hossainpur

District	Field Survey		Map finalization		Draft Report Preparation		Final Report Preparation	
	Target	Achievement	Target	Achievement	Target	Achievement	Target	Achievement
Regional Office, Khulna								
Khulna	Rampal	Rampal	Rampal	Rampal	Tala	Tala	-	-
	Kachua	Kachua	Kachua	Kachua	Paikgacha	Paikgacha	-	-
	Dacope	Dacope	Dacope	Dacope	-	-	-	-
Jashore	Kaligong	Kaligong	Kaligong	Kaligong	Monirampur	Monirampur	Keshobpur	Keshobpur
	Shalikha	Shalikha	Shalikha	Shalikha	Debhata	Debhata	Kalaroa	Kalaroa
	Mongla	Mongla	Mongla	Mongla	-	-	-	-
	Saronkhola	Saronkhola	Saronkhola	Saronkhola	-	-	-	-
	Morelgonj	Morelgonj	Morelgonj	Morelgonj	-	-	-	-
	Horinakundu	Horinakundu	Horinakundu	Horinakundu	-	-	-	-
Kushtia	-	-	-	-	-	-	Alamdanga	Alamdanga
	-	-	-	-	-	-	Kumarkhali	Kumarkhali
Regional Office, Barishal								
Barishal	Nazirpur	Nazirpur	Nazirpur	Nazirpur	Bhola Sadar	Bhola Sadar	Wazirpur	Wazirpur
	Charfassion	Charfassion	Charfassion	Charfassion	-	-	Muladi	Muladi
	Manpura	Manpura	Manpura	Manpura	-	-	-	-
Patuakhali	Kathalia	Kathalia	Kathalia	Kathalia	Betagi	Betagi	Barguna Sadar	Barguna Sadar
	Galachipa	Galachipa	Galachipa	Galachipa	-	-	-	-

(d) Findings: Major Findings of Shalikha Upazila

Physical Parameters

(a) Changes in Population over time: Naturally food requirement increased significantly.

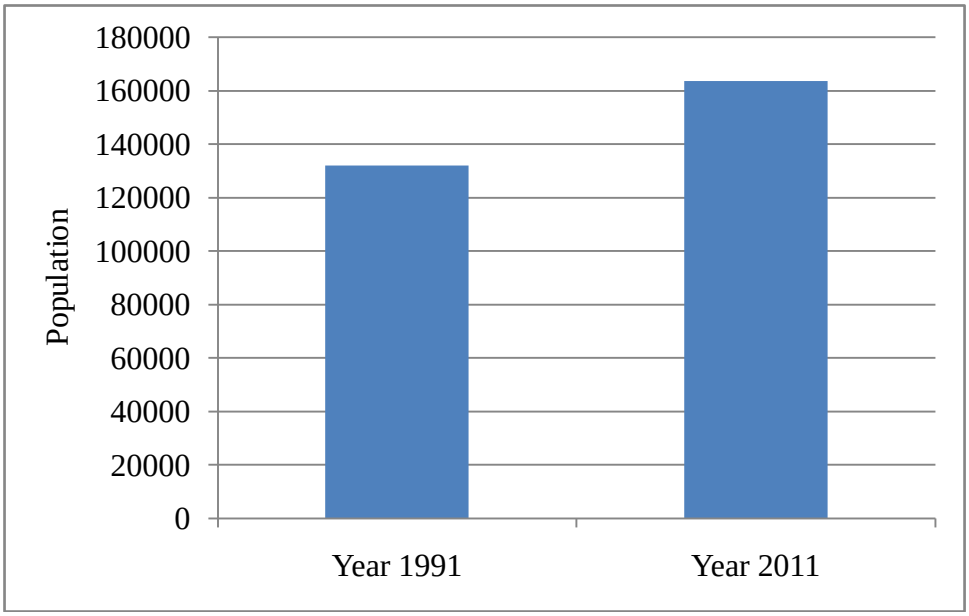


Fig.: Increase in population in Shalikha Upazila over time

(b) Changes in Settlements and Ponds: Area under settlement and ponds increased significantly.

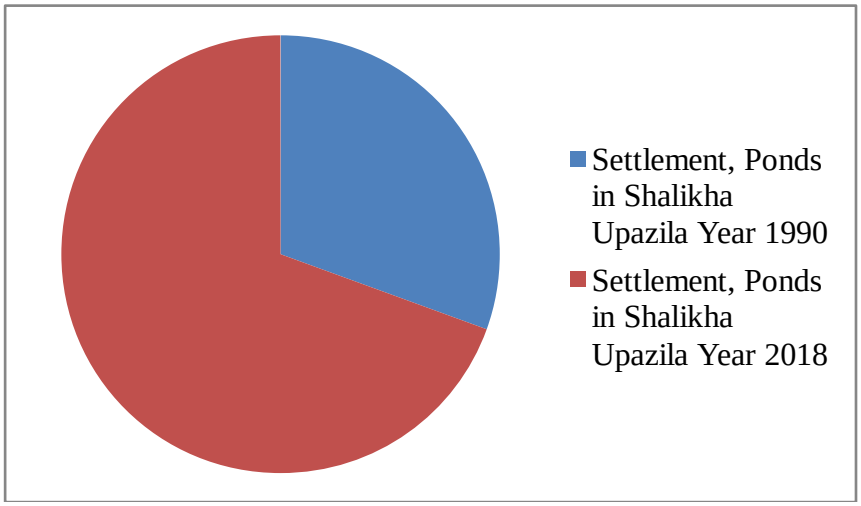


Figure: Increase in settlement and ponds in Shalikha Upazila

(c) Temperature and rainfall: In the Shalikha Upazila there are some changes in monthly maximum and minimum temperature observed considering long term average as the reference line. Maximum monthly temperature more than 30 degree Celsius was observed in the month of February to November. These changes might have effect on crop agriculture. There are some changes observed in annual rainfall and its distribution pattern. The long term average rainfall was 1,247 mm/year and maximum rainfall occurred in the month June to October. But in the recent years (2012-2016) it was observed that rainfall ranges from 1,305 to 1,867 mm/year. Total rainfall changes abruptly in every alternative years and maximum rainfall received in the month July to September. This might have effect on agriculture.

(d) Changes in Land Type

Land type	Previous Survey (1990)		Present Survey (2018)	
	Area (ha)	%	Area (ha)	%
Highland	4,217	18.4	2,934	12.8
Medium Highland	9,749	42.6	7,585	33.2
Medium Lowland	4,883	21.4	4,568	20.0
Lowland	467	2.1	391	1.7
Miscellaneous Land	3,548	15.5	7,386	32.3
Total	22,864	100.0	22,864	100.0

(e) Changes in Land Use:

Land use types	Previous Survey (1990)		Present Survey (2018)	
	Area (ha)	%	Area (ha)	%
Perennial garden	256	1.1	38	0.2
Rabi vegetable-Kharif vegetable	85	0.4	239	1.1
Rabi crop-B.Aus/Jute-Fallow	2801	12.3	-	-
Rabi crop-Jute/ B.Aus /Til-T.Aman	1342	5.9	1179	5.2
Boro-Fallow-T.Aman	1124	4.9	6164	27.0
Rabi crop- Fallow-T.Aman	3058	13.4	361	1.6
Fallow-T.Aus/Jute- T.Aman	1999	8.7	180	0.8
Boro-B.Aman	1095	4.8	357	1.2
Rabi crop-Boro-T.Aman	-	-	2126	9.3
Boro-Deepwater T.Aman	999	4.4	-	-
Boro-Fallow-Fallow	2801	12.3	3302	14.4
Fallow-B.Aman	234	1.0	-	-
Rabi crop-B.Aman	1003	4.4	-	-
Other pattern	2604	11.4	639	2.8
Miscellaneous	3463	15.2	8279	36.2
Total	22864	100	22864	100

(e) Conclusion: Updating Upazila Land and Soil Resource Utilization Guide (Upazila Nirdeshika) through Semi-detailed soil survey is a vital program for understanding the changes in land use and soil fertility status of a specific area over time. This guide can be used as a modern tool for the transfer of the agricultural technology in national agricultural development.

Program 2. Union Land, Soil and Fertilizer Recommendation Guide (Union Sahayika) Preparation

(a) Introduction: Union Land, Soil and Fertilizer Recommendation Guide (Union Sahayika) is being used as a tool for agricultural development activities at Union level. It is used to provide the existing information of Upazila Land and Soil Resource Utilization Guide (Upazila nirdeshika) to the farmers more intensely at Union level. From this guide, farmers can get land and irrigation information for their particular union and location specific fertilizer recommendations for the specific crops and varieties cultivated in that union. That is why it becomes imperative to convince the farmers for using the Sahayika for their economic benefit.

(b) Objectives

- To produce union level soil and land use database for local level agricultural development planning.
- To ensure the use of soil test based fertilizer recommendation at union level.
- Provide information regarding crop suitability and balanced fertilizer use at grass root level.

(c) Methodology

Base Materials: Existing Updated Upazila Soil and Landform Map (1:50,000).

Methods: Field survey is done at dry season. Base map (Upazila Soil and Landform Map) is divided into several grids and ground checking of each grid is done to verify changes. Land use data with other information is recorded in the profile card. Composite soil samples are collected and sent in the laboratory in the laboratory. After completing the survey map is prepared and with the result of soil analysis, Union Sahayika is prepared.

(d) Results and Discussion:

- ❑ 200 Union Sahayika has been prepared and published.
- ❑ Helped the farmers to use soil test based fertilizer doses in their fields.
- ❑ Now Sub Assistant. Agriculture Officers (SAAO) can easily help the farmers in advising farmers on fertilizer application.

(e) Conclusion: Union Sahayika is one of the important tools for using balanced fertilizer at union level. The Department of Agricultural Extension may play significant role in its extensive use.

Program 3. Monitoring & Evaluation of Farmers' Service through Mobile Soil Testing Laboratories (MSTL)

(a) Introduction: Soil Test Based (STB) fertilizer use may be one of the ways to minimize the yield gap. The farmers in our country are not yet fully aware of the benefit of the STB fertilizer use in crop production. Moreover Static Laboratories are few in numbers and located district head quarters. The Government of Bangladesh has taken steps to provide analytical services at

farmer's doorstep through MSTL. SRDI launched this program through two MSTL Program at block levels for specific location and yield goal basis fertilizer recommendation for crop based on STB since 1996. At present there are 10 MSTL for serving the farmer's of the country with soil testing facilities at Upazila level in Rabi and Kharif season every year.

(b) Objectives

- To create awareness among the farmers on benefit of using balanced fertilizer on the basis of STB and crop requirements.
- To serve the farmers with balanced fertilizer recommendation on the basis of STB & crop requirements by analyzing the soil samples at Upazila Sadar.
- To evaluate effect of soil test based fertilizer application on crop production.

(c) Methodology

About 180 farmers were selected for monitoring & evaluation under this program. The SRDI district offices monitor the activities of farmers and collect yield data with the help of DAE personnel. Yield was assessed by comparing the yield of the plots where fertilizers were applied following MSTL supplied Fertilizer Recommendation Cards (FRC) with adjacent plots having same crops and variety in the same season. The farmer's applied fertilizer dose is also recorded.

(d) Result and Discussion

In 2017-18, soil analytical service through MSTL was provided to 112 Upazila of the country and provided 5,600 farmers with Fertilizer Recommendation Cards (FRCs) (Table 2).

Table 2: Name of the Upazila and number of soil samples analyzed through MSTL under Farmer's Service Program during Rabi 2017 season and Kharif 2018 season.

Sl. No.	Upazila	District	No. of Soil Samples Analyzed	Upazila	District	No. of Soil Samples Analyzed
Rabi 2017				Kharif 2018		
	Manikganj Sadar	Manikganj	50	Daulatpur	Manikganj	46
	Raipura	Narsingdi	50	Sreepur	Gazipur	43
	Nawabganj	Dhaka	50	Palash	Narsingdi	46
	Basail	Tangail	60	Tangail Sadar	Tangail	56
	Delduar	Tangail	39	Bhuapur	Tangail	64
	Goalanda	Rajbari	50	Char Bhadrashan	Faridpur	50
	Saltha	Faridpur	43	Shibchar	Madaripur	48
	Kalkini	Madaripur	43	Kalukhali	Rajbari	50
	Gopalganj Sadar	Gopalganj	52	Kotalipara	Gopalganj	48
	Mymensingh Sadar	Mymensingh	50	Purbadhala	Netrokona	33
	Barhatta	Netrokona	52	Nandail	Mymensingh	43
	Nikli	Kishoreganj	50	Katiadi	Kishoreganj	50

Sl. No.	Upazila	District	No. of Soil Samples Analyzed	Upazila	District	No. of Soil Samples Analyzed
	Jamalpur Sadar	Jamalpur	50	Melandaha	Jamalpur	50
	Dewangonj	Jamalpur	50	Bakshiganj	Jamalpur	50
	Madarganj	Jamalpur	50	Sherpur Sadar	Sherpur	50
	Jhenaigati	Sherpur	50	Nalitabari	Sherpur	50
	Laksam	Cumilla	50	Faridganj	Chandpur	61
	Titas	Cumilla	50	Nangalkot	Cumilla	50
	Sarail	Brahmanbaria	50	Ashuganj	Brahmanbaria	48
	Noakhali Sadar	Noakhali	50	Feni Sadar	Feni	50
	Ramganj	Lakshmipur	50	Kabirhat	Noakhali	51
	Sonagazi	Feni	47	Kamalnagar	Lakshmipur	50
	Doublemooring	Chattogram	51	Fatikchhari	Chattogram	50
	Kornofuli	Chattogram	51	Anwara	Chattogram	50
	Boalkhali	Chattogram	50	Satkania	Chattogram	60
	Pekua	Cox’s Bazar	50	Kutubdia	Cox’s Bazar	50
	Rajasthali	Rangamati	51	Kawkhali	Rangamati	55
	Bandarban Sadar	Bandarban	50	Matiranga	Khagrachhari	50
	Mujibnagar	Meherpur	50	Mirpur	Kushtia	44
	Alamdanga	Chuadanga	50	Gangni	Meherpur	47
	Shailkupa	Jhenaidah	50	Harinakundu	Jhenaidah	48
	Lohagara	Narail	50	Shalikha	Magura	50
	Jhenaidah Sadar	Jhenaidah	51	Jessore Sadar	Jashore	50
	Satkhira Sadar	Satkhira	59	Kaliganj	Satkhira	50
	Dumuria	Khulna	43	Shyamnagar	Satkhira	50
	Terokhada	Khulna	46	Koyra	Khulna	50
	Debiganj	Panchagarh	81	Raiganj	Sirajganj	65
	Boda	Panchagarh	64	Faridpur	Pabna	60
	Kishorganj	Nilphamari	49	Dhamoirhat	Naogaon	39
	Kaunia	Rangpur	52	Mohadevpur	Naogaon	81
	Bera	Pabna	56	Mohonpur	Rajshahi	46
	Bholahat	Chapainawabganj	50	Baliadangi	Thakurgaon	62
	Gomostapur	Chapainawabganj	58	Birganj	Dinajpur	64
	Nachole	Chapainawabganj	42	Sherpur	Bogura	51
	Shibganj	Chapainawabganj	56	Joypurhat Sadar	Joypurhat	110
	Panchbibi	Joypurhat	53	Gangachara	Rangpur	52
	Belkuchi	Sirajganj	48	Bhurungamari	Kurigram	71
	Bishwanath	Sylhet	50	Saghata	Gaibandha	34
	Dakshin Sunamganj	Sunamganj	50	Lakhai	Habiganj	51
	Barlekha	Moulvibazar	46	Moulvibazar Sadar	Moulvibazar	50
	Chunarughat	Habiganj	68	Dakshin	Sylhet	72

Sl. No.	Upazila	District	No. of Soil Samples Analyzed	Upazila	District	No. of Soil Samples Analyzed
				Surma		
	Nazirpur	Pirojpur	50	Derai	Sunamganj	42
	Borhanuddin	Bhola	50	Barishal Sadar	Barishal	54
	Galachipa	Patuakhali	50	Kathalia	Jhalakathi	50
	Pathorghata	Barguna	50	Betagi	Barguna	51
Total			2,811	Dashmina	Patuakhali	50
				Total		2,900

In general farmers got higher yield of Transplanted Aus, Jute, Transplanted Aman, Brinjal, Cabbage, Potato, Water melon, Wheat, Mustard, Lentil, Indian spinach, Chilli, Corn, Tomato, Onion, Boro, Lemon if they use balanced fertilizer. In different locations, farmers' got 8 to 24% higher yield of BRRIdhan 29, 12 to 14% higher yield of BRRIdhan 28, 15 to 25% higher yield of mustard, 9 to 18% higher yield of wheat, 27 to 40% higher yield of potato by applying balanced fertilizer following FRC provided by MSTL in 2017-18.

Table 3. Comparative yield of FRC based fertilized crop and farmer's practice in Rabi 2017

Sl. No.	Name of Upazila	District	Crop & Variety	Average yield (t/ha)		
				Farmer's field	Demon-stration plot	Yield increase
1	Manikganj Sadar	Manikganj	Boro BRRIdhan 29	6.25	7.5	16.6
	Keraniganj	Dhaka	Boro BRRIdhan 29	6.30	7.5	16
	Delduar	Tangail	Boro BRRIdhan 29	7.5	8.5	11.8
	Kalkini	Madaripur	Boro BRRIdhan 29	6.98	7.55	7.6
	Jamalpur Sadar	Jamalpur	Boro BRRIdhan 29	6.5	7.7	15.6
	Barhatta	Mymensingh	Boro BRRIdhan 29	5.7	7.0	18.6
	Gomostapur	Chapai-nawabganj	Rabi BARISharisha 14	1.2	1.5	25
	Gomostapur	Chapai-nawabganj	Rabi Bari Gom 26	3.45	4.05	17.4
	Mirzaganj	Patuakhali	Rabi Potato(Diamont)	28.4	21.4	32.7
	Mirzaganj	Patuakhali	Rabi Tomato(Hybrid)	32	40	25
	Bamna	Barguna	Rabi Potato(Diamont)	22	30	36

(e) Conclusion: Yields of Rabi crops increased from 7 to 32 percent due to application of balanced fertilizer following FRC. Motivation activities may help farmers' in using balanced fertilizers following Fertilizer Recommendation Cards provided by MSTL. This in turn will increase crop production in the country.

1. CENTRAL LABORATORY

1.2 Introduction

Central Laboratory is operated under Support Service Division in the headquarter of SRDI and the functions are- execution of physical and chemical analyses of soil samples collected by the survey and development divisions and also samples sent by beneficiary organizations including DAE, NARS organizations, universities, farmers, entrepreneurs and NGO's. Central Laboratory also conducts chemical analysis of water, plant and fertilizer samples. It is also responsible for planning and supervision of basic and adaptive research works such as soil degradation, crop and soil moisture relationship studies, variation of nutrient status of different soils, soil toxicity, etc. Mobile soil testing laboratory named Jamuna, is also operated by this Laboratory for the awareness of farmers regarding judicial application of fertilizers and inspire the farmers using soil test base balanced fertilizer application. Central laboratory has generated technologies like identification of adulterated fertilizers at field level without laboratory test. Quality control activities on different fertilizers are one of the most important works of SRDI which is mostly done by Central Laboratory.

1.2 Major activities of Central Laboratory

1. To determine soil fertility and fertility status for the recommendation of soil test base balanced fertilizer doses for different crops;
2. To analyze soil samples for preparing Upazilla Land and Soil Resources Utilization Guide and Union Sahayika;
3. To analyze water and plant samples received from different stakeholders;
4. To provide farmers soil sample analysis through Mobile Soil Testing Laboratory and
5. To determine nutrient content of fertilizers under the quality control activities of the government.

Beside the above activities Central Laboratory provides advisory service to the farmers, impart training programs and conducts research programs on soil and fertilizer management.

1.3 Soil analyses

Central Laboratory analyzed a total of 2166 soil samples under different programs namely Farmer's Service through Static Laboratories and Mobile Soil Testing Laboratories, Preparation of Land and Soil Resources Utilization Guides, salinity survey and supporting research activities of different institutes.

1.3.1 Materials and Methods

A total of 137 soil samples were received from the farmers of 35 districts under 8 divisions. To determine the nutrient content and evaluate the fertility status of farmers samples both micro and micro nutrient elements as well as pH and organic matter content of the soil were determined. Worldwide established standard methods were followed to analyze different nutrient elements. Nitrogen was determined by Micro Kjeldahl method, phosphorus determined by Bray and Kurtz method (if pH is <7.0) or Olsen method (if pH is >7.0) for, sulfur determined by Turbidimetric method and organic matter determined by Walkley and Black Wet oxidation method etc.

1.3.2 Results and discussion

The results and discussions are made below division wise.

Table 1: Soil samples received from farmers of different divisions and analyzed at Central Laboratory in 2017-2018

Serial No.	Division	Number of Samples
1.	Dhaka	44
2.	Chattogram	31
3.	Rajshahi	11
4.	Khulna	13
5.	Barishal	12
6.	Rangpur	14
7.	Sylhet	2
8.	Mymensingh	10
	Total	137

Note: The results found here should not be taken as the country's profile. However, it is indicative of the overall fertility status of the plots of the farmers, clusteringin different divisions, who sent their samples to Central Lab for analysis.

Soil pH

It was observed that pH of the soil samples of Dhaka division ranges from 4.0 - 7.8 of which 3% samples are very strongly acidic, 23% samples are strongly acidic, 41% samples are slightly acidic, 20% samples are neutral and 14% samples are slightly alkaline. In Chattogram division soil pH ranges from 4.0 - 8.6 where 2% samples are very strongly acidic, 45% samples are strongly acidic, 16% samples are slightly acidic, 10% samples are neutral, 16% samples are

slightly alkaline and 10% samples are strongly alkaline. In Rajshahi division soil pH ranges from 5.4 - 6.9 of which 9% samples are strongly acidic, 55% samples are slightly acidic and 36% samples are neutral. In Khulna division soil pH ranges from 6.4 - 7.9 of which 8% samples are slightly acidic, 46% samples are neutral and 46% samples are slightly alkaline. In Barishal division soil pH ranges from 5.2 - 7.7 of which 8% samples are strongly acidic, 42% samples are slightly acidic, 42% samples are neutral and 8% samples are slightly alkaline in fertility status. In Rangpur division soil pH ranges from 4.8 - 6.5 of which 36% samples are strongly acidic and 64% sample are slightly acidic. In Sylhet division soil pH of farmers field ranges from 4.3 - 4.4 of which 100% samples are very strongly acidic and in Mymensingh division soil pH ranges from 4.6 - 6.9 of which 40% samples are strongly acidic, 40% samples are slightly acidic and 20% samples are neutral in fertility status.

Organic matter

The organic matter content in the soil samples of Dhaka division ranges from 0.20 % – 4.24 % where 27% samples are very low, 32% samples are low, 30% samples are medium, 7% samples are high and 4% samples are very high in fertility status. Organic matter in soil samples of Chattogram division ranges from 0.20 % – 2.69% of which 48% samples are very low, 35% samples are low and 17% samples are medium in fertility status. Soil samples from Rajshahi division organic matter content ranges from 0.54 % – 2.55% of which 18% samples are very low, 45% samples are low and 37% samples are medium in fertility status. The organic matter content of soil samples of Khulna division ranges from 0.54% – 2.42% of which 23% samples are very low, 54% samples are low and23% samples are medium in fertility status. The organic matter content of soil samples of Barishal division ranges from 0.87 % – 4.17% of which 8% samples are very low, 33% samples are low, 50% samples are medium and 9% samples are high in fertility status. The organic matter content of soil samples of Rangpur division ranges from 1.55 % – 1.82% of which 50% samples are low, 43% samples are medium and 7% samples are high in fertility status. The organic matter content of soil samples of Sylhet division ranges from 1.14 % – 3.77% of which 50% samples are low and 50% samples are medium in fertility status. The organic matter content of soil samples of Mymensingh division ranges from 0.67 % – 2.89 % of which 10% samples are very low, 30% samples are low, and 60% samples are medium in fertility status.

Total nitrogen

It is observed that the total nitrogen content of soil samples of Dhaka division ranges from 0.010 % – 0.414% of which 57% samples are very low, 32% samples are low, 7% samples are medium, 2% samples are optimum and 2% samples are high in fertility status. The total nitrogen content of soil samples of Chattogram division ranges from 0.010 % – 0.135 % of which 84% samples are very low and 16% samples are low in fertility status.The total nitrogen content of soil samples of Rajshahi division ranges from 0.027 % – 0.128 % of which 64% samples are very low and 36 % samples are low in fertility status. The total nitrogen content of soil samples of Khulna division ranges from 0.027 % – 0.121 % of which 77% samples are very low and23% samples are low in fertility status. The total nitrogen content of soil samples of Barishal division ranges from 0.044 % – 0.209 % of which 42 % samples are very low, 50% samples are low and 8% samples are medium and the total nitrogen of soil samples of Rangpur division ranges from

0.057 % – 0.189 % of which 50% samples are very low, 43% samples are low and 7% samples are medium in fertility status. The total nitrogen content of soil samples of Sylhet division ranges from 0.078 % – 0.091 % of which 100% samples are very low and total nitrogen content of 10 soil samples of Mymensingh division ranges from 0.034 % – 0.330 % of which 40% samples are very low, 50% samples are low and 10% samples are optimum in fertility status.

Phosphorus

The phosphorus content of soil samples of Dhaka division ranges from 0.43 ppm – 176.77 ppm of which 55% samples are very low, 9% samples are low, 11% samples are medium, 5% samples are optimum, 2% samples are high and 18% samples are very high in fertility status. The phosphorus content of soil samples of Chattogram division ranges from 0.41 ppm – 36.46 ppm of which 87% samples are very low, 7 % samples are low and 3% samples are medium in fertility status. The phosphorus content of soil samples of Rajshahi division ranges from 2.18 ppm – 97.14 ppm of which 55% samples are very low, 9 % samples are medium and 9% samples are optimum in fertility status. The phosphorus content of soil samples of Khulna division ranges from 0.13 ppm – 90.65 ppm of which 54% samples are very low, 8% samples are low, 15% samples are medium and 23% samples are very high in fertility status. The phosphorus content of soil samples of Barishal division ranges from 0.53 ppm – 113.59 ppm of which 50 % samples are very low, 8% samples are low, 8% samples are high and 34% samples are very high in fertility status. The phosphorus content of soil samples of Rangpur division ranges from 4.21 ppm – 92.55 ppm of which 7% samples are very low, 36% samples are medium, 14% samples are optimum, 7% samples are high and 36% samples are very high in fertility status. The phosphorus content of soil samples of Sylhet division ranges from 1.43 ppm – 7.56 ppm of which 50% samples are very low and 50% samples are low and the phosphorus content of Mymensingh division ranges from 1.15 ppm – 33.02 ppm of which 60% samples are very low, 20% samples are low and 10% samples are medium in fertility status.

Potassium

The potassium content of soil samples of Dhaka division ranges from 0.10 meq /100gm soil – 1.54 meq /100gm soil of which 45% samples are low, 18% samples are medium, 14% samples are optimum and 23% samples are very high in fertility status. The potassium content of soil samples of Chattogram division ranges from 0.06 meq /100gm soil – 0.35 meq /100gm soil of which 29% samples are very low, 29 % samples are low, 26% samples are medium and 16% samples are optimum in fertility status. The potassium content of soil samples of Rajshahi division ranges from 0.11 meq /100gm soil – 0.60 meq /100gm soil of which 27 % samples are low, 27% samples are medium, 27% samples are optimum, 10% samples are high and 9% samples are very high in fertility status. The potassium content of soil samples of Khulna division ranges from 0.20 meq /100gm soil – 0.42 meq /100gm soil of which 38% samples are medium, 54 % samples are optimum and 8% samples are high in fertility status. The potassium

content of soil samples of Barishal division ranges from 0.15 meq /100gm soil – 0.40 meq /100gm soil of which 25% samples are low, 42% samples are medium, 17% samples are optimum and 16% samples are high in fertility status. The potassium content of soil samples of Rangpur division ranges from 0.09 meq /100gm soil – 0.40 meq /100gm soil of which 22% samples are very low, 57% samples are low,14% samples are medium and 7% samples are high in fertility status. The potassium content of soil samples of Sylhet division ranges from 0.08 meq /100gm soil – 0.09 meq /100gm soil of which 100% samples are very low and the potassium content of 10 soil samples of Mymensingh division ranges from 0.07 meq /100gm soil – 0.34 meq /100gm soil of which 30% samples are very low, 60% samples are low and 10% samples are optimum in fertility status.

Sulfur

The sulfur content of soil samples of Dhaka division ranges from 1.23 ppm– 223.06 ppm of which 41% samples are very low, 20% samples are low, 9% samples are medium, 7% samples are optimum, 9% samples are high and 14% samples are very high in fertility status. The sulfur content of soil samples of Chattogram division ranges from 0.91 ppm – 252.61 ppm of which 23% samples are very low, 26% samples are low, 6% samples are medium, 10% samples are optimum, 3% samples are high and 32% samples are very high in fertility status. The sulfur content of soil samples of Rajshahi division ranges from 0.23 ppm – 16.28 ppm of which 82% samples are very low, 9 % samples are low and9% samples are medium in fertility status. The sulfur contents of soil samples of Khulna division ranges from 0.03 ppm – 258.09 ppm where 92% samples are very low and 8% samples are very high in fertility status. The sulfur content of soil samples of Barishal division ranges from 0.84 ppm – 43.39 ppm of which 33% samples are very low, 25% samples are low, 17% samples are medium, 17% samples are high and 8% samples are very high in fertility status. The sulfur content of soil samples of Rangpur division ranges from 0.64 ppm – 68.61ppm of which 50% samples are very low, 28% samples are low, 7% samples are high and 15% samples are very high. The sulfur contents of soil samples of Sylhet division ranges from 6.83 ppm – 9.82 ppm of which 50% samples are very low and 50% samples are low and the sulfur content of soil samples of Mymensingh division ranges from 1.47 ppm – 30.73 ppm of which 50% samples are very low, 20% samples are low, 10% samples are medium, 10% samples are optimum and 10% samples are high in fertility status.

Zinc

The zinc content of soil samples of Dhaka division ranges from 0.64 ppm– 37.76 ppm of which 9% samples are low, 14% samples are medium, 7% samples are optimum, 9% samples are high and 61% samples are very high in fertility status. The zinc content of soil samples of Chattogram division ranges from 0.68ppm – 2.65 ppm of which 42% samples are low, 32% samples are medium, 23% samples are optimum and 3% samples are very high. The zinc content of soil samples of Rajshahi division ranges from 1.16 ppm – 8.52 ppm of which 9% samples are medium, 27% samples are optimum, 27% samples are high and 37 % samples are very high. The zinc content of soil samples of Khulna division ranges from 0.68 ppm – 9.2 ppm of which 31% samples are low, 23% samples are medium, 15% samples are optimum, 8% samples are high and 23% samples are very high. The zinc content of soil samples of Barishal division ranges from 0.74 ppm – 3.77 ppm of which 17% samples are low, 25% samples are medium, 17% samples are optimum, 16% samples are high and 25% samples are very high. The zinc content of soil samples of Rangpur division ranges from 1.02ppm – 3.62 ppm of which 43% samples are medium, 21% samples are optimum, 27% samples are high and and 37% samples are very high. The zinc contents ofsoil samples of Sylhet division ranges from 0.75 ppm – 0.84 ppm of which 100% samples are low and the zinc content of 10 soil samples of Mymensingh division ranges from 0.88 ppm – 12.85 ppm of which 10% samples are low, 10% samples are medium, 50% samples are optimum and 10% samples are high and 20% samples are very high in fertility status.

Boron

The boron content of 44 soil samples of Dhaka division ranges from 0.003 ppm– 1.70 ppm of which 50% samples are very low, 11% samples are low, 5% samples are medium, 7% samples are optimum, 9% samples are high and 18% samples are very high in fertility status. The boron content of 31 soil samples of Chattogram division ranges from 0.001 ppm – 0.89 ppm of which 61% samples are very low, 13% samples are low, 10% samples are medium,13% samples are optimum and 3% samples are very high. The boron content of soil samples of Rajshahi division ranges from 0.12 ppm – 0.85 ppm of which 19% samples are very low, 27% samples are low, 27% samples are medium, 9% samples are optimum, 9% samples are high and 9% samples are very high. The boron content of soil samples of Khulna division ranges from 0.003 ppm – 0.58

ppm of which 39% samples are very low, 15% samples are low, 31% samples are medium, and 15% samples are optimum. The boron content of soil samples of Barishal division ranges from 0.11 ppm – 1.48 ppm of which 8% samples are very low, 17% samples are low, 17% samples are medium, 17% samples are optimum and 41% samples are very high. The boron content of soil samples of Rangpur division ranges from 0.001 ppm – 1.40 ppm of which 57% samples are very low, 22% samples are low, 7% samples are optimum and 14% samples are very high. The boron content of soil samples of Sylhet division ranges from 0.48 ppm – 0.74 ppm of which 50% samples are optimum and 50% samples are high and the boron content of 10 soil samples of Mymensingh division ranges from 0.11 ppm – 0.78 ppm of which 20% samples are very low, 20% samples are low, 20% samples are medium, 30% samples are high and 10% samples are high in fertility status.

1.4 Analyses of soil samples under Land and Soil Resources Utilization Guide Updating Program

Preparation of Land and Soil Resources Utilization Guide is one of the most important programs of SRDI. SRDI created huge database on soil physical and chemical properties through the program. A total of 68 soil samples of SaturiaUpazilla under Manikgonj district have been analyzed in the year 2017-2018. Different macro and micro nutrient elements like nitrogen, phosphorus, potassium, sulfur, boron zinc, calcium, magnesium, copper, iron, manganese as well as pH and organic matter content of the soil were determined in the laboratory following the standard procedures of respective elements.

1.5 Farmers service through Mobile Soil Testing Laboratory

Mobile Soil Testing Laboratory (MSTL) is one of the popular programs of SRDI. The objective of the service is to ensure the application of balanced fertilizer doses to the farmers' fields which will create awareness among the farmers on the benefits of soil test based balanced fertilizer application. In the 2017-2018 fiscal year MSTL Jamuna, operated by Central Laboratory, provided service to 756 farmers of 16 upazillas of 8 districts in two seasons (Rabi and Kharif) under this program. In the Rabi season ManikganjSadar (Manikganj), Delduar (Tangail), Basail (Tangail), MymensingSadar (Mymensing), Barhatta (Netrokona), Nikli (Kishoregonj), Raipura (Narsingdi), Nawabganj (Dhaka) and in the Kharif season Sripur (Gajipur),

Daulatpur(Manikgonj), TangailSadar (Tangail), Bhuapur (Tangail), Purbadhala (Netrokona), Nandail (Mymensing), Katiyadi (Kishoregonj), Palash (Narsingdi) upazilas were covered under this program.

1.6 Quality of fertilizers in 2017-2018 fiscal year under quality control activities

In 2017-2018 fiscal year Central Laboratory of SRDI received 1025 Fertilizer samples from different government and private sectors and analyzed all fertilizer samples for quality assurance. Out of that fertilizer samples cent percent Urea, Diammonium phosphate (DAP), Sulphate of Potash (SOP) and Ammonium sulfate were standard sample as per government specification. Liming material Dolomite was also 100% standard as per government specification. Central Laboratory received 47 TSP samples. Out of 47 TSP fertilizers only 2 samples were adulterated that is 96% TSP was standard. In case of Murate of Potash (MoP) 98%, Gypsum 96%, Magnesium sulfate 99% samples were standard. On the other hand, 57% NPKS mixed fertilizer were found adulterated at different levels of impurities. In case of micronutrient fertilizer the maximum adulteration was observed in Zinc (Zn) fertilizers. In 2017-2018 fiscal year 158 Zinc sulfate fertilizer samples were analyzed some in the form of Zinc sulfate monohydrate and zinc sulfate heptahydrate. Out of 158 Zinc sulfate fertilizer samples only 35 samples were standard which was 28% of the received Zinc sulfate fertilizer samples and rest 78% was adulterated at different degrees of adulteration. The adulteration of Zinc fertilizers was not only concentrated in the deficiency of Zn content but also the excessive presence of heavy metal contamination. Another government specified important source of Zinc is Chelated Zinc. Thirty three (33) Chelated zinc fertilizer samples have been analyzed in this year by Central Laboratory where 28 samples of Chelated Zinc were found standard (85%). Other widely used micronutrient fertilizer is Boron fertilizer. Boron is the most important micro nutrient fertilizer for crop production. Boric acid and Solubor are the familiar fertilizer forms. In the last fiscal year Central Laboratory analyzed 69 Solubor Boron where 67 samples were standard which was 97% of the total sample. On the other hand, it analyzed 39 Boric acid fertilizer samples where 36 samples were standard which was 92% of the total sample. In the last year we analyzed 138 organic fertilizer samples where 49% organic fertilizers were standard. It was found that the percent of adulteration in the physically blended NPKS mixed fertilizers was 57% (Table 1). It was also reported from Department of agriculture extension (DAE) that due the adverse effect of adulterated NPKS

mixed fertilizer on crop production farmers are not interested in using this fertilizer. It is notable that the quality control activities of this organization has been playing an important rule reducing the percent of adulteration remarkably as the adulteration in fertilizer was much higher in the previous time.

Table- 2 Quality of different fertilizers analyzed by Central Lab in 2017-2018

Fertilizer	Total	Standard	Adulterated	Standard (%)	
				Quality	Adulterated
Urea	48	48	0	100	0
TSP	47	45	2	96	4
DAP	50	50	0	100	0
MOP	58	57	1	98	2
SOP	45	45	0	100	0
Gypsum	73	70	3	96	4
Zinc Sulphate	158	35	123	22	78
Chelated Zinc	33	28	5	85	15
Mg Sulfate	174	173	1	99	1
Boric Acid	39	36	3	92	8
Solubor Boron	69	67	2	97	3
Ammonium Sulfate	56	56	0	100	0
Dolomite	12	12	0	100	0
Organic	138	67	71	49	51
NPKS	14	6	8	43	57
Others	11	6	5	55	45
Total	1025	801	224		

*Others fertilizers included Silvagin, Silvamix, Nutraphos-N, Nutraphos-24, Copper Vit, Wuxl super, Peak, Biochar, American NPK.

1.6.1 Trend of micro nutrient fertilizer quality

Zinc fertilizer

In the last four consecutive fiscal years zinc (Zn) fertilizer quality was not improved rather to some extent its quality is decreased (Fig. 1). In 2014-2015 fiscal years the adulterated percent of Zn fertilizers were 72%. On the other hand, in the last 2017-2018 fiscal years the adulterated percent of Zn was 78%. This important micro nutrient fertilizer is produced, imported and marketed by private sector. Some unfair traders import low quality Zn fertilizers from abroad. Some manufacturer's produce this fertilizes using below standard raw materials. More over these fertilizers are adulterated not only concentrated in the deficiency of nutrient content (Zinc and Sulfur) but also the excessive presence of heavy metals like cadmium, lead, nickel, chromium

etc. To ensure the quality of Zn fertilizer at field level monitoring should be strengthened through the fertilizer inspectors of DAE and other law enforcing agencies. Generally fertilizer inspectors of DAE are sampling from fertilizer dealers and sub-dealers. In case of Zn fertilizers it would be more effective if samples are collected lot by lot from manufacturing factories.

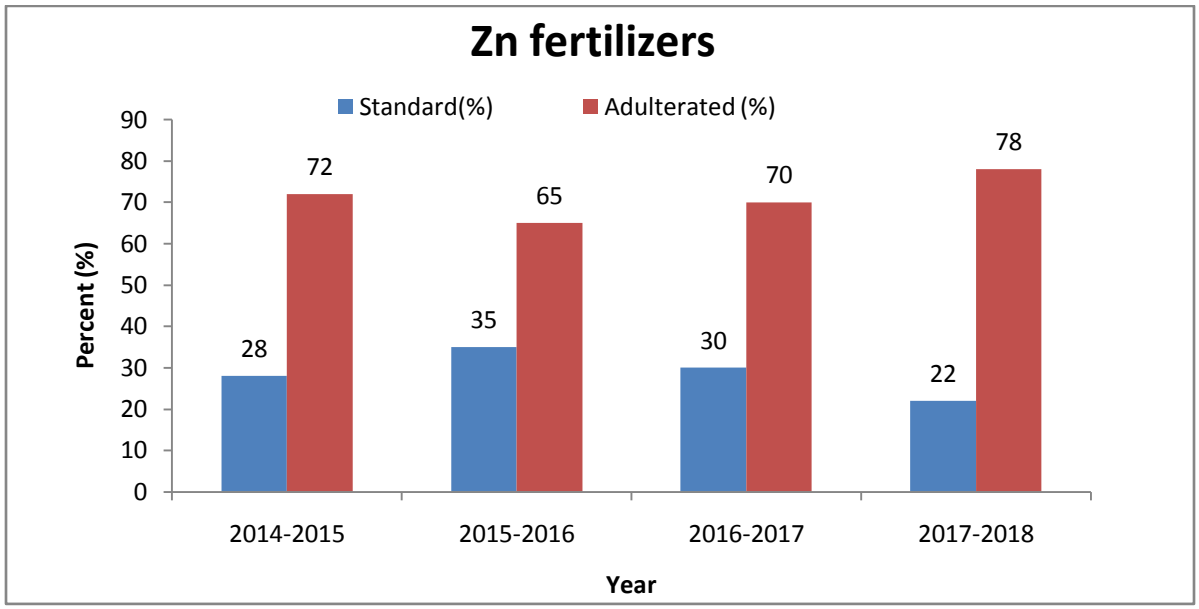


Fig. 1 Trend of Zn fertilizers quality last four consecutive fiscal years.

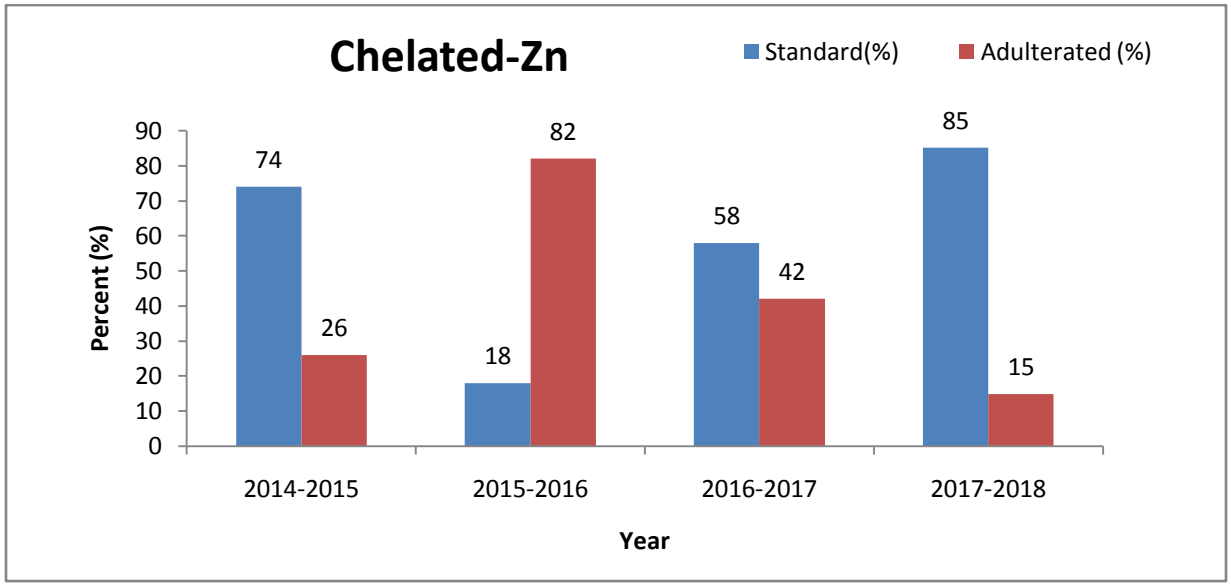


Fig. 2 Trend of Chelated-Zn fertilizers quality last four consecutive fiscal years.

Chelated-Zn fertilizers

Chelated zinc fertilizer is an expensive foliar applicable fertilizer which easily available to plants and also important source of Zn for crops. In the last four consecutive fiscal years Chelated Zinc fertilizer quality was improved. In the 2014-2015 fiscal years the standard Chelated Zinc fertilizer percent was 74%. On the other hand, in the last 2017-2018 fiscal years the percent of quality Chelated zinc fertilizer was 85% (Fig. 2).

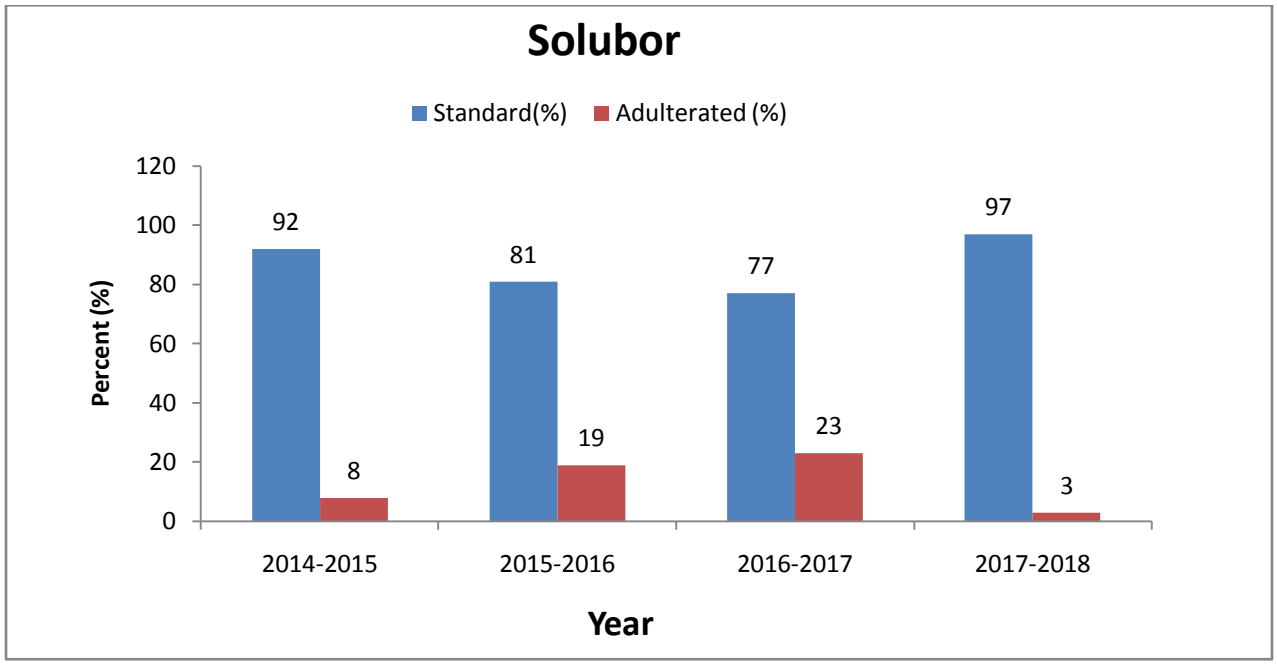


Fig. 3 Trend of Solubor quality last four consecutive fiscal years.

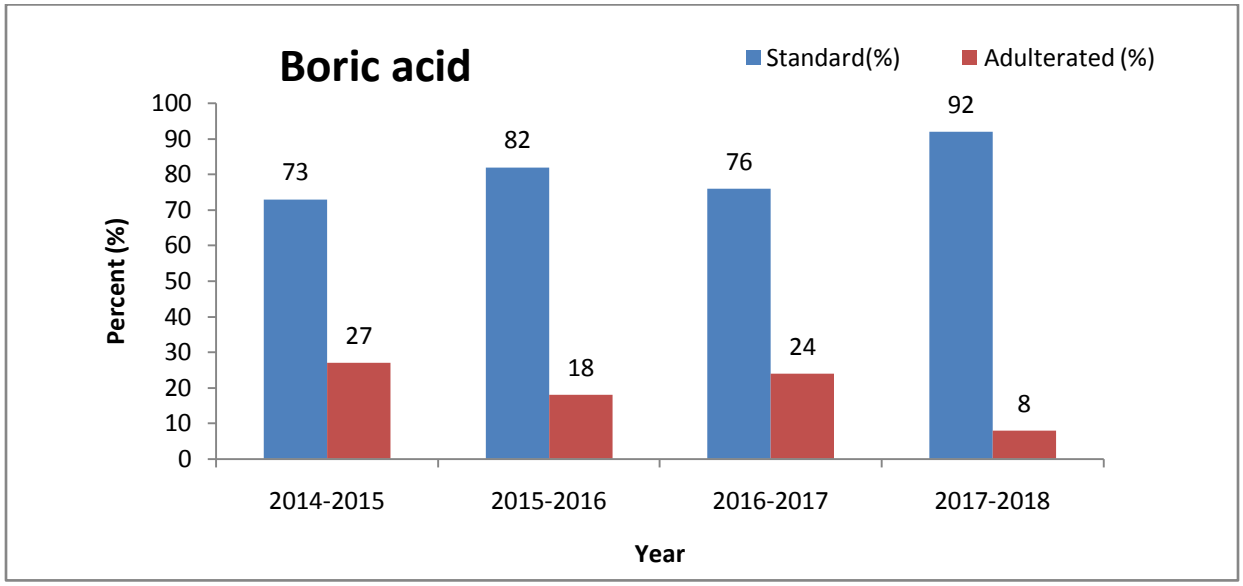


Fig. 4 Trend of Boric acid quality last four consecutive fiscal years.

Solubor and Boric acid

There are four specified Boron fertilizers in Bangladesh viz. Solubor, Boric acid, Fertibor and Granubor. Among the four fertilizers Solubor and Boric acid are most familiar to the farmers of country. In the last four consecutive fiscal years Solubor fertilizer quality was improved. In the 2014-2015 fiscal years the standard Solubor fertilizer percent was 92%. On the other hand, in the last 2017-2018 fiscal years the percent of quality Solubor fertilizer was 97% (Fig. 3). In the last four consecutive fiscal years Boric acid fertilizer quality was improved remarkably. In the 2014-2015 fiscal years the standard Boric acid fertilizer percent was 73%. On the other hand, in the last 2017-2018 fiscal years the percent of quality Boric acid fertilizer was 92% (Fig. 4).

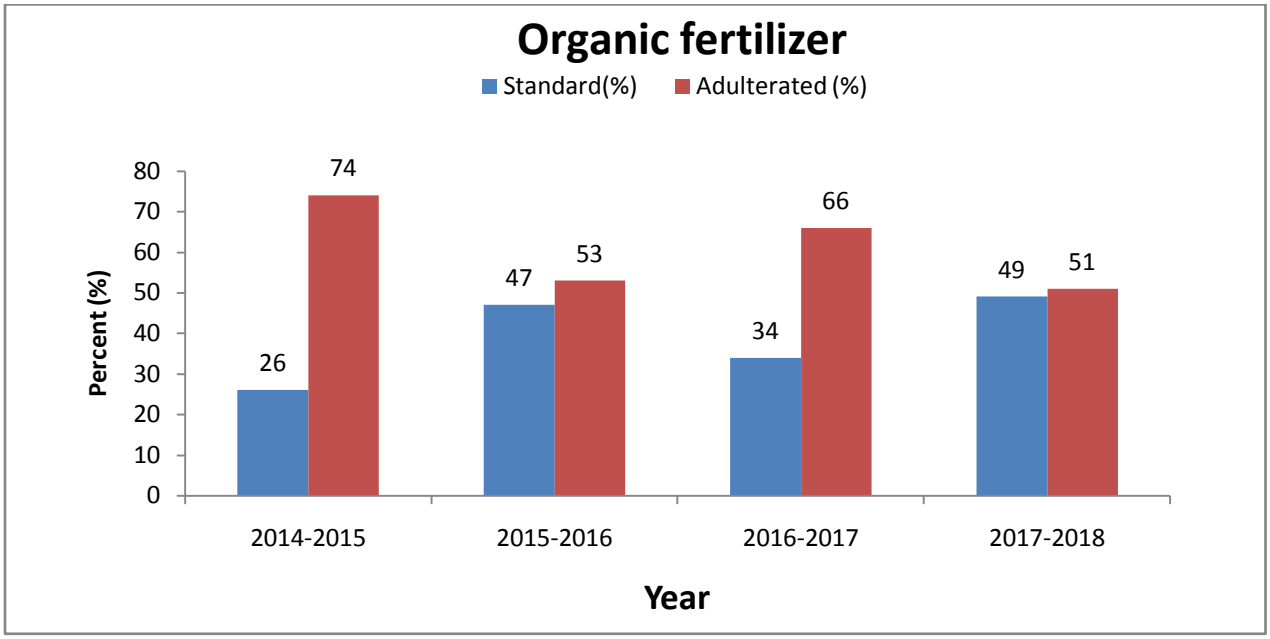


Fig.5 Trend of Organic fertilizer quality last four consecutive fiscal years.

1.6.2 Trend of organic fertilizer quality

Government specified organic fertilizer in April, 2008 with inclusion of specific physical and chemical parameters. In 2014-2015 fiscal year 74% organic fertilizers were substandard /adulterated where as in 2017-2018 the adulteration/ substandard organic fertilizers were 51% (Fig. 5). It indicates the trend of quality improvement of organic fertilizers. The improvement of organic fertilizers quality might be intensive monitoring and awareness of the organic fertilizer producers. Many young and educated entrepreneurs are involved in producing and marketing organic fertilizers by following government approved specification during the recent past. Organic fertilizers were substandard /adulterated in various aspects including nutrient deficiency, low organic carbon, presence of excessive moisture, absence of desirable C:N ratio and presence of excessive pollutant like heavy metal content like lead (Pb), Cadmium (Cd), Chromium (Cr) and Nickel (Ni) etc.

2.Soil and Land Classification Survey Section

2.1 Soil Survey Planning and Supervision

- Supervision of Photo-interpretative Soil and Landform Map preparation: Kaliganj (Gazipur), Mujibnagar (Meherpur) Upazila
- Supervision of Updating Survey of Kaliganj (Gazipur) and Shirajdikhan (Munshiganj) Upazila

Photo: Supervision of Updating Survey in Kaliganj, Gazipur

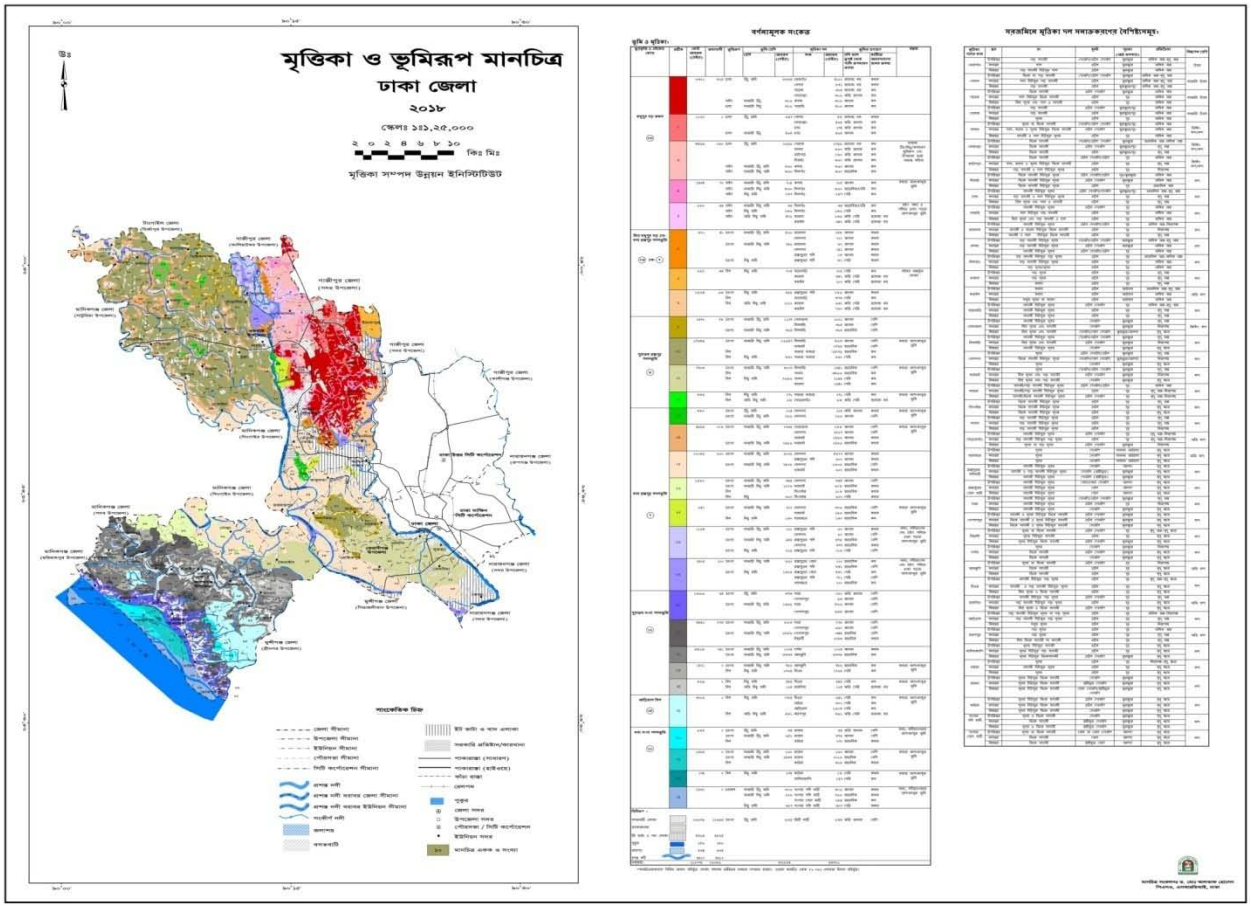
2.2 Compilation of district Soil and Landform Map

2.2.3 Rationale:

- Popularize the use and soil and landform data among Stakeholders
- Enhance district level agricultural development planning with land and soil data
- Support in planning district agricultural rehabilitation program

2.2.4 Methodology

- Upazila Soil and Landform Maps (1:50,000) were digitized and scale was converted to 1:125,000.
- Edge matching of each mapping unit was done.
- A common legend for the district map was constructed accommodating Upazila map legends.



Map 1: Compiled Soil and Landform Map, Dhaka District

2.3 Digital Soil Map Preparation for Rangpur District Applying World Reference Base (WRB)

2.3.1 Objectives: The main objectives of digital soil map preparation for Rangpur district applying World Reference Base (WRB) are to :

- Correlate soils of Rangpur district with WRB so as to harmonize the respective soils with globally recognized soil classification and naming system.
- Simplify resource management domain for planning the best possible way to transfer agro-technology relevant with the local soil environment.
- Create inventory of soil resources which could be the tool to identify climate smart agriculture adaptive to particular soils.

2.3.2 Methodology

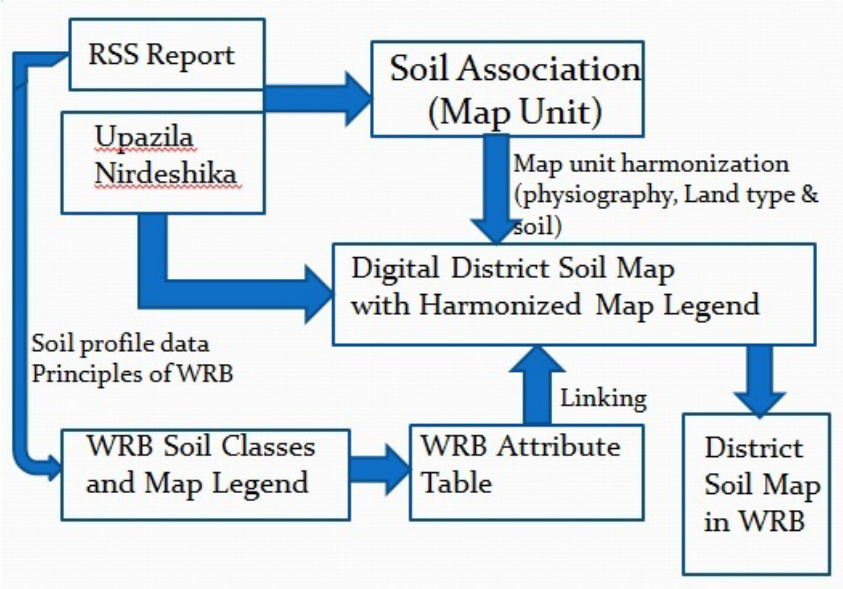


Fig. 6: Sketch representation of the method for digital mapping applying WRB principles

2.3.4 Basic Principles of WRB

- Step – 1: Detecting diagnostic horizon, properties and materials
- Step – 2: Allocating the soil to a Reference Soil Group (RSG), e.g. Acrisols, Gleysols etc.
- Step – 3: Allocating the qualifiers, such as Eutric, dystric etc.

2.3.5 Construction of Soil Map Legend (in WRB)

Map legend describes the map units. A map unit consists of

- A dominant soil (covering >=50%) of the soil cover only or
- A dominant soil plus a codominant soil (covering >=25% and <=50%)of thesoil coverand\or one or more associated soils (covering >=5% and <=25%)of the soil cover or
- Two or three codominant soils or
- Two or three codominant soils plus one or more associated soils

2.3.6 Findings

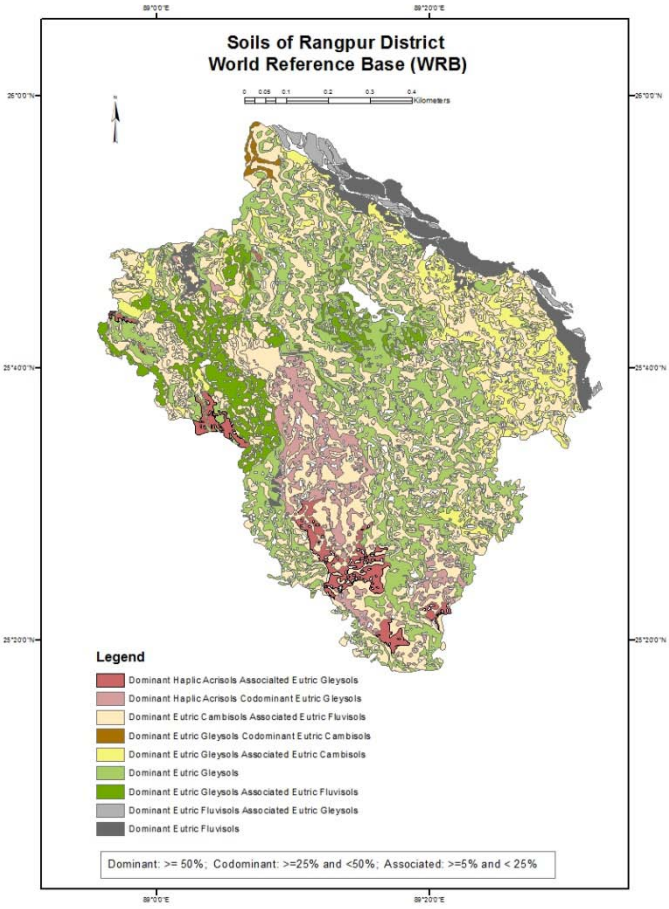
Total number of mapping units(in 7 upazilas) atupazila scale: **71**

Total number of mapping units after harmonization of mapping unit considering physiography, land type and soil at district scale: **19**

Total number of mapping units after harmonization applying WRB principles of map legend at district scale: **9**

Soil classification applying WRB

Soil Classes in WRB	Soil Group /Series	Total Area (%)
HaplaicAcrisols	Kashimpur, Belabo	6.7
EutricCambisols	Domar, Pirgachha, Palashbari	15.8
EutricGleysols	Noadda, Chandra, Nijhuri, Sahapur, Ekdala, Lauta, Khilgaon, Jamun, Gangachara, Kaunia, Bhimpur, Indrail, Lashkara, Kakina, Kachna, Chilmari	71.65
EutricFluvisols	Manda, Shaghatta, Tista Sandy Alluvium, TistaSilty Alluvium	5.85



Map 2: Soils of Rangpur District, WRB

2.4 Survey and report preparation regarding siltation on agricultural fields in flood-affected areas

The survey conducted and report prepared on sand/silt deposition on flood-victim areas of agricultural fields jointly by SRDI and BARC after field survey during November 2017.

2.5 Effects of Brick kiln on Environmental Pollution and Degradation of Agricultural Land

Summary findings

A total of 121 brick kilns have been surveyed through this project. The same number of the owners of the associated brick kilns has been interviewed. The survey area covered 86 Upazilas (sub-districts) under 48 districts throughout Bangladesh. Most of the brick kilns are using coal as fuel. Forest woods were used in 18% of the brick kilns. Surveyed brick kilns are situated within 3-20 km from the Upazila Headquarters and 2m-2km from the nearest homesteads. The average

distance between brick kilns and nearest homesteads is about ½ km (570 m) and the distance between brick kilns and Upazila HQs is about 7.36km. About 58% (69 Nos.) brick kilns were approved by the competent authority; 18% (21 Nos.) had no approval. This information was not disclosed by 21% brick kiln owners. The distance and locations maintained by brick kiln owners show clear violation of Brick Making and Establishment of Kilns (Control) Law 2013. Nearby farmers reported adverse effect of brick kilns on homestead plantation and field crops. They also reported that bearing of fruit trees is hampered; immature fruits are damaged, less fruiting in vegetables.

The total production of 121 brick kilns per annum is 31.70 million bricks. The capacity of the surveyed brick kilns ranges from 0.45 million to as high as 0.78 million bricks per year. The average capacity was 2.89 million bricks per year. Bangladesh produces around 50 billion bricks per year. Use of quality topsoil of agricultural land as raw material for bricks is a substantial environmental and economic concern, which has led the government to prohibit previously profitable brick exports to India as per law of the land.

Mostly fertile topsoil of agricultural land is exploited for making bricks. On an average 3 kg soil is required to make a brick. Thus, 150 billion kg soil is required to produce 50 billion bricks per annum in Bangladesh. One hectare land up to furrow slice i.e. 0-10 cm contains 2×10^6kg of soil. Bangladesh cannot afford loosing huge amount fertile topsoil every year.

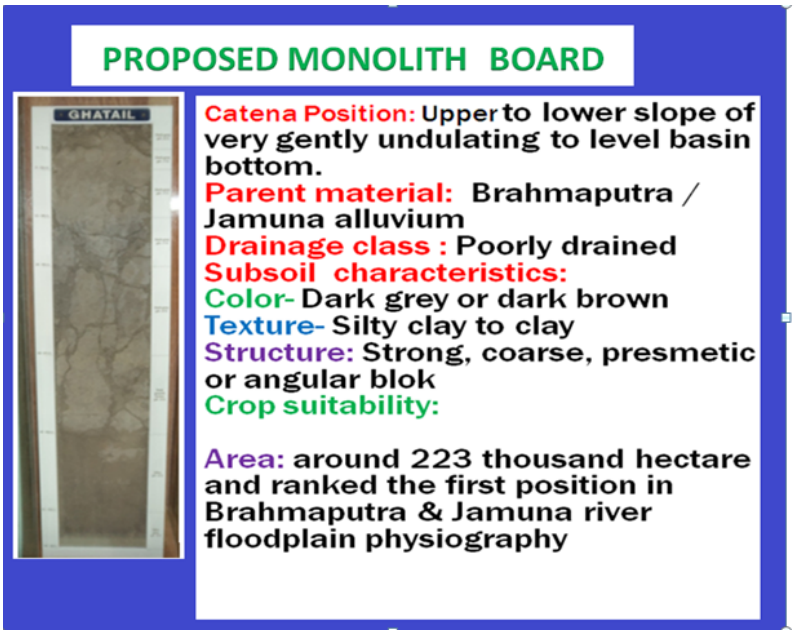
2. Soil Correlation Section

2.1 Function of Soil Correlation Section

1. Planning, supervision & execution of soil series & other taxonomic units
2. Maintenance of uniform standard of methodology on soil survey works and & records of soil information
3. Correlation of soil surveys done by other agencies / consultancy
4. Development & maintenance of the soil museum

2.2 Achievements

2.2.1 The information given on Monolith boards has been redesigned and proposed as follows.



2.2.2 Exhibits in the Soil Museum

Physiography-wise soil monoliths and soil correlation boxes collected, preserved, re-arranged, and displayed in the museum are:

- Physiography --- 11 (out of 15)
- Soil Monoliths --- 50 (48 SRDI & 2 BARC) out of 476soil series (453 soil series, 23 different river alluviums)
- Soil Monoliths, recently collected - 6
- Correlation Box with soil series display-1178
- Correlation box (blank) - 1050 (50 new)

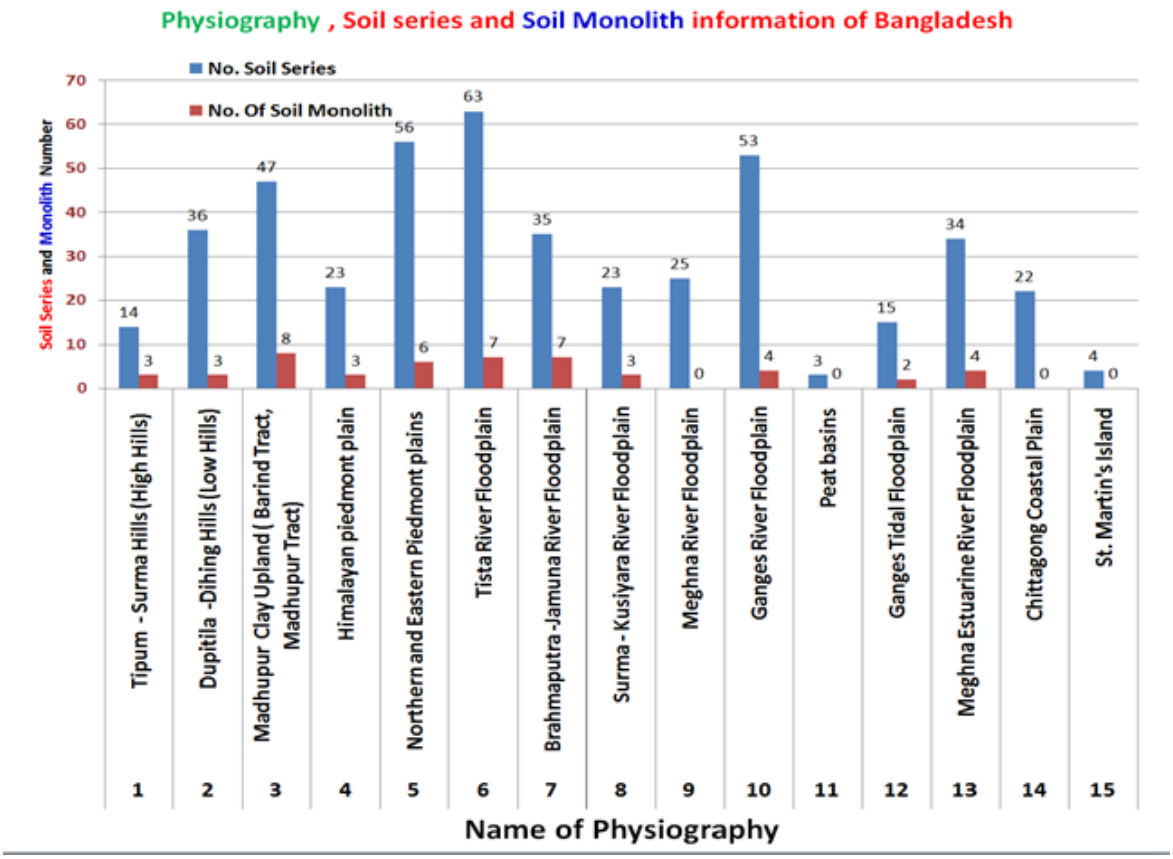


Fig.7:Graphical representation of the Soil Monoliths Exhibits in the soil museum

ANNUAL REPORT 2017-18
&
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PROGRAM 1:

INTRODUCTION OF QUESUNGUAL SLASH AND MULCH AGRO-FORESTRY SYSTEM (QSMAS) FOR ENHANCING CROP YIELDS AND SOIL QUALITY IN CHITTAGONG HILL TRACTS

ABSTRACT

The Chittagong Hill Tracts region is of great importance for growing various crops, which are different from the plains. Farmers practice traditional Jhum culture for their livelihood. They slash and burn the vegetation on hills and go for Jhum cultivation which contributes to soil and nutrient loss. It can also lead to land degradation if population pressure reduces the fallow periods needed for the recovery of natural resources.

The experiment was conducted in moderate hill slope of Soil Conservation and Watershed Management Center, SRDI, Bandarban. Experimental site comprised of four plots- QSMAS model, modern Jhum with hedge row, traditional Jhum and control (secondary forest). From three years data it was observed that system productivity of QSMAS was much higher than that of Jhum with hedge row and traditional Jhum. Total soil loss and surface run off was much lower in QSMAS model than Jhum with hedge row and traditional Jhum. Soil organic matter and CEC was increased over initial status in QSMAS and secondary forest. Micro-watershed based agro-forestry system may be an alternate option to replace Jhum culture for livelihood security of Hill dwellers in Chittagong Hill Tracts.

INTRODUCTION

The Chittagong Hill Tracts comprising the three districts of Bandarban, Rangamati and Khagrachhari has an area of 13181sq km endowed with natural beauty and high economic potentiality. The tribal along with the Bengali people are living there for long maintaining their distinct socio-cultural identities and harmony. The area is hilly with mild to very steep slopes (from 15% to over 70%) often breaking or ending in cliffs. More than 90 percent of the area is covered by hills with only 129,000 hectares (ha) of cropped land. About 87 per cent of the land is covered with forest (totaling 11,475 sq.km) mostly owned by the government (Dasgupta and Ahmed, 1998). Presently, it is increasingly becoming denuded due to unplanned management of

hills and agricultural practices at steep slope without any conservation measure. There are hills with altitudes of more than 3000 feet (Brammer, 1986) having steep and long slope. The total annual precipitation is also high (2000-3550mm). Continuous depletion of soil fertility is the major constraint to sustainable crop production in the hilly areas of Bangladesh. According to Banglapedia (2009) about 20,000 hectares of land are being brought under Jhum cultivation every year.

Jhum cultivation, sloppiness, heavy rainfall and improper management of soil enhanced nutrient depletion through erosion. Accelerated soil erosion is the greatest hazard for the long term maintenance of soil fertility. Gafur *et al*. (2003) carried out a research to find out runoff and losses of soil and nutrients from small watersheds under shifting cultivation in the CHT. Borggaard *et al*. (2003) carried out a study to analyze the sustainability appraisal of shifting cultivation in CHT. Dewan (2008) conducted a survey work to analyze the socio-economic status of Jhum cultivators. The Chittagong Hill Tracts region is of great importance for growing various crops, which are different from the plains. But unfortunately few eco-friendly sustainable agriculture practices for CHT have so for been developed.

Slash and burn practices, also known as **shifting cultivation, swidden agriculture**, or simply **jhum chash**, is an ancient form of agriculture practiced by 200 to 500 million people around the world currently. The people in the uplands of eastern Bangladesh have been practicing shifting cultivation from time immemorial and it is closely related with their socio-cultural identity (Miah and Islam, 2007). However, in the past, they practiced shifting cultivation in the same area with a fallow period of 15–20 years, which ensured the long-term sustainability of soil fertility, and ensured forest regrowth. With the rapid growth in population, the fallow period has been dramatically reduced to 3–4 years, allowing very little time for soil or vegetative regeneration (Riessen, 2000). The decrease in fallow period has led to the deterioration of faunal and microbial organisms, top soil loss, and erosion during periods of heavy rainfall (Gafur, 2001).

The two key components of slash and burn agriculture are the use of fire to prepare fields for cultivation and the subsequent abandonment of those fields as productivity declines. The inevitable decline in productivity is a result of the depletion of soil nutrients and also a result of the invasion of weed and pest species (Cornell, 2011). Slash and burn contributes to global warming by acting as a major source of greenhouse gas emissions, and by depleting reserves of carbon both above and below-ground. It can also lead to land degradation if population pressure reduces the fallow periods needed for the recovery of natural resources. With the increasing population pressure several alternatives to shifting cultivation have been suggested (FAO, 1984) which include: (1) tree crop plantation, (2) agro-forestry, (3) planted fallow system (tree and shrub fallows plus arable crop sequence), (4) livestock production, and (5) special commercial horticulture.

Eco-efficient agriculture uses resources more efficiently to achieve sustainable increases in productivity, reduces the degradation of natural resources, and creates opportunities for boosting incomes and employment in rural areas. The Quesungual Slash and Mulch Agro-forestry System (QSMAS) is one example of eco-efficient crop production for tropical sub-humid regions. It has reduced erosion and improved crop yields and quality of life for over 6,000 local families while allowing regeneration of about 60,000 hectares of secondary forest (*New Agriculturalist* 2009).

QSMAS is a smallholder production system with a group of techniques for the sustainable management of vegetation, soil, and water resources in drought-prone hillsides. The system was developed in the early 1990s in close collaboration with farmers and technicians from FAO and other institutions, as an alternative to traditional and widespread slash and burn agriculture. It has had an extraordinary impact on the livelihoods of farmers growing maize, beans, and sorghum in Central America, and has great potential to be used in other regions.

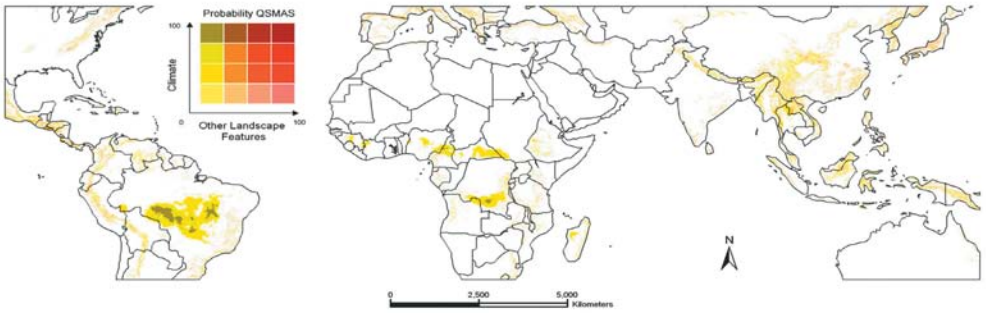


Figure 1. Site similarity analysis: bivariate map showing potential areas for targeting QSMAS across the developing countries in the tropics (performed by combining Bayesian and frequency probability statistical analyses).

Past research reports indicate that little work has been undertaken so far on replacing the traditional Jhum system with modern techniques to reduce soil erosion, biodiversity loss, deforestation, factors that contribute to environmental degradation and impacts on environment due to shifting (Jhum) cultivation practice.

Keeping the above views in mind the present research work was undertaken to introduce a eco-friendly productive crop production system in sloping lands of CHT which will mitigate the process of land degradation due to Jhum culture as well as take care of food security of Hill people.

Goal: Introduce an eco-efficient crop production system in sloping lands of CHT

Objective (s):

i) Establish Quesungual Slash and Mulch Agro-forestry System (QSMAS) in CHT.
ii) To improve both the productivity and economic returns of land currently engaged in slash

and burn agriculture.

iii) To create awareness about soil conservation and watershed management among hill dwellers.

MATERIALS AND METHODS

Eco-efficient agriculture uses resources more efficiently to achieve sustainable increases in productivity, reduces the degradation of natural resources, and creates opportunities for boosting incomes and employment in rural areas.

To validate the principles of Quesungual agro-forestry system in Soil Conservation and Watershed Management Centre, SRDI, Bandarban watershed four land use systems were established: traditional Jhum (slash-and-burn), Jhum with modern management, Quesungual slash and mulch agro-forestry systems (QSMAS), and demarcated areas of secondary forest as a control. Crops like rice, maize; millet, cotton, sesame and common beans, marfa, yard long bean, sweet gourd, ginger and turmeric were accommodated in a traditional system, application of slashed vegetation/crop residues as mulch and QSMAS, to measure and compare differences among production systems. Soil sampling for initial fertility assessment and determine change in fertility status after each cropping season for three years.

Soil sampling consisted of digging test pit of 50 cm depth and sampling of soil at 0-13, 13-43, 43-63 cm depths just before sowing every year. Composite soil samples will be collected from each plot for fertility determination. Chemical characterization included determination of pH, organic matter (OM), N, P, K, S, Zn, B, Ca, Mg, Mn, Fe, Cu. In the field, productivity of rice, maize; cotton, sesame and common beans, marfa, sweet gourd, ginger and turmeric were evaluated in three cropping seasons, from 2014 to 2017.

Statistical analyses of soil fertility and crop yields data were done to determine the change in soil fertility and crop productivity over the years.

Layout of experimental plots

Experimental site: SCWMC, Meghla, Bandarban

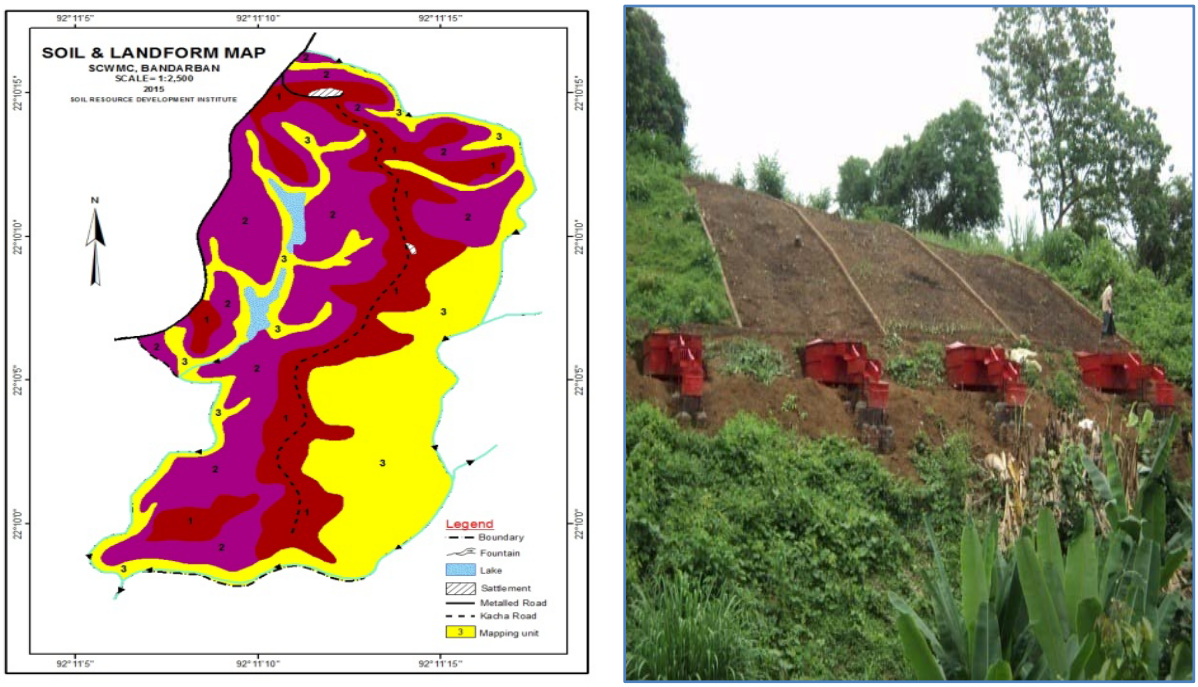


Figure 2. Layout of experimental site (moderate slope; Plot size (5mX20m) =100m^2)

RESULTS AND DISCUSSIONS

SOIL FERTILITY STATUS

Initial fertility status was compared with fertility status of each plot after crop harvest. Soils are mostly highly acidic to slightly acidic in nature. Initial Organic matter status was low to medium while it was high to medium after crop harvest. Initial Nitrogen status was very low to low while it was low to medium after crop harvest. Phosphorus status was very low. Initial Potassium status is medium to optimum while it was medium to very high after crop harvest. Sulfur status was reduced from medium to low to low to very low. Zinc status was also reduced from initial status i.e. low to medium. Boron status reduced from very high to low to medium. Calcium, Magnesium, Copper, Iron and Manganese status is remained almost unchanged (Table 1). Physical analysis was done to determine the soil texture (Table 2). CEC, which indicates soil fertility, seems to be improved over time under QSMAS and secondary forest system. Highest CEC increase was observed in QSMAS plot (Figure 15). Whereas, CEC was reduced in Jhum with hedge and Traditional Jhum system.

Table 1. Initial soil fertility status and fertility status after crop harvest

Plot No./ Year	Depth of soil sample	pH	OM (%)	N (%)	P	K	S	Zn	B	Ca	Mg	Cu	Fe	Mn
					meq/100g soil		µg/g soil			meq/100g soil			µg/g soil	
1/2015	0-13	4.9	1.82 M	0.10 L	2.85 VL	0.33 O	15.0 M	1.10 M	0.93 VH	2.53 L	1.40 O	1.06 VH	75.93 VH	15.18 VH

1/2016		4.5	4.13 H	0.24 M	5.32 VL	0.52 VH	6.05 VL	1.01 M	0.18 L	5.82 O	2.46 VH	0.72 H	71.80 VH	11.22 VH
2/2015	0-13	5.7	1.62 L	0.09 VL	1.21 VL	0.35 O	8.17 L	0.64 L	0.86 VH	1.77 L	1.16 M	0.81 VH	76.28 VH	12.67 VH
2/2016		4.5	2.88 M	0.17 L	3.88 VL	0.26 M	6.08 VL	0.09 VL	0.22 L	2.20 L	1.08 M	0.42 M	11.72 O	2.34 H
3/2015	0-13	4.9	1.32 L	0.07 VL	1.38 VL	0.32 O	9.17 L	0.88 L	0.92 VH	3.21 M	1.37 O	0.99 VH	86.34 VH	10.20 VH
3/2016		4.5	3.12 M	0.18 L	6.86 VL	0.42 H	7.35 VL	0.96 M	0.16 L	2.50 L	1.17 O	0.44 M	43.8 VH	14.3 VH
4/2015	0-13	4.9	1.10 L	0.06 VL	2.19 VL	0.26 M	5.20 VL	0.78 L	0.79 VH	2.18 L	1.16 M	0.88 VH	81.15 VH	7.80 VH
4/2016		4.5	3.24 M	0.19 M	6.80 VL	0.46 VH	8.42 L	1.02 M	0.21 M	1.25 VL	1.04 M	0.14 VL	42.2 VH	2.80 O

Note: VL=very low; L=low; M= medium; O=optimum; VH=very high

Table 2. Mean, standard error, correlation coefficient and significance of soil fertility indicators over time

Soil nutrients	Mean ± SE		Correlation	significance
	2015	2016		
pH	5.10±0.20	4.50±0.00	0.00	0.00
OM	1.47±0.16	3.34±0.27	0.53	0.47
N	0.08±0.01	0.20±0.02	0.53	0.47
P	1.91±0.38	5.72±0.71	0.19	0.81
K	0.32±0.02	0.42±0.06	-0.49	0.51
S	9.39±2.05	6.98±0.57	-0.73	0.27
Zn	0.85±0.10	0.77±0.23	0.72	0.28
Ca	2.42±0.31	2.94±1.00	0.24	0.77
Mg	1.27±0.07	1.44±0.34	0.71	0.29
Cu	0.94±0.06	0.43±0.12	0.68	0.32
Fe	79.93±2.45	42.38±12.27	0.01	0.99
Mn	11.46±1.59	7.67±3.01	0.28	0.72

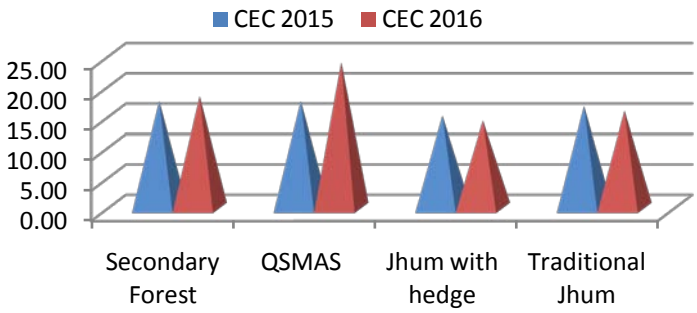


Figure 15. Comparative CEC data of experimental plots over time

Table 3. Soil texture analysis data

Plot No.	Sampling depth (cm)	Soil texture	Sand (%)	Silt (%)	Clay (%)
1	0-13	Sil loam	17	59	24
2	0-13	Silt loam	19	59	22
3	0-13	Silt loam	20	58	22
4	0-13	Silt loam	18	58	24
		Layer wise sample			
	0-13	Silt loam	13	61	26
	13-43	Clay loam	24	44	32
	43-63+	Clay loam	21	40	39

Crop yield and system productivity

Each plot had the same crop combination except control (secondary forest). Rice (local), maize (local), sesame, millet, sweet gourd, chilly, marfa, yardlong bean, country bean, cotton, ginger, turmeric were planted in mixture. But in QSMAS model the crops were arranged in sub plots within the main plot. Grafted fruit trees-mango, carambola and seedlings of papaya were planted in the plot.

After harvestings crop yield data were recorded and analyzed. It was observed that rice yield was higher in traditional Jhum practice than other practices. But system productivity of QSMAS

model plot was much higher than other plots (Table 4, 5 & 6). Comparative yield and economic data of component crops are shown in Tables 7 and 8.

Table 4. Yield (kg/100 sqm) and return (BDT) of crops harvested from experimental plots (2015).

Sl.No	Yield (kg/100 sq m)				Price (BDT/Kg)	Return in BDT			Remarks
	Crops	Traditional Jhum	Jhum with hedge row	QSMAS model		Traditional Jhum	Jhum with hedge row	QSMAS model	
1	Rice (local)	15.00	10.00	6.00	15.00	225.00	150.00	90.00	QSMAS model out yielded all the other plots
2	Maize (local)	3.00	5.00	6.00	50.00	150.00	250.00	300.00	
3	Sesame	1.00	1.50	1.50	60.00	60.00	90.00	90.00	
4	Millet	1.00	0.50	0.60	80.00	80.00	40.00	48.00	
5	Sweet gourd	4.00	5.00	6.00	35.00	140.00	175.00	210.00	
6	Chilly	0.40	0.50	0.50	120.00	48.00	60.00	60.00	
7	Marpha	3.00	4.00	4.00	40.00	120.00	160.00	160.00	
8	Yardlongbean	4.00	5.00	6.00	40.00	160.00	200.00	240.00	
9	Countrybean	-	-	6.00	60.00	-	-	360.00	
10	Cotton	1.50	2.00	3.00	200.00	300.00	400.00	600.00	
11	Ginger	3.00	5.00	7.00	60.00	180.00	300.00	420.00	
12	Turmeric	12.00	15.00	17.00	20.00	240.00	300.00	340.00	
13	Mango (4)							-	No fruiting was observed
14	Papaya (5)							-	
15	Carambola (3)							-	
					Total =	1703.00	2125.00	2918.00	

Table 5. Yield (kg/100 sqm) and return (BDT) of crops harvested from experimental plots (2016)

Sl.No.	Yield (kg/100 sq m)				Price (BDT/Kg)	Return in BDT			Remarks
	Crops	Traditional Jhum	Jhum with hedge row	QSMAS model		Traditional Jhum	Jhum with hedge row	QSMAS model	
1	Rice (local)	14.00	13.00	8.00	15.00	210.00	195.00	120.00	QSMAS model out yielded all the other plots
2	Maize (local)	3.00	5.00	4.00	50.00	150.00	250.00	250.00	
3	Sesame	0.80	1.00	0.90	60.00	48.00	60.00	54.00	
4	Millet	0.90	0.80	0.50	80.00	72.00	64.00	40.00	
5	Sweet gourd	3.50	4.00	5.00	35.00	122.00	140.00	175.00	
6	Chilly	1.20	1.00	0.70	80.00	96.00	80.00	56.00	
7	Marpha	2.50	4.00	3.00	40.00	100.00	160.00	120.00	

8	Yardlongbean	5.00	9.00	6.00	35.00	175.00	315.00	210.00	
9	Countrybean	-	-	4.00	40.00	-	-	160.00	
10	Cotton	1.00	1.50	1.20	200.00	200.00	300.00	240.00	
11	Ginger	3.00	6.00	4.00	50.00	150.00	300.00	200.00	
12	Turmeric	12.00	17.00	14.00	10.00	120.00	170.00	140.00	
13	Mango (4)	-	4 nos.	2.00	80.00	-	-	160.00	
14	Papaya (5)	-	5 nos.	40.00	15.00	-	-	600.00	
15	Carambola (3)	-	3 nos.	3.00	10.00	-	-	30.00	
					Total =	1443.00	2034.00	2505.00	

Table 6. Yield (kg/100 sqm) and return (BDT) of crops harvested from experimental plots (2017)

Sl.No.	Yield (kg/100 sq m)				Price (BDT/Kg)	Return in BDT			Remarks
	Crops	Traditional Jhum	Jhum with hedge row	QSMAS model		Traditional Jhum	Jhum with hedge row	QSMAS model	
1	Rice (local)	9.00	10.00	7.00	22.00	198.00	220.00	154.00	QSMAS model out yielded all the other plots
2	Maize (local)	2.00	4.00	5.00	50.00	100.00	200.00	250.00	
3	Sesame	0.70	0.80	1.00	60.00	42.00	48.00	60.00	
4	Millet	0.60	0.80	0.90	40.00	24.00	32.00	36.00	
5	Sweet gourd	3.00	5.00	6.00	35.00	105.00	175.00	210.00	
6	Chilly	0.50	0.70	0.90	80.00	40.00	56.00	72.00	
7	Marpha	2.00	3.00	4.50	40.00	80.00	120.00	180.00	
8	Yardlongbean	3.00	5.00	6.00	35.00	105.00	175.00	210.00	
9	Countrybean	-	-	5.00	40.00	-	-	200.00	
10	Cotton	0.60	0.80	1.00	200.00	120.00	160.00	200.00	
11	Ginger	2.50	3.50	4.00	50.00	125.00	175.00	200.00	
12	Turmeric	9.00	14.00	12.00	10.00	90.00	140.00	120.00	
13	Mango (4)	-	4.00	7.00	80.00	320.00	320.00	560.00	
14	Papaya (5)	-	20.00	26.00	15.00	300.00	300.00	390.00	
15	Carambola (3)	-	5.00	7.00	10.00	50.00	50.00	30.00	
					Total =	1699.00	2171.00	2912.00	

Table 7. Comparative return (BDT) from component crops over time

Table 8. Comparative yield of component crops over time

Crops	Mean ± SE			Correlation	Sig.
	2015	2016	2017		
Rice	10.33± 2.60	11.67±1.86	8.67±0.88	0.61	0.22
Maize	4.67±0.88	4.00±0.58	3.67±0.88	1.00	0.85
Sesame	1.33±0.17	0.90±0.17	0.83±0.09	0.76	0.30
Millet	0.70±0.16	0.73±0.12	0.77±0.09	-0.87	0.43
Sweet gourd	5.00±0.58	4.17±0.44	4.67±0.88	0.98	0.29
Chilli	0.47±0.03	0.97±0.15	0.70±0.12	0.87	0.41
Marpha	3.67±0.33	3.17±0.44	3.17±0.73	0.80	0.42
Yardlong bean	5.00±0.58	6.67±1.20	4.67±0.88	0.98	0.65
Cotton	2.17±0.44	1.90±0.56	0.80±0.12	0.93	0.90
Ginger	5.00±1.15	3.67±1.45	3.33±0.44	0.89	0.77
Turmeric	14.67±1.45	14.33±1.45	11.67±1.45	0.68	0.87

Crops	Mean ± SE			Correlation	Sig.
	2015	2016	2017		
Rice	155.00± 39.05	175.00± 27.84	190.67±19.40	0.61	0.22
Maize	233.33± 44.10	216.67± 33.33	183.33±44.10	1.00	0.85
Sesame	80.00± 10.00	54.00± 3.46	50.00±5.29	0.76	0.30
Millet	56.00± 12.22	58.67± 9.61	30.67±3.53	-0.87	0.43
Sweet gourd	175.00± 20.21	145.67± 15.56	163.33±30.87	0.98	0.39
Chilli	56.00± 4.00	77.33± 11.62	56.00±9.24	0.87	0.41
Marpha	146.67± 13.33	126.67± 17.64	126.67±29.06	0.80	0.42
Yardlong bean	200.00± 23.09	233.33± 42.06	163.33±30.87	0.98	0.67
Cotton	433.33± 88.19	246.67± 29.06	160.00±23.09	0.89	0.80
Ginger	300.00± 69.28	216.67± 44.10	166.67±22.05	0.93	0.67
Turmeric	293.33± 29.06	143.33± 14.53	116.67±14.53	0.68	0.87

Soil loss from experimental plots

As Bandarban is a high rainfall area if the soil surface is exposed due to deforestation it becomes vulnerable to water erosion. Soil loss from hills depends on surface cover, rainfall intensity, nature of slope and aspects of slope. Bandarban experienced a significant amount of rain every year though its distribution uneven over months. Rainfall intensity is higher in the months of May to August (Figure 16). Multi-slot divisor was established at the bottom of each plot. Total surface run–off and total soil loss was calculated per shower and cumulative figure was made by adding each observation. Last three years it was observed that highest total soil loss (39.17t ha^{-1} y^{-1}-2015) occurred in traditional Jhum plot followed by Jhum with hedge and mulch and QSMAS model.

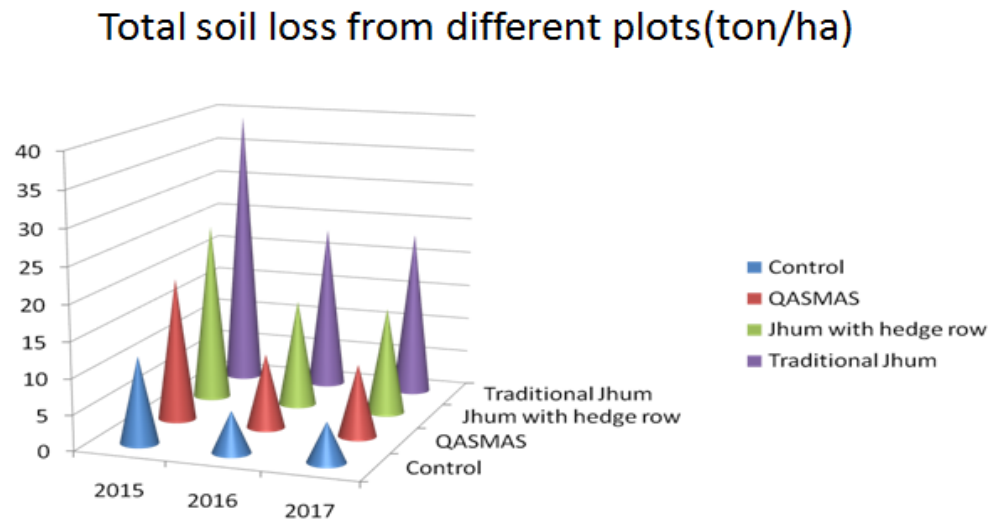
Table 9: Monthly distribution of rainfall in experimental area over time (mm)

Year	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total Rain fall(m.m)
2015	-	-	-	-	291	918.4	854	860.4	200	507	7.0	-	3637.80
2016	6	6	54	17	187	684	532	468	358.5	144	71.0	-	2527.50
2017	-	-	131	268	363	806	818	494	596.5	249	12.0	-	3737.50

The lowest total soil loss was observed in control plot (secondary forest). In 2016 similar trends were observed. The finding is in conformity with that of CIAT (2010). Gafur *et al.* (2003) conducted a research to find out the runoff and losses soil and nutrients from small watersheds under shifting cultivation in the Chittagong Hill Tracts. In similar studies, Shoaib *et al.*(1998) recorded total soil loss to be 40-45t $ha^{-1}y^{-1}$ in traditional Jhum culture highest being observed in steep slope and the lowest in gentle slope. There is an evidence that the use of contour hedgerows on steep slopes (40-50%) can reduce erosion by 55-80% and run off by 30-70% compared to shifting cultivation (Khisa, 2001). It was observed that QSMAS protects soil by markedly reducing soil erosion (Figure 17) in comparison to Jhum plots. This result is in conformity with the findings of CIAT (2010).

Table 10: Total soil loss from experimental plots (t ha^{-1} y^{-1}) in 2015, 2016 and 2017

Particulars		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total (t $ha^{-1}y^{-1}$)
Control	2015	-	-	-	-	0.80	3.32	3.12	3.14	1.09	0.67	-	-	12.14
	2016	-	-	-	-	-	2.28	1.53	0.83	0.52	0.63	-	-	5.79
	2017	-	-	-	-	0.45	1.12	1.47	0.82	0.51	0.72	0.5	-	5.59
QASMAS	2015	-	-	-	-	1.68	6.18	4.52	4.49	1.52	1.65	-	-	20.04
	2016	-	-	-	-		4.55	2.57	1.63	0.96	0.72	-	-	10.43
	2017	-	-	-	-	1.11	1.98	2.67	1.42	1.04	1.10	0.79	-	10.11
Jhum with hedge row	2015	-	-	-	-	2.15	7.84	5.58	5.67	1.96	1.90	-	-	25.10
	2016	-	-	-	-	-	7.01	4.34	1.89	1.06	0.86	-	-	15.16
	2017	-	-	-	-	1.64	3.14	3.54	1.92	1.68	1.84	1.30	-	15.06
Traditional Jhum	2015	-	-	-	-	2.68	10.52	9.18	9.49	4.07	3.23	-	-	39.17
	2016	-	-	-	-	-	9.4	8.4	2.77	1.25	1.36	-	-	23.18
	2017	-	-	-	-	2.55	4.40	5.80	2.82	2.46	2.86	2.41	-	23.30



It was observed that highest total soil loss occurred in traditional Jhum plot followed by Modern Jhum (with mulch) and QSMAS model. The lowest total soil loss was observed in control plot (secondary forest). The finding is in conformity with that of CIAT (November 2010).

Figure 17. Reduction of soil loss over time under different land use systems

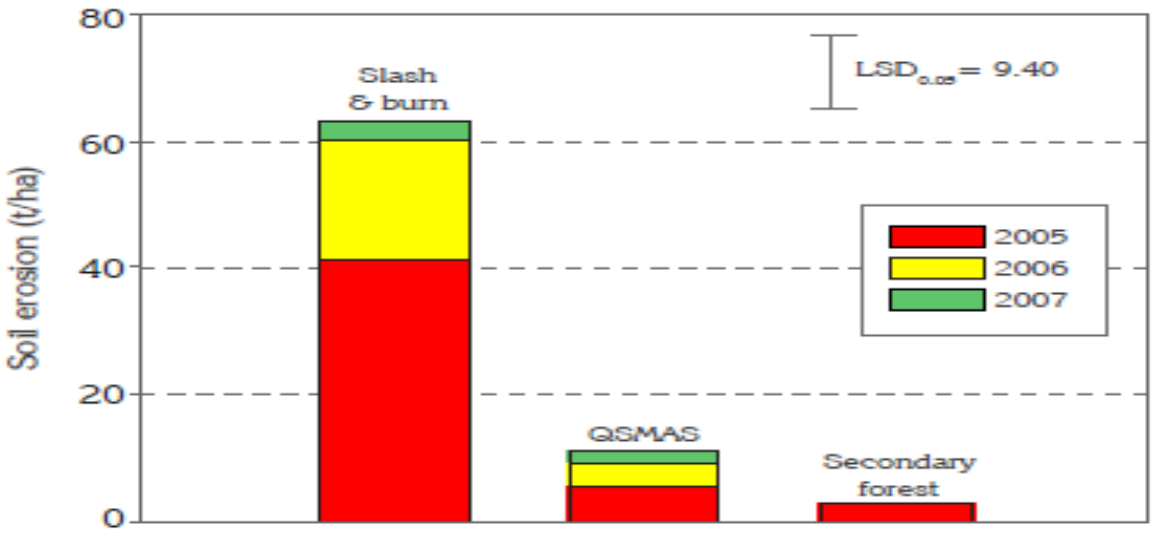


Figure 18. QSMAS protects soil by markedly reducing soil erosion (87%, 84% and 67% less after 1, 2 and 3 years, respectively) compared to slash and burn system

Generally, 11.2 Mg ha^{-1} yr^{-1} is considered as permissible erosion limit based on the assumption that this rate of erosion equals soil formation. However, the actual erosion occurring in different

sites sometimes goes far beyond this assumption. Thus, considering a single value approach as critical limit for soil erosion would be misleading (Lakaria *et al*. 2010)

Runoff and sediment load

The total runoff per hectare during 2015, 2016 and 2017 cropping season was highly variable between experimental plots, although there was no difference in terms of the rainfall received during the same period. The distribution of runoff during the years is shown in Table 11 as monthly values. The distribution of runoff follows the rainfall amount and intensity pattern with the maximum monthly runoff occurring in June, irrespective of land use. On average, the highest runoff volume was from traditional Jhum. The runoff from the watersheds and the sub-watersheds seems to have been influenced by factors such as topographic characteristics, land use and management practices implemented (Hartantoa *et al*., 2003; Gary and Carmen, 2007).

Table11. Total surface run off (%) from experimental plots in 2015, 2016 and2017

Particulars		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Control	2015	-	-	-	-	4.40	35.61	65.30	41.74	47.40	17.73	-	-
	2016	-	-	-	-	-	35.92	29.65	30.17	29.40	50.43	-	-
	2017	-	-	-	-	7.07	36.69	17.69	18.17	14.27	11.73	15.24	
QASMAS	2015	-	-	-	-	4.87	46.05	67.41	51.63	57.71	21.80	-	-
	2016	-	-	-	-	-	41.17	47.90	39.53	30.84	35.63	-	-
	2017	-	-	-	-	8.42	41.14	20.31	21.29	16.18	13.82	17.61	
Jhum with hedge row	2015	-	-	-	-	5.18	50.31	69.22	60.62	66.73	22.82	-	-
	2016	-	-	-	-	-	44.73	55.74	47.30	32.28	40.57	-	-
	2017	-	-	-	-	9.43	43.57	22.40	22.86	20.02	16.60	19.97	
Traditional Jhum	2015	-	-	-	-	5.87	52.19	71.03	72.90	75.76	23.84	-	-
	2016	-	-	-	-	-	49.20	64.54	51.65	33.72	45.50	-	-
	2017	-	-	-	-	10.45	48.02	25.80	24.42	25.77	17.99	22.34	-

Nutrient loss through surface runoff and erosion

The impact of soil erosion on the productive potential of agricultural lands is well known (Pathak *et al*., 2004), but the magnitude depends on local circumstances. In the study areas, the organic matter depletion was also observed irrespective of land use. The loss of the essential plant nutrients (N, K, S, Zn, B, Ca, Mg and Mn) in association with the suspended sediments and runoff during the measurement period was remarkable (Figures 19 through 27). The selective erosion of plant nutrients in runoff is a well known phenomena (Sharpley, 1985), and the

sediment lost from the experimental plots on the micro-watershed was clearly enriched in all elements except P, relative to the topsoil of the watershed. The highest loss was displayed by Mn, Zn and S possibly resulting from reductive dissolution of oxides caused by sudden saturation of the soils in the earlier heavy rainfalls of the season. The results are in partial conformity with Gafur *et al*. (2003). This suggests that soil conservation control efforts should be prioritized in areas with high soil and nutrient loss potential so that their productivity is maintained.

Table 12. Nutrient loss (tha^{-1}) from plots under different land use (2016)

Particulars	N	P	K	S	Zn	B	Ca	Mg	Cu	Mn
Secondary forest	5.40	0.04	0.65	0.88	0.18	0.01	5.1	0.25	0.024	0.093
QSMAS	4.00	0.04	0.44	0.54	0.16	0.02	2.0	0.21	0.031	0.178
Jhum with hedge	4.80	0.60	0.26	0.94	0.17	0.01	2.1	0.19	0.031	0.154
Traditional Jhum	4.80	0.04	0.26	0.56	0.17	0.01	1.7	0.26	0.028	0.193

It was observed that highest nitrogen loss i.e. 5.4 tha^{-1}occurred from secondary forest plot and the lowest (4.0tha^{-1}) from QSMAS plot along with other nutrient elements. In case of Jhum with hedge and Traditional Jhum plot nitrogen loss was 4.8tha^{-1} along with other nutrient elements. Gafur (2001) found that in each year, the eroded soil from all the Jhum fields in CHT carries out about 4,309 tons of nitrogen along with other nutrients and about 14,071 tons of commercial fertilizers would be required to replace nutrients in eroded soil that would cost approximately US $1.8 million annually.

Figure 19. Dynamics of OM status due to soil erosion

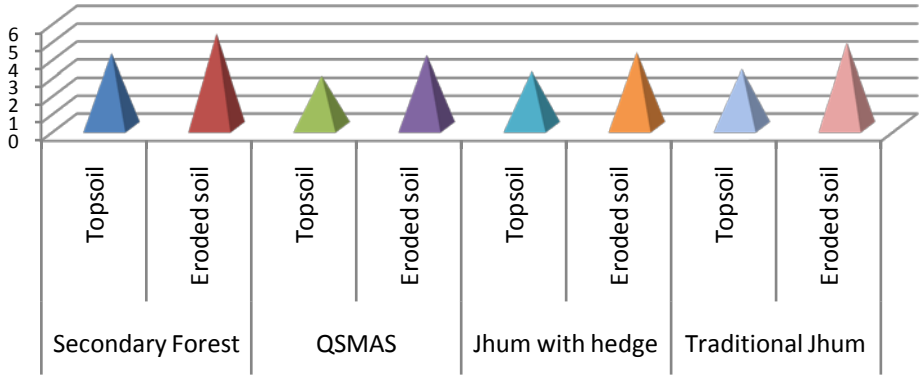


Figure 20. Dynamics of Total N due to soil erosion

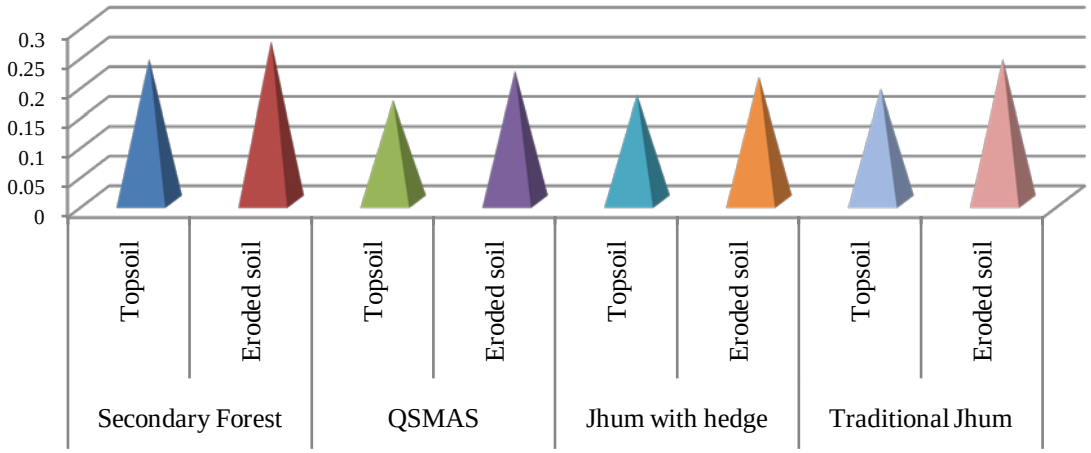


Figure 21. Dynamics of P status due to soil erosion

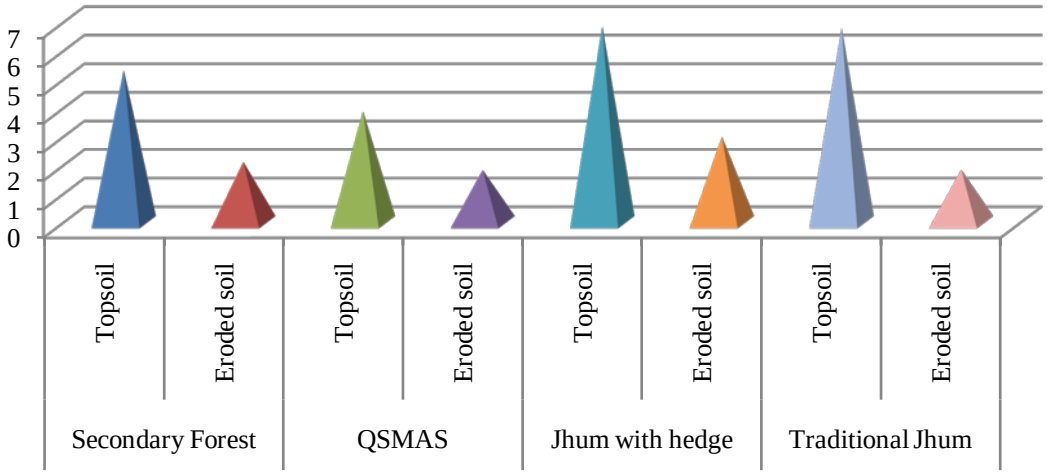


Figure 22. Dynamics of K status due to soil erosion

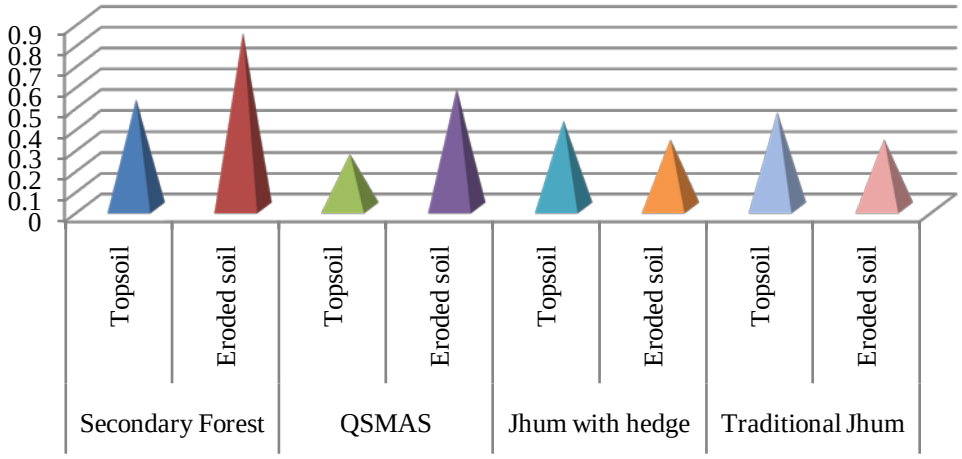


Figure 23. Dynamics of S status due to soil erosion

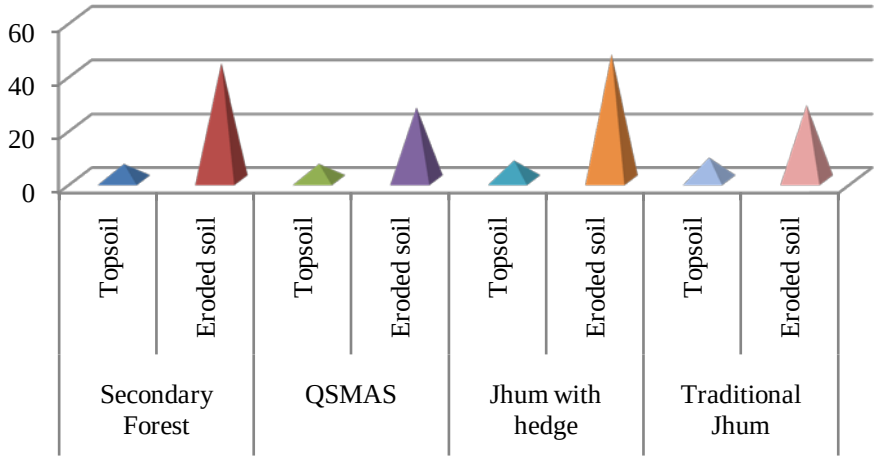


Figure 24. Dynamics of Zn status due to soil erosion

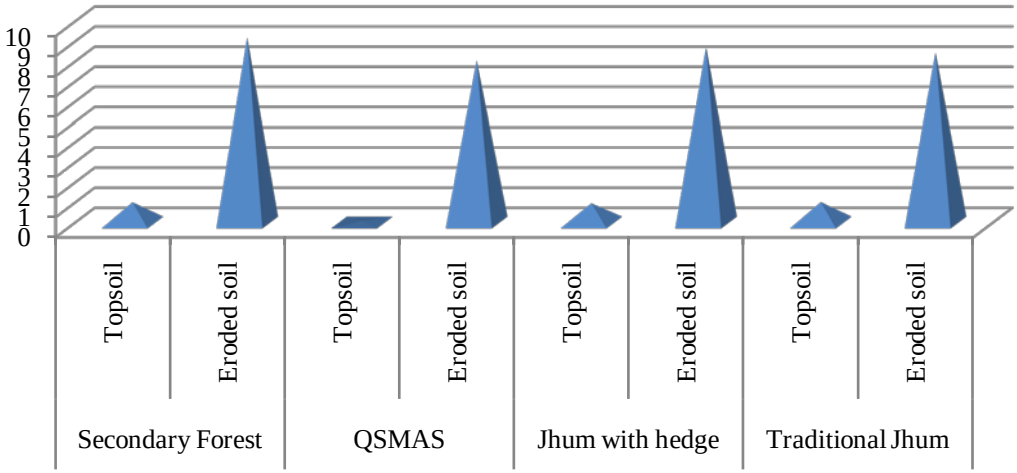


Figure 25. Dynamics of B status due to soil erosion

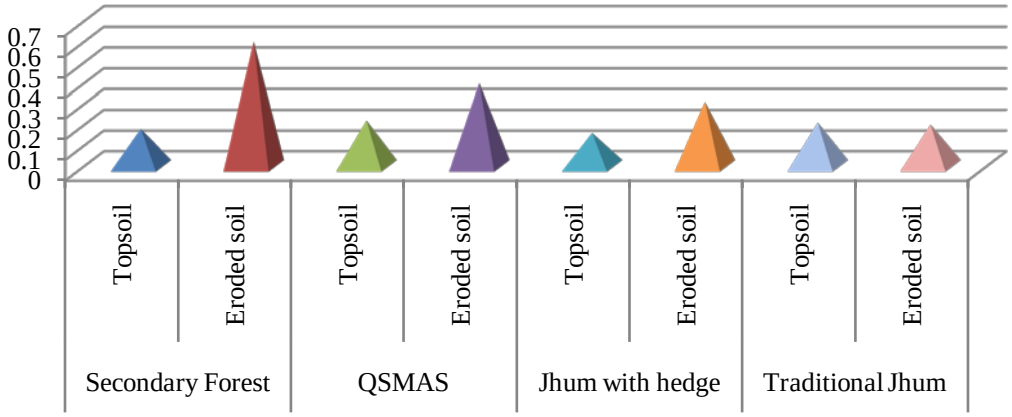


Figure 26. Dynamics of Ca status due to soil erosion

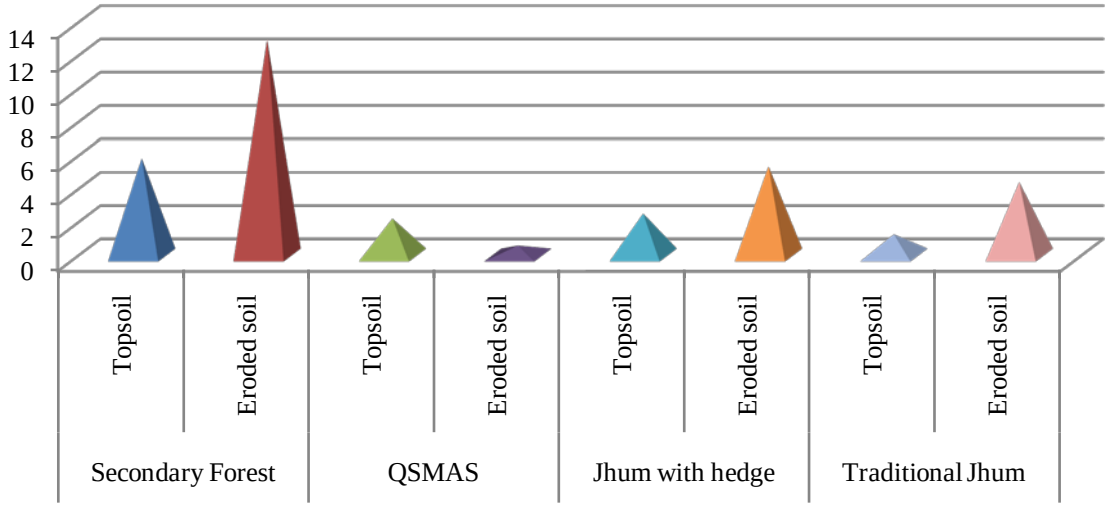


Figure 27. Dynamics of Mg status due to soil erosion

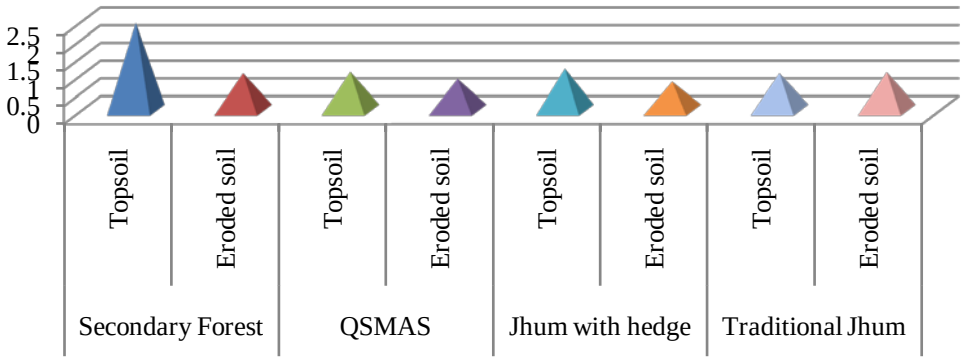
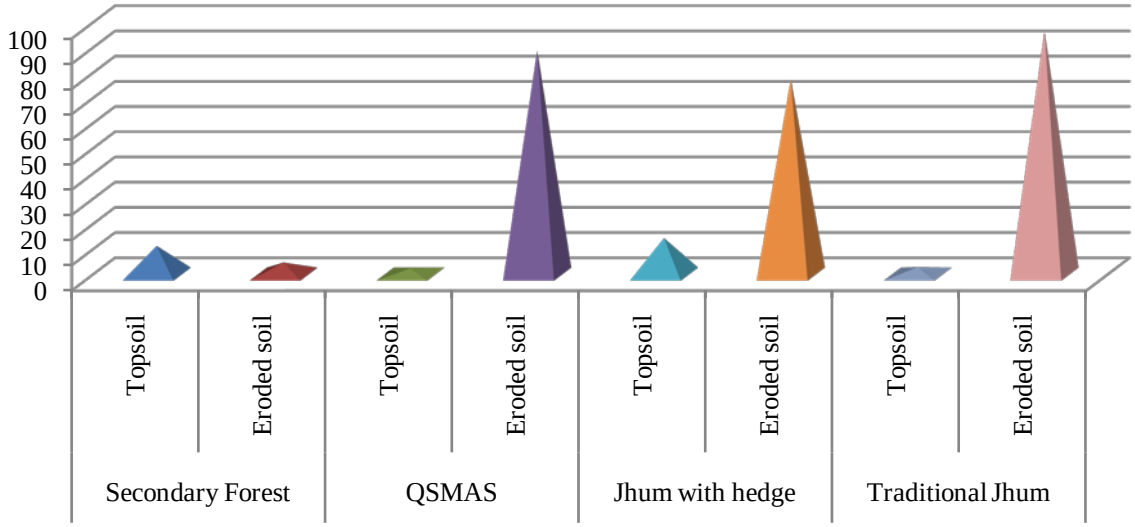


Figure 28. Dynamics of Mn status due to soil erosion



CONCLUSION

Fertility status was observed to be improved due to improved land use and management system.

System productivity of QSMAS plot was much higher than that of other plots. It was observed that highest total soil loss occurred in traditional Jhum plot followed by Jhum with hedge row and QSMAS model. The lowest total soil loss was observed in control plot (secondary forest).

Therefore, effective measures should be taken to discourage slash and burn shifting cultivation and upscale farmers knowledge base and information for awareness building along with other supports to enable them to adopt agro-forestry as a sustainable land-use system.
Agro-forestry is considered as one of the major strategies for sustainable forest management as well as poverty reduction in Bangladesh, where there is obvious priority for food crop production. Farmers need technical know-how, capital investment, marketing facilities and institutional supports (mainly title to their land) to move from Jhum to sedentary farming practices such as agro-forestry. Micro-watershed based agro-forestry system may be an alternate option for Jhum culture for livelihood security of Hill dwellers in Chittagong Hill Tracts. Government should design necessary program to address the needs of upland farmers, e.g., substantial initial investment, to support them to move from shifting cultivation to agro-forestry systems.

RECOMMENDATION

Effective measures should be taken to discourage Slash and burn cultivation and upscale farmers knowledge base and information for awareness building along with other supports to enable them adopt slash and mulch agro forestry as a sustainable land use system.

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PROGRAM 2:

DEVELOPMENT OF INTEGRATED WATERSHED MANAGEMENT AT SCWMC IN CHT.

ABSTRACT

In hilly region of Bangladesh receive huge amount of rainfall in the country. But this rainfall was not well distributed. This huge amount of excess rainfall drains out of CHT along with eroded soil material through numerous channels (streams), canals and rivers of the hills without significant natural and artificial obstacle. Thus, following heavy downpour of the rainy season, the area suffers from severe drought and water scarcity in the dry season. Hence, it is imperative to preserve excess water of the rainy season by creating suitable dams in the hilly areas to boost up local water need round the year and secure sufficient quality water in the drier months for irrigation, fishery and other multipurpose uses. The experiment has been conducted near by the multipurpose dam at the research area of Soil Conservation and Water Management Centre, SRDI- under Bandarban Hill District. The main objectives of the research program was to manage and utilize the rain & runoff water for irrigation, fishery, poultry & household purpose, to protect, conserve and improve the slopping land of watershed, minimizing soil erosion hazard, sustained production and settled agriculture & to improve and increase the production of food, fruits, fuel and fodder and to bring scattered inhabitants in clusters to ensure healthy & safe environment. Several activities have been carried out simultaneously in suitable locations. In each activities soil conservation technique has been introduced. Soil conservation measures of both the mechanical and bio-engineering were adopted. Mechanical measure has been accomplished with bench terracing, grassed waterways, contour trench, half moon terracing etc. Most degraded sites have already been reclaimed by using jute geo-textile. Biological method has been adopted by introducing different hedge species and which will be planted in contour lines. Fishes were introduced in the reservoirs. Irrigation for plants and seasonal crops would be done. This Research will help the hill dwellers to use the rain & runoff water for Agriculture & family life. Poultry and fish cultivation will fill-full the demand of food i.e. protein. Various food species will mitigate the demand of vitamins and minerals. It will also support them by providing cash value. Mechanical measures of soil conservation practices would be helpful for minimizing soil erosion hazard and rehabilitation of degraded lands.

INTRODUCTION

Hills of Bangladesh receive highest rainfall in the country. The average annual rainfall in CHT is 2682 mm (1941–2000; c.v. 18%) with distinct wet and dry seasons. The rainy season starts in May and continues up to October, with a sharp increase in the rainfall from May to June and the

July rainfall accounting for 24% of the annual rainfall. The annual reference evapo-transpiration is approx. 1350 mm leaving a potential rainfall excess of approx. 1350 mm y^{-1}. This huge amount of excess rainfall drains out of CHT along with eroded soil material through numerous channels (streams), canals and rivers of the hills without significant natural and artificial obstacle. Thus, following heavy downpour of the rainy season, the area suffers from severe drought and water scarcity in the dry season. Hence, it is imperative to preserve excess water of the rainy season by creating suitable dams in the hilly areas to boost up local water need round the year and secure sufficient quality water in the drier months for irrigation, fishery and other multipurpose uses.

Land degradation is one of the major ecological issues of the world. Land degradation means loss in the capacity of given land to support growth of useful plants on a sustained basis (Singh, 1994).Due to different types of land degradation, Bangladesh lost a substantial amount of production which in terms money may be hundreds of billion taka in every year (BARC, 1999). Faulty Jhum cultivation in hilly area causes gully erosion and loss of soil ranges from 10 to 120 t $ha^{-1}yr^{-1}$ (Farid *et al.*, 1992).Soil degradation is difficult to quantify and the impact of soil loss and destruction is not evident immediately. Recently, however, the magnitude of the cumulative effects has been described in some studies. Since 1970, the farmers world over have lost an estimated 480 billion tons of top soil, roughly equivalent to all of India's crop lands (Brown, 1991). In Canada, soil degradation has been costing farmers US $ one billion a year. In India, about 173 m ha or 53% of the total geographical area are subjected to varying degrees and forms of soil erosion (Bali, 1990). Analyses of annual soil erosion rates in India have indicated that 5334 million tones (i.e. 16.33 tone/ha/year) of soil is detached annually and of this about 29% is carried away by the rivers into sea. Nearly 10% of it is being deposited in reservoirs losing 1-2% of its capacity (Narayana and Ram Babu, 1983). Scientific management of land and water resources is the key to increase productivity.

Vegetation and land use play an important role controlling the intensity and frequency of overland flow and surface erosion (Mitchell, 1990; Gafur *et al.*, 2001b). Naturally, woody perennials and tree species produce large amounts of aboveground biomass. Because of their perennial nature, there is a continuous addition of organic matter and biomass to the soil. Tree crops influence the microclimatic factors such as soil and air temperature, net radiation reaching the ground surface evaporative demand, etc. Expectedly, soil and air temperature is lower during the day in the vicinity of perennial hedges than farther away from them. Under this condition, soil organic matter content is being continuously increased, activity of soil fauna increased and soil structure improved (Lal, 1991).

So far very little scientific effort have been taken to grow different crops/annual fruits in different hill slopes of CHT, which could reduce pressure on already squeezed suitable Jhum land. Considering all these circumstances, a land use system that will ensure or sustain the production as

well as conserve soil fertility and reduce soil loss should be developed particularly for the hilly regions of Bangladesh.

This proposed research program was, therefore, designed to develop technique for minimizing soil loss and fertility development to achieve better economic return along with reducing the water scarcity and ensure food security.

OBJECTIVES

a. To manage and utilize the rain & runoff water for irrigation, fishery, poultry & household purpose.

b. To protect, conserve and improve the slopping land of watershed, minimizing soil erosion hazard, sustained production and settled agriculture.

c. To improve and increase the production of food, fruits, fuel and fodder and to bring scattered inhabitants in clusters to ensure healthy & safe environment.

MATERIALS AND METHODS

The experiment was conduct near by the multipurpose dam at the research area of Soil Conservation and Water Management Centre, SRDI- under Bandarban Hill District. Several activities were carried out simultaneously in suitable locations. In each activities soil conservation Technique will be introduced. Different horticultural fruit species has been planted along with hedge plant for minimizing erosion hazard. The experimental plots has been selected in such way that the area individually can be treated as a micro watershed and each plot has been considered as a treatment. The area has been divided into smaller parts depending on slope gradient and soil characteristics. Prior to plantation composite topsoil samples will collect from each site and physical, chemical and mineralogical analysis will done to compare the soil characteristics before and after cultivation. The seedlings/saplings has been planted in contour line (across the slope) with following plant spacing and row spacing on the basis of species. Preparation of land has been started at suitable time. Intercultural operations has been done as and when required. Data on yield and yield contributing characters will take at harvest time and economic analysis will made following standard statistical procedure. Soil conservation measures of both the mechanical and bio-engineering has been adopted. Mechanical measures has been accomplished with bench terracing, grassed waterways, contour trench, half moon terracing etc. Most degraded sites has already been reclaimed by using jute geo-textile. Biological method would be adopted by introducing different hedge species and which has been planted in contour lines.

Different horticultural crops like mango, Jujube (Kul) Orchard (Apple Kul & BOU Kul), Multi-fruit Garden and citrus species has been planted on adjacent to the watershed both on the flat & slopping lands following contour lines. Pits for seedlings would be drug in the month of April to May. Manures and fertilizers like cow dung, N, P & K will be applied as per recommendation. Planting of the seedlings has been done in the month of June to July depending on rain. Intercultural operation will be done manually as when and where necessary. Half moon terrace has been made to conserve moisture before the end of the monsoon. Mulch has been done in the half-moon terraced to keep the soil moisture, adding biomass & maintain the good health of the soil. Year round different seasonal vegetative crops will be grown in bench terraced area and necessary irrigation would be done from nearby multi-purposed dam water. Intercultural operations like weeding and earthling up of the soil will do equally in all treatments to get better results. Before sowing of seeds, a mixture of cowdung, N, P and K as urea, triple super phosphate and murate of potash will apply at different doses. Other management practices and preventive measures will take as and when need. Data on different attributes of different crops will record timely following standard procedures. Meteorological information's like rainfall,

humidity percentage, daily maximum and minimum temperature, soil temperature in different depth will be collected.

Fishes has been introduced in the reservoirs. Experimental site also be selected near by the reservoirs. Irrigation for plants and seasonal crops would be done. Training & Demonstrations for various levels would be held on.

RESULT & DISCUSSION

Table 13. App Cost and return (BDT) from experimental plots

Sl. No	Particulars	App Cost	Return in BDT			Remarks
			FY 2015-16	FY 2016-17	FY 2017-18	
1.	Fish cultivation	93,000/-	-	20,000/-	30000/-	
2.	Multi-fruit Garden (Established garden)- Interculture only.	9,000/-	12,000/-	15,000/-	18,000/-	
3.	Newly planted Mango orchard	32,000/-	Nill	500/-	1,700/-	Primary stage and Partly bearing.
4.	Newly planted Citrus orchard	5,000/-	1,200/-	1,500/-	1,800/-	
5.	Vegetables on Bench Terrace	10,000/-	15,300/-	12,800/-	14,200/-	
6.	Lichi garden (Established garden)- Interculture only	15,000/-	60,000/-	Nill (Alternate bearing)	40.000/-	
7.	Barkul Orchard (Apple Kul & BOU Kul)	1,000/-	500/-	700/-	1,400/-	Growing stage and Partly bearing.
8.	Coconut & battle-nut (Interculture only)	3,000/-	3,800/-	4,200/-	4,500/-	

Soil loss from degraded land under different treatment for the year-2016 session is presented in Table 14. It was recorded that highest soil loss was recorded in control plot (**15.51** ton/hac) where no geo-jute or jute mat was used, followed by plot managed by 500 GSm (**8.67** ton/hac) and 700 GSm **(5.28** ton/hac). As 700 GSm jute mat is denser than 500 GSm Jute mat, so it provides better soil cover than that of 500 GSm jute mat. On the other hand 500 GSm jute mat is better than 700 GSm jute mat for growing vegetation at primary stage as it is lighter than 700 GSm. Jute mat.

Table 14: Soil loss from degraded land under different treatment for the year-2016

Month	Soil loss (Ton/hac)		
	700 GSM	500 GSM	Controlled
June/2015	2.37	3.74	7.26
July/2015	1.40	2.05	3.97
August/2015	0.66	1.18	1.65
September/2015	0.43	1.05	1.36
October/2015	0.42	0.65	1.27
Total	5.28	8.67	15.51

Run-off from degraded land under different treatment for the year-2016 throughout the rainy season was calculated and shown in Table-13. It was recorded that the highest runoff was recorded in controlled plot where there was no geo-jute or jute mat, followed by plot managed with 700 GSm & 500 GSm .

Table 15: Run-off from degraded land under different treatment for the year-2016

Month	Run-off (%)			Monthly Rainfall(mm)
	700 GSM	500 GSM	Controlled	
June/2015	27.89	29.52	36.63	684
July/2015	34.61	39.41	52.85	532
August/2015	45.41	48.62	64.68	468
September/2015	29.71	32.35	35.87	359
October/2015	34.26	36.72	41.66	144

Table 16: Chemical properties of Soil under different jute-mat (Before setting the experiment)

Particulars	pH	OM %	K	Ca	Mg	TN (%)	P	S	B	Cu	Fe	Mn	Zn
		Meq/100g soil					u gm/g soil						
700-GSM Plot	4.5	3.36	0.36	3.43	2.08	0.40	6.70	11.3	0.20	0.76	68.8	25.2	1.50
500-GSM Plot	4.3	3.09	0.30	2.28	1.54	0.43	3.67	1.7	0.25	0.70	50.2	14.0	0.94
Control Plot	4.6	2.83	0.49	4.73	2.88	0.22	6.88	12.4	0.28	0.78	72.0	24.2	2.24

Table 17: Chemical properties of Soil under different jute-mat (After Two years)

Particulars	pH	OM %	K	Ca	Mg	TN (%)	P	S	B	Cu	Fe	Mn	Zn
		meq/100g soil					μ gm/g soil						
700-GSM Plot	5.9	3.77	0.39	9.08	2.71	0.19	3.28	1.11	0.03	0.69	77.05	7.23	1.48
500-GSM Plot	5.9	3.36	0.35	11.56	3.37	0.18	2.83	0.27	0.23	0.85	80.22	6.81	1.57
Control Plot	5.2	2.98	0.30	8.75	2.47	0.17	2.96	3.67	0.18	0.63	51.5	5.3	1.02

In maximum Parameters Soil nutrient were increased after setting the jute geo-textile.

CONCLUSION

This activity has been proposed aiming to mitigate the basic need of a small family consisting of five members. This Research will help the hill dwellers to use the rain & runoff water for Agriculture & family life. Poultry and fish cultivation will fill-full the demand of food i.e. protein. Various food species will mitigate the demand of vitamins and minerals. It will also support them by providing cash value. Other crops like coconut and battle-nut will enrich the economy in various ways. Mechanical measures of soil conservation practices would be helpful for minimizing soil erosion hazard and rehabilitation of degraded lands. Seasonal vegetables grown in Bench Terrace will supply them food as it is easy to irrigate on bench terraced area for suitable crop's yield. Other mechanical measures i.e. half moon terracing would be helpful to conserve moisture for the drought time and added mulching would enrich the soil fertility by increasing organic matter in soil. Barkul (BARI kul and Apple kul) is a naturally drought tolerant plant and suitable for drought prone areas. It has also great demand in local market. Irrigation for different orchard (Mangoes, lichi, malta, lemon etc) can be done from the nearby multi-purpose reservoir. On the other hand , the reservoir can serve the purpose water used for house hold activities of the hill dwellers. The economical return from the experiment will be obtained & calculated for the next time. Further the whole activities would be used for training and demonstration purposes.

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PROGRAM 3:

STUDY ON MANAGEMENT AND ECONOMIC VALUE OF *SCHUMANNIANTHUS DICHOTOMA* (*MURTA*/ PATIBET) IN HILLY JHIRI LAND AT CHT.

ABSTRACT

Schumannianthus dichotoma (*Murta*/Patibet) is widely grown in wetland areas of Bangladesh, providing the raw materials for prayer and bed mats and also minimizing soil erosion. A suitable field situated in a Jhiri locating of the South-south-east side of the SCWMC administrative Building has been selected for cultivation of *Patibet.* The main objectives of the research program was to study the suitability and yield or productivity of Murta in Hilly Region of Bangladesh, to ensure the fallow lands of hilly Jhiri in to productive and minimize soil erosion hazard & to strengthen the economical efforts of the hill dwellers by increasing off farm activities & to supplement the traditional Jhum Practices. Propagation was from rhizomes and branch cutting, and little intensive management was required. Harvesting was usually done annually, from mid September to the end of March. Soil has been made up for proper propagation. Necessary intercultural operation is going on accordingly. Weeding is needed only

for vines and climbing weeds, generally before the rainy season. Weeding, especially of the main weed, Asam lata (*Eupatorium odoratum*), should usually be carried on along with harvesting, or occasionally.There were no significant pest and disease attacks in *Patibet* plantations. *Patibet* can play a vital role in the economy and environment CHT of Bangladesh. It can easily be cultivated in hilly Channel/Jhiri that remain fallow and remain wet even in the dry season. These lands are not suitable for cultivation of other cash crops. The cultivation of *Patibet* is inexpensive and does not conflict with the production of agricultural crops. This program will minimize soil erosion hazard in Chittagong Hill Tracts. This study will ensure income generating crops instead of harmful jhum cultivation and safe hill environment.

INTRODUCTION:

Schumannianthus dichotoma is popular cultivated species with local names in different regions of Bangladesh, such as *Patipata* and *Pati-jung* in Chittagong, *Mostak* in Noakhali, *Pat-bat* and *Murta* in Sylhet and Tangail and *Paitrabon* in Barishal (Rashid *et al*. 1993; Islam 2005). It is in the Marantaceae (Hooker 1892; Prain 1903), with 20 species in the genus *Schumannianthus*. It is a shrub with oblong or oblong lanceolate leaves 1.5–3.0 ×1.0 cm, broadly rounded at the base (Mohiuddin and Rashid 1988), erect, conspicuous glossy green and dichotomously branched stems 3–5 m high, and basal diameter of 2–5 cm (Prain 1903; Anon 1950; FMP 1992). It has a tuberous rootstock (Hooker 1892) with stem buds on culms (new shoot buds). The species is found in Northeast India,West Bengal, the Coromandal Coast and the Malay Peninsula (Hooker 1892; Anon 1950; Chowdhury and Konwar 2006). In Bangladesh, it covers sizeable areas in the Sylhet Division forests (Anon 1970) and grows well in swampy areas (Rao and Verma 1972; Ara *et al*. 2000); it is grown in partial shade, and prefers clay or clay-loam soil with high moisture. The plant cannot tolerate direct sun. It is propagated from rhizomes that are planted directly in the field at 1 × 1 m spacing (Merry 2001). *Murta* is cheaper to grow than jute or rice, and gives a good economic return (Mohiuddin and Rashid 1988) as the raw material for *Shitalpati* (Chowdhury and Konwar 2006; Chowdhury *et al*. 2007), a traditional bed mat in Bangladesh, and other mats. The mat is woven from the dyed fibres, 3–5 mm wide, with coloured designs on a natural beige background. Bed mats made of *Murta* are attractive and comfortable, Especially during the hot summer months(Banik 2001).

A growing body of research suggests that non-woody forest products (NWFPs) can help communities to meet basic needs without destroying forest resources. In local, urban, national and international markets, forest goods and medicines contribute substantially to national economic growth (FAO 1995). NWFPs complement wood-based forest management and can contribute to integrated forms of development that yield higher rural incomes and conserve biodiversity without competing with agriculture (Sharma 1995). According to the FAO (1995), NWFPs are important to three main groups: i) rural populations (the largest group) who have traditionally used these items; ii) urban consumers (the smallest group, but increasing) who purchase these items; and iii) traders and product processors whose numbers are increasing as urban markets for these products grow.

As a NWFP, *Murta* generated significant revenue for the Forest Department of Bangladesh. 100 ha of *Murta* is worth US$91,783 annually, rising to more than US$35,3012 after processing (Anon 1990), US$706/ha more than paddy (Rashid *et al*. 1993). From 1981 to 1991, the average annual revenue collected by the government was US$6057 (US$1 = Tk. 70) (Banik 2001). Only

a small percentage of *Murta* products are exported and most are for domestic consumption. In 1992, BSCIC (Bangladesh Small Cottage Industries
Corporation) reported 175 *Sitalpati* processing units consuming materials worth US$37,571 at a production cost of US$61,428. The resultant products were sold for US$11,6714 (Banik 2001). *Murta* plays a vital role in the economy and environment of the country (Rashid *et al*. 1993), if properly managed, and products can be exported abroad. From 1999 to 2003, the Bangladesh government received average annual revenue of US$4567 from *Murta* (BBS 2001), less than in the previous decade. To maximise income, it is necessary to undertake intensive research on the management, cultivation and marketing of *Murta* and its products (Merry 2001; Chowdhury *et al*. 2007). For instance, the effect of collecting rhizomes on the productivity of parent plants; costs of raising seedlings; enthusing local people to cultivate *Murta* (Merry 2001); and marketing (Banik 2001).

The vast areas of *Murta* in the northern Sylhet forests annually trap huge amounts of mud and silt, saving nearby low-lying areas from flash floods. *Murta* also has a positive role in the regeneration of tree species by trapping seeds and providing protection to young plants (Banik 2001). Mohiuddin and Rashid (1988) found that the number of new culms and their height is higher in Sylhet than in other sites. Although the use of *Murta* has recently expanded (Banik 2001), the cultivated area has decreased (Rashid *et al*. 1993). The deteriorating condition of this resource demands immediate attention for its scientific management (Mohiuddin and Rashid 1988; Chowdhury *et al*. 2007). Consequently, this study was carried out in the Chittagong Hill Tracts region to ascertain traditional management practices and their contribution to sustainable development of the rural economy.

OBJECTIVES

1. To study the suitability and yield or productivity of Murta in Hilly Region of Bangladesh.
2. To ensure the fallow lands of hilly Jhiri in to productive and minimize soil erosion hazard.
3. To strengthen the economical efforts of the hill dwellers by increasing off farm activities & to supplement the traditional Jhum Practices.

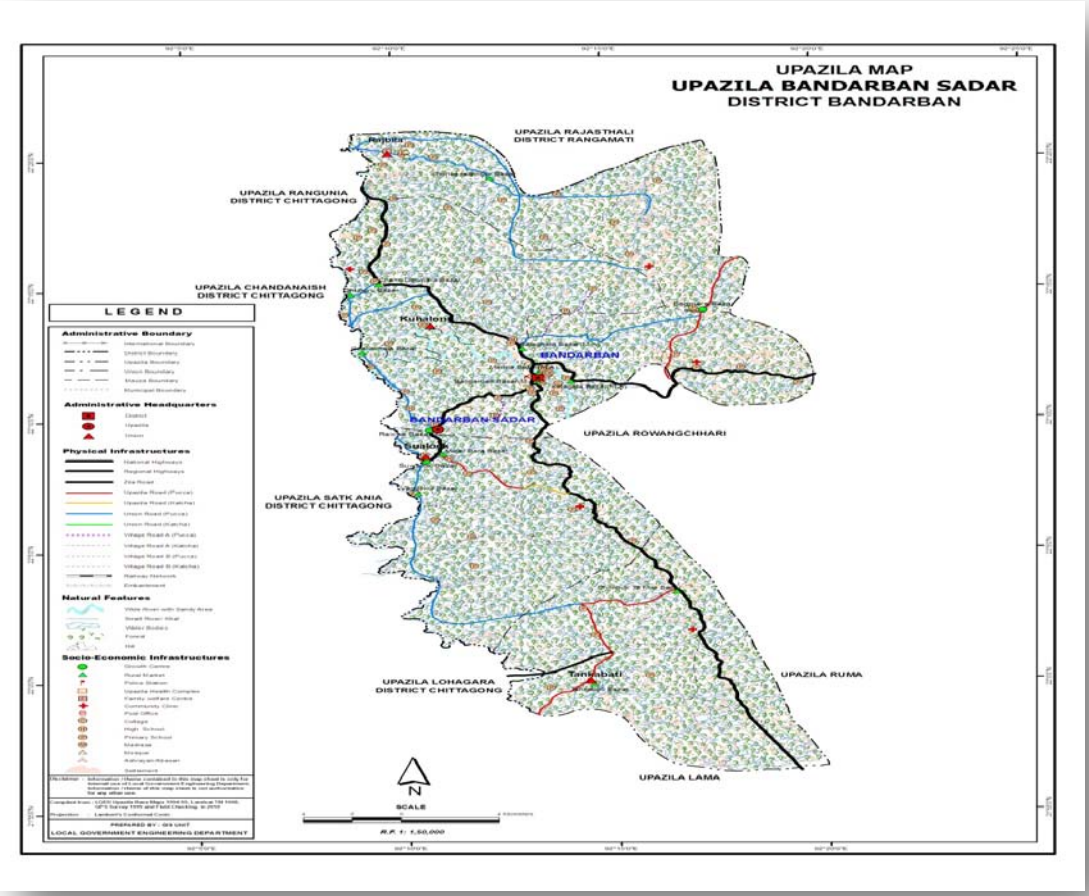

Figure 29: Map of the study area

MATERIALS AND METHODS

The study has been introduced in fy 2016-2017. A suitable field situated in a Jhiri locating of the South-south-east side of the SCWMC administrative Building has been selected for cultivation of *Patibet.* For Judging the adaptability with the climatic condition of this region, in the primary stage about 500 rhizomes covering an area of 85'-0' ' x 20'-0' ' = 1700.00 sft. has been planted in rows maintaining contour lines. Rhizomes were collected from nearby Upazila of Chittagong district. Soil has been made up for proper propagation. Necessary intercultural operation with applying proper fertilization has been done accordingly. Field investigations are going on and it will be carried at least for 3 financial years.. After completion of 3 years observation, the activity will be transferred to public field. Then a multistage random sampling method will be applied to relocate at least two village and households of Bandarban Sadar Union for the study within as the primary sampling and ultimate sampling units, respectively. Two villages would be selected randomly and, from each, one village would be selected for detailed investigation. The total number of households in the two villages will be obtained from the District Census, conducted to

assess the socio-economic status of households in the villages. From each village, 20 households will be selected for survey by random sampling. A semi-structured questionnaire will be used to collect data from the heads of the households to assess the area allocated for cultivation of *Patibet*, propagating materials, different silvicultural techniques, and contribution of *Murta* to the household economy. New avenues of questioning would be pursued as the interviews developed. To analyse the data obtained from field.Three propagating materials, rhizomes, branch cuttings and seeds, may be used for *Murta* (Rashid *et al*. 1993). All the farmers used rhizomes and branch cuttings, as also found by Chowdhury *et al*. (2007). One third (33%) of farmers used only rhizomes and 23% used branch cuttings, while 44% used both rhizomes and branch cuttings, and none used seeds. Bangladesh Forest Research Institute has developed a method of raising seedlings from seed (Merry *et al*. 1997), the farmers have not accepted it yet. It noted that there are difference in survival for rhizomes, rooted cuttings and seedlings was insignificant.

According to the criteria for cultivation of *Schumannianthus dichotoma (Murta)* is going on. The plantation site *Schumannianthus dichotoma (Patibet)* should be weeded twice a year Rashid *et al*. (1993), Merry (2001) and Chowdhury *et al*. (2007). Weeding is needed only for vines and climbing weeds, generally before the rainy season. Weeding, especially of the main weed, Asam lata (*Eupatorium odoratum*), should usually be carried on along with harvesting, or occasionally.

Cultivation of *Schumannianthus dichotoma (Patibet)* is needed both addition of soil and application of fertilizer. Soil should be done during the dry season, usually after harvesting and before the onset of the monsoon. Soil addition should be done throughout the *Patibet* plantation, and particularly within and around the *Murta* clumps. Soil should be dug to enhance aeration Chowdhury *et al*. (2007). *Patibet* cultivation is needed application for organic fertilizer. Application of cow dung is the best as fertilizer Mohiuddin and Rashid *Ahmed et al.*1988), Rashid *et al*. (1993) and Chowdhury *et al*. (2007).

There were no significant pest and disease attacks in *Patibet* plantations Rashid *et al*. (1993). So pest and disease control management has not been taken in to consideration.

Patibet is harvested when it is matured. Experience is used to assess the maturity of *Patibet* sticks, based on colour: culms with two to three branches and slightly reddish are considered mature. Harvesting of *Patibet* is done manually using *daos* (a sharp curved knife). Actual period of harvesting Patibet is from mid-September to the end of March. But a small quantities of *Patibet* can be harvested throughout the year. Harvesting is possible almost every year (Merry 2001). Harvesting of *Patibet* can be done to ground level, leaving almost nothing of the cut sticks in the clumps. The bark of one *Patibet* plant yields seven or eight thin strands. Harvested *Patibet* is bundled and brought into the yard where sticks are manually split into bark strands. Some strands are dyed to make them attractive, lucrative and ready for use in cottage industries; otherwise, harvested *Patibet* (without processing) is bundled and sold in the market (Chowdhury *et al*. 2007).

The field in where the *Schumannianthus dichotoma (Patibet)* is cultivated under this Research, is almost a table top plain land in cross sectional abut a sloping land in longitudinally. The elevation difference from upper end to lower end is 3’-0”. The field is divided in to three plots. Elevation difference from upper plot to middle plot is 1’-9” and from middle plot to lower plot is 1’-3”. The plots are located in the valley land in between two hills which is locally known as Jhiri. This type of land generally remains abandoned all the times (years after years). Soil moisture varies for its difference of elevation. The moisture content of soil of the lower part of the hill is generally higher than that of higher. *Schumannianthus dichotoma* (*Murta*/Patibet) is widely grown in wetland areas. No additional soil is added to the rows of Murta plants as it can

interrupt the natural surface flow during the rainy season. Intercultural operation including applying inorganic fertilizer has been done as per recommendation. Growth of plants and number of plants per Culm were observed closely. No irrigation is done in the draught season.

RESULTS AND DISCUSSION

It was found that there is a significant difference in growth of plants and number of plants per Culm of Murta in different plots. Plants height was also different in difference plots. Plants height of the lower plot is higher than that of immediate upper plot. Plants of Murta in the upper most plot are thin and pale (average height 1'-6" to 2'-0") where the plants growth of the second plot is satisfactory and green in colour (average height 3'-0" to 4'-0"). The plants of the lower plot were healthier and vigorous than second plot with dark green in colour (average height 4'-0" to 5'-0"). On the other hand the number of plants per Culm in upper, middle and lower plot was on an average 7 to 9, 10 to 14 and 12 to 16 respectively.

Table 18: Comparative growth study of the plants in different plot in difference elevation

Plot No	Appearance	Av. palant Height	Av.plants Diameter	Av. Leaf per plant	Av. Plants per Culm	Remarks
1 (Upper)	Yellowish green	1'-6" to 2'-0"	4 to 6 mm	4 to 6	7 to 9	Early stage
2 (Middle)	Green	3'-0" to 4'-0"	5 to 8 mm	5 to 9	10 to 14	Growing stage
3 (Lower)	Dark green	4'-0" to 5'-0"	7 to 12 mm	9 to 14	12 to 16	Can be harvested selectively.

Table 19: Average number of articles sold annually and expected income per household

Articles	Articles sold/industry	Income (US$) (no. articles ¥ net average profit per article)
Simple prayer mat (36″ × 45″, 0.12–0.25″ thick)	13	4.64
Prayer mat with colour strip (same size, = 0.12″ thick)	16	22.17
Prayer mat with colour design (same size, 36″ ×45″, = 0.12″ thick)	10	18.14
Simple bed mat (63″ ×81″, 0.12–0.25″ thick)	200	142.86
Bed mat with colour strip (63″ ×81″, = 0.12″ thick)	15	28.86
Total		216

Table 20: Variation in price for different products from producer to retailer

Articles	Selling Price (US$)				Difference between Artisan and Retailer
	Artisan	Middlemen	Wholesaler	Retailer	
Simple prayer mat	0.60	Not involved	Not involved	Not involved	–
Prayer mat with colour strip	1.93	2.07	2.14	2.29–2.43	0.36–0.50
Prayer mat with colour design	2.57	2.80	2.86	3.14–4.29	0.57–1.71
Simple bed mat	1.57	–	–	–	–
Bed mat with colour strip	3.14	3.36	3.43	3.71–5.00	0.57–1.86

Source: "Management and economic value of *Schumannianthus dichotoma* in rural homesteads in sylhet region of Bangladesh."Romel Ahmed, A.N.M Fakhrul Islam, Mostafizur Rahman & Md. Abdul Hakim. International Journal of Biodiversity Science & Management.

Table-21: Chemical properties of Soil before setting the experiment

pH	OM %	K	Ca	Mg	TN (%)	P	S	B	Cu	Fe	Mn	Zn
	meq/100g soil					µgm/g soil						
5.9	4.44	0.28	8.37	2.87	0.222	5.65	9.40	0.18	5.20	139.60	79.60	2.04
Slightly Acidic	High	Opt.	V.H	V.H	Opt.	Low	Low	Low	V.H	V.H	V.H	High

Table 22: Soil Texture of experimental plot

Soil Textural Class	Sand	Slit	Clay
	%		
Silt Loam	26	64	10

CONCLUSION

Patibet can play a vital role in the economy and environment CHT of Bangladesh. It can easily be cultivated in hilly Channel/Jhiri that remain fallow and remain wet even in the dry season. These lands are not suitable for cultivation of other cash crops. The cultivation of *Patibet* is inexpensive and does not conflict with the production of agricultural crops. This program will minimize soil erosion hazard in Chittagong Hill Tracts. This study will ensure income generating crops instead of harmful jhum cultivation and safe hill environment. It is necessary to develop effective propagation methods which will lead to higher production; these must be user-friendly

so that farmers can adopt them easily. Adequate training and motivation is required to encourage people to cultivate *Patibet* elsewhere in Bangladesh, and infrastructure should be developed to support *Patibet*-based cottage industries and community based marketing facilities, complemented by access to adequate knowledge and information, to ensure that the economic and environmental benefits to the rural people are maximized.

After successful completion of the Research, the cultivation of Patibet would be taken to the Farmer's field as transferable technology through adequate training and motivation. The cultivation of *Schumannianthus dichotoma* at SCWMC, Bandarban is in the initial /growing stage. More research is needed for further result.

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PROGRAME 4:

EFFECT OF DIFFERENT HEDGE SPECIES ON CONTROLLING SOIL EROSION, RUNOFF, AND NUTRIENT MINING OF SNACK GOURD AT GENTLE SLOPE IN CHT.

ABSTRACT

The study involving Snack Gourd conducted at the Soil Conservation and Watershed Management Centre (SCWMC), Soil Resource Development Institute (SRDI), Bandarban to investigate the effect of Effect of different hedge species and slope gradient on controlling soil erosion, runoff and nutrient mining at gentle slope in CHT. The treatments were: T_1: *Indigofera* hedge, T_2: Pineapple hedge and T_3: Control (without hedge). Slope percent of the experimental plot was12% . Hedge species were planted in following contour lines maintaining 5 m alley distance. Measurement of soil loss and run-off was carried out by established and locally fabricated multi-slot divisors. Natural condition of the slopes was not disturbed or no any soil work was done to make artificial slope. Species of hedge plants have a great effect on plant growth and crop yield. Hedge plant of low height (*pineapple*) provides a better performance than that of higher height hedge plant because it provides intensive light & better root binding. But higher height hedge plant provides more bio-mass than lower height hedge plants. Performance of pineapple hedge species on soil loss minimizing capacity was recorded the best on all slope gradients. Hedge always plays a vital role on plant growth, crops productivity, fruit length & weight as well as minimizing of soil erosion.

INTRODUCTION

The conservation of soil and water is essential for sustainable production, environment preservation and balanced ecosystem (Sarma *et al*., 2000). Loss of soil by water erosion on slopping lands adversely affects the physical, chemical and biological properties of soils, leading to low crop productivity (Larson *et al.*1985 and Sur *et al*.,1994). Land use change associates erosion is mostly responsible for land degradation and desertification in different part of Asia and Africa, bringing about large reduction in vegetation growth, siltation of water courses, filling of valleys and reservoirs and the formation of deltas along the coastal areas. Erosion is accompanied by deposition of alluvial materials by flooding and filling of valleys, waterways or extending coastal plains and deltas towards the sea. Contour hedgerows are also effective in controlling run off and soil erosion and improve soil physical properties. Control plots have higher run off and soil loss than those plots with hedgerow (Khisa *et al.,* 1999). Uddin and Firoz (2001) recommended

hedgerow for cultivation on sloppy land. They described that hill slope may be divided into a series of alley separated by hedgerow on contour lines, because hedgerow plants are effective in controlling soil erosion and reducing run off. A number of research works have been conducted in the tropics regarding soil fertility improvement under agroforestry practices. Agboola *et al.* (1982) as cited by Attah-Krah and Sumberg (1988) reported that the soil chemical properties like pH, OM, N, available P and CEC improved with the use of *Gliricidia sepium* as hedgerow. Attah-Krah *et al.,* (1986) as cited by Nair (1993) reported that organic matter content and nutrient levels of soil were higher under alley cropping as compared to soil without trees.

Trees and shrubs have several functions to control erosion like (i) increase soil cover, by liter and pruning (ii) provide partly permeable hedgerow barriers (iii) lead to the progressive development of terraces, through soil accumulation upslope of hedgerows (iii) increase soil resistance to erosion, by maintenance of organic matter (iv) stabilize earth structures by root

systems and (v) make productive use of the land occupied by the conservation works (Young 1989 a). Alley cropping or hedgerow cultivation is very helpful in controlling of soil erosion in the hilly area. Hill Tract Development Board of Bangladesh identified five nitrogen fixing tree species like *Leucaena leucocephala, Gliricidia sepium, Indigofera tysmani, Fleminigia spp,* and *Desmodium rensonii* etc. and two grass species *Vetiviera zizanoides* and *Thysanolaena maxima* for controlling runoff and erosion in the hilly region of Bangladesh (Khisa *et al.,* 2002). Singh *et al.* (1990) found that runoff and soil loss were substantially reduced when small watersheds with agriculture were replaced either by trees and grasses (silvipasture) or with mechanical measures. In a study, Wiersum (1984) found that different agroforestry systems cause lowest soil erosion.

Facing the location specific, environmental friendly agricultural development challenges in CHT, Soil Conservation and Watershed Management Center (SCWMC), Bandarban has stepped up its efforts to generate scientific information on the major land use practices in the region, This study is the first attempt to investigate and quantify the effect of different hedge species on soil loss and run-off and its economic performance on crop cultivation. Therefore, the present study undertaken to find out the feasible hedge species for controlling soil erosion and for crop cultivation in the CHTs.

OBJECTIVES

a. To compare soil loss, runoff and nutrient mining in cultivating Snack Gourd under different hedge species.
b. To evaluate the economical aspects of cultivation under different hedge species.

MATERIALS AND METHODS

The experiment was carried out under non replicated condition. Three experimental plots of 100 sqm. (5 m x 20 m) on gently (12%) were selected in the SCWMC, Bandarban. Two different species were used as hedge species like; *Indigofera* and *Pineapple*. Hedge species were planted in 2013 following contour lines maintaining 5 m alley distance but the data of the experimentation were recorded during 2016. Measurement of soil loss and run-off was carried out by established and locally fabricated multi-slot divisors. Natural condition of the slopes was not disturbed or no any soil work was done to make artificial slope. Pits were dug 1.80 m c/c in rows maintaining contour. Total number of pits in each plot were 24. Fertilizers were applied as per recommendation of soil test value. 3 to 4 nos of seed were sown in each pit.

After germination, two seedling were allowed for yield. Cultural operations were done as usual in all the plots. Soil loss and run-off from each 100sqm (5m x 20m) experimental plots were measured after each shower throughout the rainy season. Daily and eventually monthly soil loss and run-off were estimated from each treatment by processing aliquot of sample every day. Every morning (if rains previous day) amount of run-off water is measured in the multi-slot and aliquot of about 2 Litre is sampled from each tank. Suspended sediment in the sampled aliquot is measured by simple filtering and oven drying. Corresponding rainfall is recorded from the automatic and ordinary rain gauge of SCWMC. Climatic data like rainfall, temperature, humidity, evaporation etc. were recorded daily. Snack Gourd was selected as a test crop. Different agronomic practices were done when it was necessary.

RESULTS AND DISCUSION

Soil loss under different hedge species in gentle slope at Snack Gourd growing plot during 2016-18 sessions is presented in table 23. Soil loss under Snack Gourd at the alley of different hedge species throughout the rainy season was calculated. It was recorded that highest soil loss was recorded in control plot **(**15.35 &16.04 t/ha) where no hedge species were used, followed by *indigofera* hedge species used plot (8.57 &6.06 t/ha) and pineapple hedge species used plot (5.05 &5.46t/**ha**).

Table 23: Soil loss under the cultivation of different hedge species in 2016-17 (t/ha/year)

Particulars	Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	De	Total
Indigofera	2016-17	-	-	-	-	-	2.45	3.09	1.34	0.62	1.07	-	-	8.57
	2017-18	-	-	-	-	0.85	1.94	2.57	1.45	1.63	0.62	-	-	9.06
Pineapple	2016-17	-	-	-	-	-	1.19	1.80	0.69	0.41	0.96	-	-	5.05
	2017-18	-	-	-	-	0.61	0.85	1.78	0.84	1.01	0.37	-	-	5.46
Control	2016-17	-	-	-	-	-	3.85	6.04	2.66	1.09	1.71	-	-	15.35
	2017-18	-	-	-	-	1.83	3.36	3.81	1.73	3.68	1.63	-	-	16.04

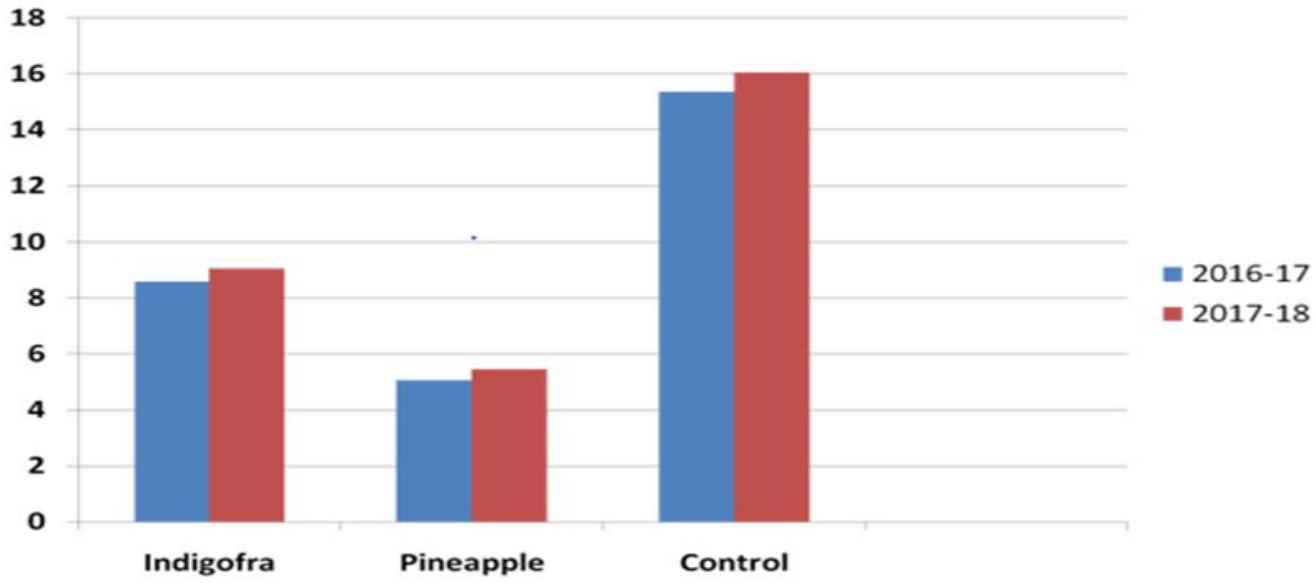

Figure 30: Soil loss under the cultivation of different hedge species in 2016-18 (t/ha/year)

Runoff under Snack Gourd at the alley of different hedge species throughout the rainy season were calculated (Table 24). It was recorded that highest runoff was recorded in control plot

where no hedge species were used, followed by *indigofera* hedge species used plot and pineapple hedge species used plot.

Table 24: Run off under the cultivation of different hedge species in 2016-2018

Particulars		Month wise runoff (%) 2016-18											
		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Indigofera	2016-17	-	-	-	-	-	43.14	52.79	49.45	35.98	28.23	-	-
	2017-18	-	-	-	-	7.07	41.14	28.41	19.21	25.30	22.41	-	-
Pineapple	2016-17	-	-	-	-	-	36.57	49.80	47.25	32.46	25.76	-	-
	2017-18	-	-	-	-	6.39	36.69	26.32	18.17	17.19	16.85	-	-
Control	2016-17	-	-	-	-	-	46.11	56.22	51.66	39.49	33.17	-	-
	2017-18	-	-	-	-	9.77	44.79	33.64	22.34	31.29	29.80	-	-

CONCLUSION / RECOMMENDATION

1. Use of different hedge has created positive effect on the morphological and reproductive characteristics as well as at the yield of Snack Gourd.
2. Between two hedges pineapple hedge reduced relatively higher soil loss due to its soil binding capacity of roots.
3. Between two hedges pineapple hedge reduced relatively higher runoff.

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PROGRAM NO. 5

STUDYING SOIL LOSS AND YIELD PERFORMANCE OF PINEAPPLE BASED JACKFRUIT ORCHARD ON HILL SLOPE FOLLOWING CONTOUR LINE.

ABSTRACT

The study was conducted at the Soil Conservation and Watershed Management Centre (SCWMC), Soil Resource Development Institute (SRDI), Bandarban .Area of the selected site is 61.0 m x 21.0 m (200'-0" x 70'-0") likely about 0.32 acre. Average slope of the site was 35%. The main objectives of the research program were to introduce technique for effective land use in achieving food security as an alternative farming system, to study the yield of pineapple as an intermediate crop with permanent horticulture &to determine soil loss. Contour lines were selected at 0.50 meter vertical interval. Pineapple suckers were planted in the predefined contour with application of necessary manures and fertilizers. Pits for planting Jackfruit were dug before plantation of pineapples' sucker. Soil loss was recorded in peg methods. 21 number Color pegs were inserted in to a certain depth at a distance of 10.0 m. peg to peg and row to row before the rain. Intercultural operation is going on as necessary. Jackfruit was main horticultural crop and pineapple was intermediate crops. Main crops will need a certain period for its production. Pineapple was introduced as an intermediate crop for introducing technique of effective land use for achieving food security and also an alternative farming system. The intermediate crop has been planted across the slope following contour. It will act as hedge rows which will be very helpful for minimizing soil erosion hazard as well as providing for the intermediate period.

INTRODUCTION

Land, water and vegetation are the most important natural resources for providing environmental and livelihood security to the mankind. They provide food, fodder, firewood, fibre and other material needs of the people. History bears testimony to the high regard that man holds for these resources. However, with the advent of civilization leading to cultivation of land and subsequently ever increasing pressure of man and animal population, the natural balance between there resources has been distorted and as a consequence, serious problems of soil and water conservation have arisen. The movement of water on land if not properly managed may cause soil erosion and render land incapable of sustained production. Land degradation is one of the major ecological issues of the world. Land degradation means loss in the capacity of given land to support growth of useful plants on a sustained basis (Singh, 1994).Due to different types of land degradation, Bangladesh lost a substantial amount of production which in terms money may be hundreds of billion taka in every year (BARC, 1999). Faulty Jhum cultivation in hilly area causes gully erosion and loss of soil ranges from 10 to 120 t $ha^{-1}yr^{-1}$ (Farid *et al.,* 1992). Soil degradation is difficult to quantify and the impact of soil loss and destruction is not evident immediately. Recently, however, the magnitude of the cumulative effects has been described in some studies. Since 1970, the farmers world over have lost an estimated 480 billion tons of top soil, roughly equivalent to all of India's crop lands (Brown, 1991). In Canada, soil degradation has been costing farmers US $ one billion a year. In India, about 173 m ha or 53% of the total geographical area are subjected to varying degrees and forms of soil erosion (Bali, 1990). Analyses of annual soil erosion rates in India have indicated that 5334 million tones (i.e. 16.33 tone/ha/year) of soil is detached annually and of this about 29% is carried away by the rivers into sea. Nearly 10% of it is being deposited in reservoirs losing 1-2% of its capacity (Narayana and Ram Babu, 1983). Scientific management of land and water resources is the key to increase productivity.

Soil erosion in agricultural systems is a very important to manage. If the productive layer or topsoil is eroded away, then the ground is very unproductive in producing crops. Soil erosion generally occurs only on slopes, and its severity increases with the severity of slope. The Chittagong Hill Tracts represents a very fragile hill ecosystem and is characterized by steep to extremely steep slopes with ninety percent of its landscape belonging to upland category that limits its land capabilities. Most of the slopping areas are closely dissected and sharp ridged, slopes are mostly steep to very steep dominated by shallow to moderately deep, nutrient poor, loamy to clayey and slightly to very strongly acid soils. These factors combined cause soil erosion, siltation of lakes and rivers and soil fertility decline thereby creating a food insecurity situation in the region. Major agricultural activity in this area is traditional rainfed farming which is locally known as 'Jhum' and commonly known as 'Shifting cultivation' or 'Slash and burn' farming system. About 1.0 million peoples in CHT of which 13 different ethnic groups are directly or indirectly depend on jhum (Shoaib, 2000). It is estimated that it takes 300-1000 years to form an inch of soil. In areas of seriously erosion, this one inch of soil may be lost in a couple of years (Khybri, 1983). Jhum, the dominant form of land use in CHT, widely practiced by tribal communities and remains as a major source of livelihood for most of the hill people. It is estimated that about 26,000 families practices Jhum every year and about 1,43,000 people depend on Jhum for subsistence. This cultivation system has become unsustainable because diminished suitable land availability has forced the tribal communities into shorter and shorter jhum cycles (now down to 3-5 years per cycle) there by reducing soil fertility and increasing soil erosion hazards. Agroforestry has been considered to be financially more attractive than jhum.

Environmentally it also appeared to be more suitable for CHT as the rate of soil erosion under this system was found considerably lower than under other land use systems such as jhum and root crops (Gafur, 2001).

Vegetation and land use play an important role controlling the intensity and frequency of overland flow and surface erosion (Mitchell, 1990; Gafur *et al*., 2001b). Naturally, woody perennials and tree species produce large amounts of aboveground biomass. Because of their perennial nature, there is a continuous addition of organic matter and biomass to the soil. Tree crops influence the microclimatic factors such as soil and air temperature, net radiation reaching the ground surface evaporative demand, etc. Expectedly, soil and air temperature is lower during the day in the vicinity of perennial hedges than farther away from them. Under this condition, soil organic matter content is being continuously increased, activity of soil fauna increased and soil structure improved (Lal, 1991).

So far very little scientific effort have been taken to study the yield of short duration crop (pineapple) as an intermediate crop with permanent horticulture. which could reduce pressure on already squeezed suitable Jhum land. Considering all these circumstances, a land use system that will ensure or sustain the production as well as conserve soil fertility and reduce soil loss should be developed particularly for the hilly regions of Bangladesh. This proposed research program was, therefore, designed to develop technique for minimizing soil loss and fertility development to achieve better economic return and ensure food security.

Objectives

1. To introduce technique for effective land use in achieving food security as an alternative farming system.
2. To study the yield of pineapple as an intermediate crop with permanent horticulture.
3. To determine soil loss in peg method.

MATERIALS AND METHODS

The research has been introduced in the financial year 2016-2017. Site was selected to the east side of the farm shed at SCWMC Research station, SRDI, Bandarban. Area of the selected site is 61.0 m x 21.0 m (200'-0" x 70'-0") likely about 0.32 acre. Average slope of the site is 35%. After selection of the plot, the jungle was cleaned by manual labour. Contour lines were selected at 0.50 meter vertical interval. Pineapple suckers were planted in the predefined contour with application of necessary manures and fertilizers. Pits for planting Jackfruit were dug before plantation of pineapples' sucker. Recommended dose of fertilizers and manure were applied in to the pits. Pineapple suckers were collected and planted during the month of May-2016. There are 14 rows of pine apple plantation. Saplings of Jackfruit were collected from horticulture centre. Jackfruit's saplings were planted in the pits maintaining plant to plant and row to row distance 25'-0" during the month of july-2016. There are 18 nos. of jackfruit sapling were planted in this plot. 21 number Color pegs were inserted in to a certain depth at a distance of 10.0 m. peg to peg and row to row before the rain. The pegs were 1'-6" long and were colored by red & white every 6". One third length of the peg were driven in the soil and two third were above the soil. Grounds RL near different pegs were recorded before the rain and after rain in each year. The Cumulative difference of the two depths is considered as the depth of transported soil.. Intercultural operations were done manually when necessary. Yield performance of pineapple is being studied. . It was found that near about 50% of the pineapple plans are on bearing stage. The pineapples will be destroyed when the jack fruits are being harvested.

RESULTS AND DISCUTION

Soil loss by peg method was studied for 2016-2017 and 2017-2018. There were three rows of peg in the plot in combination of seven pegs in each row. At first soil loss for seven pegs of upper, middle and bottom rows were determined by using leveling instrument. Then the average depth of transported for each row were calculated accordingly. It was found that the average depth of transported soil were 0.655 mm, 0.710 mm and 0.780 mm for the pegs of upper, middle and bottom lines respectively for 2016-2018. On the other hand, the average depth of transported soil for upper, middle and lower parts were 0.60 mm, 0.62 mm and 0.67 mm respectively during the period of 2017-2018. Then the average depths of soil loss for three rows were calculated and it was found 0.715 mm and 0.630 mm for the year 2016-2017 and 2017-2018 respectively. Finally the total soil loss soil loss was calculated assuming 1mm depth soil loss is equal to 13.70 t/ha and it was 9.796 t/ha and 8.631 t/ha per year. It was also found that both the main crop and the intermediate crops were growing satisfactory. A data for determination of soil loss is given below:

Table 25: Soil Loss under pineapple based Jackfruit orchard on steep slope

Location of peg	Average soil loss in mm		Average of all rows (in mm)		Total soil loss (t/ha)		Mean total soil loss (t/ha)
	2016-2017	2017-2018	2016-2017	2017-2018	2016-2017	2017-2018	
Upper	0.655	0.60	0.715	0.63	9.796	8.631	9.212
Middle	0.710	0.62					
Bottom	0.780	0.67					

Table 26: Yield and return from pineapple based Jackfruit orchard on steep slope

Financial year	Yield (main and associated crop)		Economical return		Remarks
	Pineapple	Jack fruit	Pineapple	Jack fruit	
2016-2017	Initial stage	Initial stage	Initial stage	Initial stage	
2017-2018	Flowering stage	Growing stage	1000/- (Expected)	Growing stage	

CONCLUSION AND RECOMMENDATION

The conductive research is being carried on. Here, Jackfruit is main horticultural crop and pineapple is intermediate crops. Main crops need a certain period for its production. Pineapple was introduced as an intermediate crop for introducing technique of effective land use for achieving food security and also an alternative farming system. The crops are in growing stage. In the mean time, the both crops are going to be matured for its production. It is found that near about 50% plants of the intermediate crops are on bearing stage in the month of May-2018 whereas only one tree of the main crop is bearing only one jackfruit. It is also expected that Tk. 1,000/- could be earned by selling the pineapples in the local market and earning from main crop is negligible. Soil loss data for the year 2016-2017 and 2017-2018 has been recorded accordingly

and it was found on average 9.796 ton hac^{-1}/year and 8.631 ton hac^{-1}/year respectively. The intermediate crop has been planted across the slope following contour. It will act as hedge rows which will be very helpful for minimizing soil erosion hazard as well as providing for the intermediate period. Intercultural operation is going on as necessary.

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TRANSFERABLE TECHNOLOGY / ADAPTIVE RESEARCH

PROGRAME-1

TITLE: INTRODUCTION OF BENCH TERRACE FOR DEMONSTRATION AND YEAR ROUND CROP PRODUCTION.

OBJECTIVES

- To reduce the quantum of overland flow/sheet flow or runoff, and their velocity.
- To minimize the soil erosion.
- To conserve soil moisture.
- To conserve soil fertility and to facilitate farming operations such as ploughing, irrigation etc. on sloping land.
- To promote intensive land use, permanent agriculture and checking shifting cultivation on steep lands.

MATERIALS AND METHODS

A suitable site for bench terrace was being selected at Faruk para (Chhaingya Marma para) for demonstration. It is situated just south of the Nilachal Parjaton Area and just down the Tiger Hill. Actually the site was selected to a farmer's field. The spot area of the Bench Terrace was nearly 1.0 acre & the slope gradient of the spot was nearly gentle to steep (Average- 26%). There are 11 number of Bench having variable width (2.75m to 1.0m) with an vertical interval of 0.60m. The bench terrace is made mainly inward typed and the risers are constructed maintaining 1:1 slope. The risers are protected against erosion by putting grass sod. The top portion of the spot was formed very wide and broad based terrace where tillage operation could be operated using modern tools without any difficulties. Various Robi & kharif crops like Red Amaranthus, Mustard, Bean, sweet Gourd, Pumpkin, Radish, Felon, Khaishya, kalmi, Spinash, tomato, cabbage, cauliflower etc were grown there successfully.

CONCLUSION

Terracing is one of the most accepted measures of controlling erosion on sloping and undulated lands. It is widely adopted in many countries of the world. Suitable bench terrace will facilitate intensive cultivation make the land suitable for multiple use in hilly areas. It is also helpful to increase the beauty of the land along with increasing the stability. At present most of the farmers are practicing Jhum on hill slope, which accelerate erosion. On sloping lands farmers usually can't use fertilizer or other input to produce more crops per unit of land. Bench terrace helps in proper water management, application of fertilizers or manure. It will also help to increase cropping intensity within a stable farming system. Now a day, Bench Terrace are widely being used in the hilly areas of India, Nepal, Srilanka, Tamilnadu etc. But the hill dwellers are not concerned about the construction, use and benefit of the Bench Terrace. Considering above factors study of sustainability of Bench terrace has

been taken account in the farmer's field. As the measure is very cost effective, so widely subsidy is very essential to popularize the Bench Terracing mainly in the hilly areas in our country.

PROGRAME 2:

REHABILITATION OF DEGRADED/ERODED SLOPING LAND BY JUTE GEO-TEXTILE ON DIFFERENT HILL SLOPES OF CHT.

OBJECTIVES:

1) To study the effectiveness of geo-jute (untreated) in controlling soil erosion.
2) To rehabilitate degraded/eroded/landslide hilly areas
3) To stabilize/rejuvenate degraded/landslide areas of CHT

MATERIALS AND METHODS

Several degraded land at different places like Raisha Para, Satkomol para, etc. were chosen to rehabilitate by using jute geo-textile.

1. Locally available grass mulches were given on the selected degraded surface.

2. Geo-jute had been spread over the area under treatment with some exposure at grass or tree planting points.

3. The two adjoining width were generally overlapped by about 10 cm and fastened with jute threads.

4. Wooden sticks were inserted into the ground throughout geo-jute strand so that the geo-jute touches the earth surface .

5. Grasses like creeper (*Mimosa invisa)*, broom grass **(***Thysanolaena maxima*), khagra ***(Saccharum spontanum*)** etc. were planted to check erosion by spreading soil cover and root zone in exposed locus on geo-jute strands at close saucing.

6. 50-100 pits per 100 m^2 are made to put seeds of different grasses & live pools.

7. Quick growing shrubs/ trees were also be planted in pits for root zone netting.

Depending upon the condition of the field, 1 to 3 nos. of drains/grass waterways were established at the upper end to check runoff water flash into the landslide area that may cause further extension of the divested area in either.

No. of Implementation Areas: 4 (Four)

CONCLUSION

1. Like any other natural fibre, jute geo-textile gets biodegraded in soil.
2. The live poll will give vegetation coverage and soil losses will be minimized at the area treated with jute geo textile.
3. The decomposition of the fibre will takes place within the ecological process that assists in the retention of moisture, improvement of soil permeability and establishment of vegetation.

PROGRAME-3

TITLE: ESTABLISHMENT OF DIFFERENT HEDGE SPECIES IN FARMERS' FIELD AS TRANSFERABLE TECHNOLOGY IN CHT.

OBJECTIVES

a) To introduce modern hill cultivation and suitable technology for Soil Conservation and Watershed Management.

b) To mitigate the need of fuel, fodder and economical purpose of the hill dwellers.

c) To minimize soil erosion hazard.

d) To increase bio-mass in soil properties.

e) To accelerate the infiltration and water holding capacity of soil.

MATERIALS AND METHODS

The experiments were conducted at farmers' field in different areas like Gonespara, Meghla,Talukdar para, Parjatan Chakmapara, Raicha, Balaghata para and Nilachol etc. Different hedge species like Pine apple (fruit), Bogamedula (Shrubs), Nappier & Vetivera, (Grass), Broom, Khagra (local economical crop) etc. were selected depending on the slope, crops, need

and demands of the beneficiaries. The sites may be of either newly planted or preparing for plantation. It may also be agricultural land if the field slope is gently to moderately slopping. Firstly the sites were cleaned. Then contour lines having interval of 4-6m horizontally were fixed depending on the used fruit species and the expectation of the beneficiaries by using leveling instrument or field made most temporarily use 'A-frame'. Hedge was practiced in single line. After fixation of spacing of hedge line, the hedge areas were cleaned properly. Then organic and inorganic fertilizer was mixed in the slightly dibbled pits. Seeds/sucker/ seedlings of the selected hedge was sown/planted in those pits maintaining contour lines. Gap filling was made sure if and when necessary. Intercultural operation had also been carried out. When the plants' height of the hedge exceeded 70 cm, the hedge plants were cut down at knee height level. After cutting the hedge plants, the residues part of the hedge were spread just in front of the hedge plants for filtering/arresting the eroded soil from the upper ends.

No. of Implementation Areas: 10 (ten) sites

CONCLUSION

The conservation of soil and water is essential for sustainable production, environment preservation and balanced ecosystem. Loss of soil by water erosion on slopping lands adversely affects the physical, chemical and biological properties of soils, leading to low crop productivity. Contour hedgerows are also effective in controlling run off and soil erosion and improve soil physical properties. Controlled plots have higher run off and soil loss than those plots with hedge row. Hill slope may be divided into a series of alley separated by hedgerow on contour lines, because hedgerow plants are effective in controlling soil erosion and reducing run off.

Trees and shrubs have several functions to control erosion like (i) increase soil cover, by liter and pruning (ii) provide partly permeable hedgerow barriers (iii) lead to the progressive development of terraces, through soil accumulation upslope of hedgerows (iii) increase soil resistance to erosion, by maintenance of organic matter (iv) stabilize earth structures by root systems and (v) make productive use of the land occupied by the conservation works. This study was, therefore, designed to select suitable hedge species and their alley width in respect to slope which minimized soil loss and increase crop yield.

PROPOSED RESEARCH PROGRAM (2018-2019)

Program No.1

Effect of indigenous & modern cultivation methods of pineapple on soil erosion, run off, nutrient mining at CHT.

Objectives

1) To estimate & compare soil loss, runoff and nutrient mining under indigenous and modern cultivation systems of pineapple.
2) To calculate effect of soil loss on soil chemical properties.
3) To create awareness about soil conservation & watershed management among hill dwellers.

Expected output/justification

The conservation of soil and water is essential for sustainable production, environment preservation and balanced eco system. Loss of soil by water erosion on slopping lands adversely affects the physical, chemical and biological properties of soils, leading to low crop productivity,

use of indigenous methods of pineapple cultivation has created negative effect on soil erosion. This program improves soil healthy by reducing soil erosion hazard and enhances crop production. This research hiss encourages the hill dwellers to adopt the cultivation system to losing zero tillage across the hill slope in contour.

Program No.2

Effect of plantation of Bamboo for erosion control and its economic purposes

Objective:

1. Reclamation of gullied land by minimizing erosion hazards.
2. For Landscape, aesthetic and economic purposes.
3. For environmental and ecological conservation.

Expected output:

Bamboo has evergreen leaves, dense canopy and numeral culms which can help to intercept considerable amount of rainfall. Falling raindrops change their direction and ways and reduce velocity, and therefore decrease soil erosion after multiple interceptions by tens of shoot layers and larger amount of culms. They respond to the variability in precipitation by alternating their plan form, channel geometry and sedimentation pattern which in turn influence floods and associated landscape evolutions (Rao *et al. 2012*).

Bamboo can improve poor soil conditions by building up humus content, increasing beneficial microbiological activity and improve soil structure. Bamboo leaves can filter air pollutants, recycle CO_2 and replenish the atmosphere with Oxygen. It helps to purify our streams/water supplies by taking up excess nutrients. Bamboo is also helpful against landslides and soil loss by preventing erosion.

Deep and narrow gullies are recommended to be put under permanent vegetation of grasses and trees. Bamboo plantation for productive and protective utilization of such degraded lands is not pnly a profitable option for local stake holders but also financially and economically viable policy option for funding agencies and Government and Non-Government agencies.

Program No.3

Studing of Brushwood Check Dam for minimizing erosion hazard and reclamation of gullied land.

Objectives

a). To reduce the velocity of runoff.
b) To prevent deepening and widening of the gully.
c) To collect sedimentation and to recharge water table.

Expected outcomes

The proposed study is to Introducing of Brushwood Check Dam for minimizing erosion hazard and reclamation of gullied land will be conducted in a gully formed by the Southeast side of the Administrative Building of SCWMC, SRDI, Bandarban. It a large gully with uneven shaped. Larger gully rehabilitation requires more complex intervention to prevent continued erosion Check dams can be implemented in a stepped-approach for larger gully to slowly trap sedimentation and reclaim gully. In the hills of CHT, stone is not generally available everywhere, but brushes and unused trees are available Where stones are not readily available, Brushwood check dam can be constructed for slowly reclamation of the gullied land.

Brushwood check dam increases absorption /infiltration of water into the soil. It also reduces the speed of runoff and therefore also reduces the erosive power of surface flows. Brushwood check dams allow for planting of crops once the dam is matured. It needs branches and plant materials/brushwood, ideally use of cuttings of trees that will strike fort the struts. Brushwood check dam can be build easily. But it needs for regular maintenance and repairing.

Program No.4:

STUDYING BROOM GRASS FOR CONTROLING SOIL EROSION AND ITS ECONOMIC VALUE AT CHT.

Objectives

a) To find out a significant source of income.
b) To prevent frequent landslides, retain ground moisture and to increase fertility.
c) To provide green forage for livestock.
d) To increase ground water recharge and to enrich the ecological balance.

Justification

Thysanolaena maxima is a genus of plants in the grass family, the only genus in the tribe. It is locally known as Broom grass, Jharu ful, Fuljhru, Foruin etc. It's other names are Tiger Grass, Nepalese Broom Grass, Broom stick, Nepali amliso or kuchcho, jhadu (phool jhadu) in Hindi. Broom grass is a significant source of income for subsistence communities, primarily for the women who collect it to manufacture and sell them as brooms. It can help the women to become more empowered by raising their financial status and lessening the burden of other tasks and thus it can ensure sincere impact of the ladies in the society. In addition to providing cash income when sold as brooms the plant provides a variety of uses to the farmers such as, the leaves provide green forage for livestock, the roots promote soil conservation, and the dried up stems can be used as stakes to support growing vegetables. Broom grass has a direct impact in preventing frequent landslides, helps to retain ground moisture and fertility, and can improve soil quality by reducing soil erosion. Broom grass grows in clumps and has many tangled up roots that grow to about one metre below the ground. This makes it highly effective in preventing soil erosion on hillsides as the grass is less likely to fall compared to other plants and trees that would have been planted there. The roots and leaves of the plant slow down water drops and the flow of water after heavy rain by absorbing the water in the soil Broom grass has the ability to crowd out invasive species when intercropped and is beneficial in retaining soil nutrients to re-grow vegetation. The grass also possesses numerous medicinal properties that are essential in subsistence communities. Broom grass does not compete for land with cereal crops so they can be grown simultaneously.

Growing broom grass on degraded land has been proven to help rehabilitate it as it helps retain ground moisture and promote fertility. There is no irrigation required to grow the grass and it does not produce any wastewater. No external inputs or energy is needed to grow the plant as it only requires human labour, which can be extensive in the first year of growing. Broom grass farming is highly recommended in new shifting cultivation systems on marginal lands to repair the damage from previous slash and burn methods. So it is very helpful to increase the local biodiversity in the communities and endangered animals can reappear.

Program No.5

Studying effect of Natural vegetative strip (NVS) for minimizing soil erosion in cultivation of vegetables.

Objectives:

1. To examine the effect of NVS on the maintenance of soil fertility and reducing soil erosion in moderate hill slope.
2. To examine the effect of NVS on crop productivity in hill slope.

Expected output/Justification

Minimization of soil erosion through natural vegetative strip (NVS) is an indigenous technology which used by the hill dwellers since time immemorial. The conservation of soil and water is essential for sustainable production, environment preservation and balanced eco system. Loss of soil by water erosion on slopping lands adversely affects the physical, chemical and biological properties of soils, leading to low crop productivity in this manner the experiment will established to control soil erosion and sustain crop productivity and aware the people as well as the peoples who involved to develop the people of the remote area.

Program No.6

Development of Integrated Watershed Management at SCWMC in CHT (On going).

Program No.7

Study on Management and economic value of *Schumannianthus dichotoma* (*Murta* /Patibet) in hilly Jhiri land at CHT (On going).

Program No.8

Effect of different Hedge Species On Controlling Soil Erosion, Runoff, And Nutrient Mining Of Snack Gourd At Gentle Slope In CHT (On going).

Program No. 9

Studying Soil Loss and Yield Performance of Pineapple Based Jackfruit Orchard on Hill Slope following Contour line (On going).

RESEARCH ACTIVITIES 2017-18

Proposed Research program (2018-19)

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Experiment No. 1: Selection of suitable sunflower varieties under dibbling cultivation in coastal saline soil

Abstract

The experiment was conducted at SMRC, Batiaghata, Khulna during rabi season of 2017-18 to identify suitable sunflower varieties by dibbling method for escaping high soil salinity in late drained land. Two sunflower varieties viz. BARIsurjomukhi 2 and Suvarna were used in the experiment. Just after harvesting of T. Aman, sunflower seeds were sown in line by dibbling method. Balanced fertilizer was applied in the plots. Total amount of TSP, MOP, Gypsum and Zinc sulphate were applied 5 days before seed sowing as basal. Urea was top dressed in three equal splits at 15, 40 and 60 days after sowing. The experiment was laid out in a Randomized Complete Block (RCB) design with three replications. The highest yield (1.55 t/ha) was obtained from BARI surjomukhi 2. The lowest yield was obtained from Suvarna (1.48 ton/ha) which was statistically similar with the variety BARI surjomukhi 2.

OBJECTIVES:

i) To identify suitable sunflower varieties by using dibbling method for escaping high soil salinity in late drained land.
ii) To increase cropping intensity in coastal saline area by introducing sunflower in late drained land.

MATERIALS AND METHODS:

The experiment was carried out at SMRC, Batiaghata, Khulna during Rabi season of 2017-2018. Two varieties of sunflower were used viz. BARIsurjomukhi 2 and Suvarna. Just after harvesting of T. Aman, sunflower seeds were sown by dibbling method in line. Line to line and seed to seed distance was 60 cm and 30 cm respectively. Two Germinated seeds were dibbled in a hole. After 15 days of germination one healthy plant was kept and other one was removed. Sun flower

seeds were sown on 30-11-2017 and after 40 days of emergence first weeding was done at 'Zo' condition by spade. Balanced fertilizer was used by considering initial soil status and requirements of sunflower. Total amount of TSP, MOP, Gypsum and Zinc sulphate were applied 5 days before seed sowing as basal. Urea was top dressed in three equal splits at 15, 40 and 60 days after sowing. Weeding was also done when necessary. Insects and pests were controlled by using insecticides and pesticides when necessary. Sunflower was harvested on 06-04-2018.

Table: Initial status of soil in experimental

pH	OM	K	Total N	P	S	Zn	B
	(%)	meq/100 gm soil	(%)		µg/g^{-1}		
7.9	2.23	0.21	0.140	21.15	23.18	0.91	0.58
Critical level		0.12	0.12	7.00	10.00	0.60	0.20

RESULTS AND DISCUSSIONS:

Under dibbling condition, BARI surjomukhi -2 gave highest yield which was 1.55 t/ha. The lowest yield (1.48 t/ha) was obtained from variety Suvarna but the yield was also satisfactory.

Table: Yield of sunflower

Sunflower Varieties	yield (t/ha)
BARI surjomukhi 2	1.55
Suvarna	1.48
CV(%)	6.11

During experiment period soil salinity of experimental plot was increasing from sowing to harvesting. The highest soil salinity (EC: 8.94 dS/m) was recorded in March.

Table: Month wise soil salinity of Experimental plot.

Month	Soil Salinity: EC (dS/m)
November/2017	1.84
December/2017	2.36

January/2018	4.52
February/2018	6.07
March/2018	8.94

CONCLUSION:

The experiment will be continued for the next year for confirmation of the result obtained in first year.

Experiment No. 2: Selection of suitable wheat varieties under zero tillage condition in coastal saline soil

Abstract

The experiment was carried out at SMRC, Batiaghata, Khulna during rabi season of 2017-18 to identify suitable wheat varieties under zero tillage condition for escaping high soil salinity in late drained land. The experiment was laid out in a Randomized Complete Block (RCB) design with three replications and two varieties. The wheat varieties were BARIGom 25 and BARIGom 26. Just after harvesting of T. Aman, the total amount of TSP, MOP, Gypsum and Zinc sulphate were applied as basal in wet condition. After 5 days wheat seeds were broadcast in the wet land under zero tillage condition. Urea was top dressed in three equal splits at 15, 40 and 60 days after seed sowing. The highest yield (2.64 t/ha) was obtained from BARI Gom 25. The lowest yield was obtained from BARI Gom 26 (2.31 ton/ha) which was statistically similar with that of BARIGom 25.

OBJECTIVES:

i) To identify suitable wheat varieties by zero tillage method for escaping high soil salinity in late drained land.

ii) To increase cropping intensity in coastal saline area by introducing wheat in late drained land.

MATERIALS AND METHODS:

The experiment was conducted at SMRC, Batiaghata, Khulna during Rabi season of 2017-2018. The varieties of wheat were BARI Gom 25 and BARI Gom 26. Just after harvesting of T. Aman, the total amount of TSP, MOP, Gypsum and Zinc sulphate were applied as basal in wet condition. After 5 days wheat seeds were broadcasted in the field. Urea was top dressed in three equal splits at 15, 40 and 60 days after sowing. Thinning and first weeding was done after 20 days of sowing. Weeding was also done when necessary. Insects and pests were controlled by using insecticides and pesticides when necessary. Wheat was harvested on 30-03-2018.

Table: Initial status of soil in experimental plot

pH	OM	K	Total N	P	S	Zn	B
	(%)	meq/100 gm soil	(%)		µg/g^{-1}		
7.7	2.27	0.27	0.132	20.17	29.98	0.98	0.29
Critical level		0.12	0.12	7.00	10.00	0.60	0.20

RESULTS AND DISCUSSIONS:

Under zero tillage condition, highest yield was obtained from BARI Gom 25 (2.64 t/ha) and the lowest yield was obtained from BARI gom 26 (2.31 t/ha).

Table: Yield of wheat

Wheat varieties	yield (t/ha)
BARI Gom 25	2.64
BARI Gom 26	2.31
CV(%)	6.37

During experiment period soil salinity of experimental plot was observed to be increasing from sowing to harvesting. The highest soil salinity (EC: 9.14 dS/m) was recorded in March. Table: Month wise soil salinity of Experimental plot.

Month	Soil Salinity: EC (dS/m)
November/2017	2.63

December/2017	4.18
January/2018	5.58
February/2018	7.22
March/2018	9.14

CONCLUSION:

Under zero tillage condition, the growth and yield of wheat was satisfactory.

RECOMMENDATION:

Under zero tillage condition, BARI Gom 25 and BARI Gom 26 may be recommended to farmer's field for cultivation in saline soil of coastal area.

Experiment No. 3:Effect of split application of DAP on the yield of kharif bottle gourd on raised ail in T. Aman rice field of saline area

Abstract

The experiment was conducted at SMRC, Batiaghata, Khulna during kharif season of 2017-18 to evaluate the effect of split application of DAP on the yield of kharif bottle gourd on raised ail in T. aman rice field of coastal saline soil. The experiment was designed with 4 treatmentsviz.T_0 : Control(Total P applied as basal), T_1 : 50% P as DAP solution applied 2 splits, T_2 : 50% P as DAP solution applied 4 splits and T_3 :50%P as DAP solution applied 6 splits. The entire amount of TSP, MOP, Gypsum and Zinc sulphate were applied as basal for control (T_0). In case of Treatment T_1, T_2 and T_3, 50% dose of P was applied as basal and other 50% dose of P was applied as splits by DAP. The experiment was laid out in a Randomized Complete Block (RCB) design with three replications. The highest yield (51.59 t/ha) was obtained from T_1 treatment followed by T_2 (48.51 ton/ha) and T_3(47.17 ton/ha). The lowest yield was obtained from T_0 treatment (42.62 ton/ha).

OBJECTIVES:

i) To evaluate the performance of split application of DAP solution in Kharif bottle gourd cultivated on raised ail of T. Aman rice

iii) To introduce kharif bottle gourd in the coastal saline area.

MATERIALS AND METHODS:

An experiment was carried out at SMRC, Batiaghata, Khulna during kharif-2 season, 2017. The experiment was laid out in RCBD design with three replications. There were four treatments in this experiment. The treatments were –T_0 : Control (Total P applied as basal), T_1 : 50% P as DAP solution applied 2 splits, T_2 : 50% P as DAP solution applied 4 split and T_3 :50%P as DAP solution applied 6 split. Raised pits on ail in T. Aman field were made properly at 10-07-2017. Basal dose of manure and chemical fertilizers was applied in pit based on soil test value. Fertilizers were applied @ 130, 145, 30, 20, 15gm/pit of Urea, TSP, MOP, Gypsum and Zinc sulphate (heptahydrate), respectively. The entire amount of TSP, MOP, Gypsum and Zinc sulphate were applied as basal for control (T_0). In case of Treatment T_1, T_2 and T_3, 50% dose of P was applied as basal and other 50% dose of P was applied as splits by DAP. Urea was top dressed in three equal split at 15, 40 and 60 days after sowing. Pit to pit distance was 2.0 m. Germinated seeds were sown in pit at 21-08-2017. Intercultural operation was done as and when necessity. Insect and pest were controlled by using insecticides and pesticides. Green fruit collection was started from 15-10-2017 and ends at 12-12-2017.

Table: Initial status of soil in experimental plot

pH	OM	K	Total N	P	S	Zn	B
	(%)	meq/100 gm soil	(%)		µg/g^{-1}		
8.1	1.12	0.29	0.101	3.21	86.97	0.53	0.82
Critical level		0.12	0.12	7.00	10.00	0.60	0.20

RESULTS AND DISCUSSIONS:

In the experiment, the highest yield (51.59 t/ha) was obtained from the treatment T_1 where 50% of P was applied as DAP solution at 2 splits, followed by T_2 (48.51 t/ha) and T_3 (47.17 t/ha). The

lowest yield was found from T_0 (42.62t/ha) treatment where full doses of Phosphorus was applied as basal.

Table: Yield of sweet gourd was under different treatments

Treatment	Bottle gourd yield (t/ha)
T_0(Control)	42.62c
T_1(50% P as DAP solution applied 2 split)	51.59a
T_2(50% P as DAP solution applied 4 split)	48.51b
T_3(50% P as DAP solution applied 6 split)	47.17b
CV(%)	8.37

CONCLUSION:

The experiment may be continued for the next year for confirmation of the result.

Experiment No. 4: Effect of integrated nutrient management on soil salinity and yield of musk melon in saline soil

Abstract

The experiment was conducted at SMRC, Batiaghata, Khulna during kharif 1 season of 2017-18 to evaluate the effect of organic manure on soil salinity and yield of musk melon in saline soil. The variety of musk melon was local (Rongila). The experiment was designed with 7 treatments viz T_1: Control (STB chemical fertilizer), T_2 : Recommend cowdungwith chemical fertilizer (IPNS), T_3 : (Recommend + 25%) cowdungwith chemical fertilizer (IPNS), T_4 : (Recommend+50%)cowdungwith chemical fertilizer (IPNS), T_5 : Recommend poultry manurewith chemical fertilizer (IPNS), T_6: (Recommend + 25%) polultry manurewith chemical fertilizer (IPNS), T_7: (Recommend+ 50%) poultry manurewith chemical fertilizer (IPNS). The experiment was laid out in a Randomized Complete Block (RCB) design with three replications. The highest yield (26.05 t/ha) was obtained from T_7 treatment followed by T_4 (24.99 ton/ha) and T_6 (23.67 ton/ha). The lowest yield was obtained from T_1 treatment (18.43 ton/ha).

OBJECTIVES:

i) To identify effective organic manure with right dose to reduce soil salinity.

ii) To find out the suitable combination of organic and inorganic fertilizer for optimizing the yield of musk melon.

MATERIALS AND METHODS:

An experiment was conducted at SMRC, Batiaghata, Khulna. Musk melon was used as test crop. The experiment was laid out in RCB design with three replications having 6×4 m plot size. The land was prepared by 3 ploughing by power tiller. Pits were made properly. Manure and basal dose of fertilizer was applied during pit preparation. Pit to pit and line to line distance was 2.0 m. Germinated seeds (variety- deshi, Rangila) were sown in pit. Urea, TSP, MOP, Gypsum and Zinc sulphate were applied @ 110, 100, 15, 20, 20 gm/pit, respectively. The total amount of TSP, MOP, Gypsum and Zinc sulphate were applied as basal. Urea was top dressed in three equal splits at 15, 40 and 60 days after sowing. Necessary intercultural operations were done as and when necessary. The ripe musk melon collection was started from 19-04-2017 and ended at 08-05-2017. After collection, the samples were analyzed statistically following MSTAT-c software.

Treatments: Seven treatments of the experiment were -

T_1 : STB chemical fertilizer
T_2 : Recommend cowdung with chemical fertilizer (IPNS)
T_3 : (Recommend + 25%) cowdung with chemical fertilizer (IPNS)
T_4 : (Recommend +50%) cowdung with chemical fertilizer (IPNS)
T_5 : Recommend poultry manure with chemical fertilizer (IPNS)
T_6 : (Recommend + 25%) poultry manure with chemical fertilizer (IPNS)
T_7 : (Recommend + 50%) poultry manure with chemical fertilizer (IPNS)

Table: Initial status of soil in experimental plot

pH	OM	K	Total N	P	S	Zn	B
	(%)	meq/100 gm soil	(%)		µg/g^{-1}		
7.5	1.54	0.26	0.089	6.46	147.80	0.36	0.72
Critical level		0.12	0.12	7.00	10.00	0.60	0.20

Table: Nutrient status of different organic manure

Organic manure	pH	OC	Total N	P	K	S	Zn	B	C:N
					(%)				
Cowdung	7.5	19.2	2.0	1.3	0.8	0.03	0.05	0.15	9.6:1
Poultry manure	8.1	22.3	2.8	0.1	0.5	0.02	0.01	0.11	8.0:1

RESULTS AND DISCUSSIONS:

It was observed that soil salinity was lowest in January and highest in April. Salinity data showed that organic manure contributed in decreasing soil salinity.

Table: Month wise soil salinity of the experimental plot during growing period

Treatments	Month wise Soil salinity(dS/m)				
	Jan/18	Feb/18	Mar/18	Apr/18	May/18
T_1	4.7	7.9	11.8	16.6	10.9
T_2	4.7	7.5	11.3	15.4	9.8
T_3	4.7	7.2	11.1	15.2	9.5
T_4	4.7	7.0	10.8	14.9	9.2
T_5	4.7	7.4	11.2	15.3	9.6
T_6	4.7	7.1	10.9	15.1	9.4
T_7	4.7	6.9	10.7	14.8	9.0

From the experiment, highest yield (26.05 t/ha) was obtained from T_7 treatment followed by T_4 (24.99 ton/ha) and T_6 (23.67 ton/ha). The lowest yield was obtained from T_1 treatment (18.43 ton/ha).

Table: Yield of musk melon under different treatments

Treatment	Yield (t/ha)
T_1 (STB chemical fertilizer)	18.43
T_2 (Recommend cowdung) with chemical fertilizer(IPNS)	20.95
T_3 (Recommend + 25%) cowdung with chemical fertilizer(IPNS)	22.82

T_4 (Recommend +50%) cowdung with chemical fertilizer(IPNS)	24.99
T_5 Recommend poultry manure with chemical fertilizer(IPNS)	21.80
T_6 (Recommend + 25%) poultry manure with chemical fertilizer(IPNS)	23.67
T_7 (Recommend + 50%) poultry manure with chemical fertilizer(IPNS)	26.05

CONCLUSION:

Maximum Soil salinity was reduced by using poultry manure and plant growth & yield of musk melon was highest from the treatment T_7: (Recommend +50%) poultry manure with IPNS chemical fertilizer. But the yield obtained from T_4 was close to T_7.

RECOMMENDATION:

For reducing soil salinity and getting better yield of musk melon farmers can use poultry manure or cowdung as organic manure.

Experiment No. 5: Selection of suitable kharif sweet gourd varieties in coastal saline soil

Abstract

The experiment was conducted at Salinity Management and Research Centre, Batiaghata, Khulna during kharif 2017-2018 to select suitable sweet gourd varieties namely Sweety (Laltirr Seed Limited), Sonia (Krisibid Seeds Limited), Super sweet (Northern Agriscience Limited), Lalima (Metal Agro Limited), Haland (Ispahani Agro Limited) and BARI Hybrid Mistikumra -1 for coastal saline soil. The highest yield (27.83 t/ha) was recorded from Haland variety followed by Sonia (24.80 t/ha), Sweety (23.13 t/ha), BARI hybrid misti kumra-1 (22.21 t/ha) and Lalima (11.97 t/ha) while Super sweet gave the lowest yield (7.69t/ha).

OBJECTIVES:

i) To select suitable sweet gourd varieties managing saline soil and water for coastal saline area.

ii) To bring seasonally fallow land under crop production.

MATERIALS AND METHODS:

An experiment was carried out at SMRC, Batiaghata, Khulna. . The experiment was laid out in RCBD design with three replications. The experiment was set up on kharif-1 season of 2018. Six hybrid varieties of sweet gourd namely Sweety (Laltirr Seed Limited), Sonia (Krisibid Seeds Limited), Super sweet (Northern Agriscience Limited), Lalima (Metal Agro Limited), Haland (Ispahani Agro Limited) and BARI Hybrid Mistikumra -1 cultivated for screening purpose. The land was prepared by three times ploughing by power tiller.Pits were made properly. Manure and basal dose of fertilizer was applied during pit preparation. Pit to pit and line to line distance was 2.0 m. Germinated seeds were sown in pit. Urea, TSP, MOP and Zinc sulphate (heptahydrate) were applied @ 111, 119, 23, 4 gm/pit, respectively. The total amount of TSP, MOP and Zinc sulphate were applied as basal. Urea was top dressed in three equal splits at 15, 40 and 60 days after sowing. Necessary intercultural operations were done as and when necessary. Fruits (bitter gourd) collection was started from 21-05-2018 and ended at 26-05-2018. Data on yield components like fruit length, fruit diameter, individual fruit weight and no. of fruits per plant were recorded from 10 randomly selected plants as per varieties and replications. After collection, the samples were analyzed statistically following MSTAT-c software.

Table: Initial status of soil in experimental plot

pH	OM	K	Total N	P	S	Zn	B
	(%)	meq/100 gm soil	(%)	µg/g-1			
7.8	1.87	0.40	0.131	10.17	40.34	0.54	0.98
Critical level		0.12	0.12	7.00	10.00	0.60	0.20

RESULTS AND DISCUSSIONS:

Among the six hybrid varieties of sweet gourd Haland gave statistical highest yield (27.83 t/ha) followed by Sonia (24.80 t/ha), Sweety (23.13 t/ha), BARI hybrid misti kumra-1 (22.21 t/ha) and Lalima (11.97 t/ha). The lowest yield was obtained from Super sweet (7.69t/ha).

Table: Yield of sweet gourd in saline soil

Varieties	Yield (t/ha)
Sweety	23.13b
Sonia	24.80b
Super sweet	7.69d
Lalima	11.97c
Haland	27.83a
BARI Hybrid Mistikumra -1	22.21b
CV (%)	6.07

Table: Month wise soil salinity in the experimental plot during cultivation

Year	Month wise Soil salinity (EC: dS/m)				
2018	Jan	Feb	Mar	April	May
	7.98	8.87	11.28	12.67	8.96

Soil salinity was increased from the month of January to April. The highest soil salinity was recorded in the month of April (12.67dS/m), followed by March (11.28dS/m), May (8.96dS/m) and February (8.87dS/m). The lowest soil salinity was observed in the month of January (7.98dS/m).

CONCLUTIONS AND RECOMMENDATIONS:

Among six hybrid varieties of sweet gourd Haland, Sonia, Sweety and BARI hybrid mistikumra -1 may be recommended for cultivation in farmer's field under slightly to moderate soil salinity in coastal area.

Experiment No. 6: Selection of suitable kharif ribbed gourd varieties in coastal saline soil

Abstract

A field experiment was carried out at Salinity Management and Research Centre, Batiaghata, Khulna during kharif 2017-2018 cropping year to select suitable ribbed gourd varieties in coastal saline soil. Five hybrid varieties namely Hero (Laltirr Seed Limited), Sindabad (Getco Agro Vision Limited), Super moon (Northern Agri science Limited), Ishakha (Mollika Seed Company) and BARI Jhinga-02 were used in the study. Among the varieties highest yield (10.41 t/ha) was obtained from Hero followed by Sindabad (9.39 t/ha), BARI Jhinga-02 (6.78 t/ha) and Super moon (6.00 t/ha). The lowest yield was found from Ishakha variety which was 4.09 t/ha.

OBJECTIVES:

a) To select suitable rib gourd varieties managing saline soil and water for coastal saline area
b) To bring seasonally fallow land under crop production.

MATERIALS AND METHODS:

An experiment was carried out at SMRC, Batiaghata, Khulna during kharif-1 season, 2018. The experiment was laid out in RCBD design with three replications. Five hybrid varieties of rib gourd namely Hero (Laltirr Seed Limited), Sindabad (Getco Agro Vision Limited), Super moon (Northern Agri science Limited), Ishakha (Mollika Seed Company) and BARI Jhinga-02 were cultivated for selection of suitable variety in coastal saline soil. The land was prepared by three times ploughing by power tiller. Pits were made properly. Manure and basal dose of fertilizer was applied during pit preparation. Pit to pit and line to line distance was 2.0 m. Germinated seeds were sown in pit. Urea, TSP, MOP and Zinc sulphate (heptahydrate) were applied @ 77, 40, 10, 3 gm/pit, respectively. The total amount of TSP, MOP and Zinc sulphate were applied as basal. Urea was top dressed in three equal splits at 15, 30 and 55 days after sowing. Necessary intercultural operations were done as and when necessary. Fruits were collected after every 2 days interval. Crop harvest period was 01-04-2018 to 13-05-2018. Data on yield components like fruit length, fruit diameter, individual fruit weight and no. of fruits per plant were recorded from 10 randomly selected plants as per varieties and replications. After collection, the samples were analyzed statistically following MSTAT-c software.

Table: Initial status of soil in experimental plot

pH	OM (%)	K meq/100 gm soil	Total N (%)	P	S	Zn	B
					µg/g-1		
7.8	1.99	0.37	0.136	12.76	45.18	0.63	1.03
Critical level		0.12	0.12	7.00	10.00	0.60	0.20

RESULTS AND DISCUSSIONS:

Soil salinity was increased from the month of January to April. The highest soil salinity was recorded in the month of April (11.22 dS/m), followed by March (9.96 dS/m), May (8.89 dS/m) and February (5.45 dS/m). The lowest soil salinity was observed in the month of January (4.18dS/m).

Table: Month wise soil salinity in experimental plot

Year	Month wise Soil salinity (EC: dS/m)				
2018	January	February	March	April	May
	4.18	5.45	9.96	11.22	8.89

From the experiment statistically highest yield (10.41 t/ha) was obtained from the variety Here, followed by Sindabad (9.39 t/ha), BARI Jhinga-02 (6.78 t/ha) and Super moon (6.00 t/ha). The lowest yield was found from Ishakha (4.09 t/ha) which was statistically dissimilar with other varieties.

Table: Yield of ribbed gourd

Varieties	Yield (t/ha)
Hero	10.41a
Sindabad	9.39b
Super moon	6.00c

IshaKha	4.09d
BARI Jhinga-02	6.78c
CV(%)	5.41

CONCLUTIONS AND RECOMMENDATIONS:

Among these five varieties of ribbed gourd, Hero and Sindabad may be recommended for cultivation in farmer's field under slightly to moderate soil salinity in coastal area.

Experiment No. 7: Selection of suitable kharif snake gourd varieties in coastal saline soil

Abstract

A field experiment was conducted at Salinity Management and Research Centre, Batiaghata, Khulna during kharif 2017-2018 cropping year to select suitable snake gourd varieties in coastal saline soil. There were five hybrid snake gourd varieties namely Asa (Rahim Afroz C I C Agro Limited), Surma (A R Malik Seeds pvt.Limited), Barnali(Mollika seed Company), Nagraj (Northern Agri science Limited) and BARIchichinga -1 were cultivated in this study. The highest yield (19.71 t/ha) was recorded from Asa variety followed by Barnali (19.56 t/ha), Surma (18.43 t/ha) and BARIchichinga -1(17.87 t/ha) while Nagrajgave the lowest yield (6.98t/ha).

OBJECTIVES:

a) To select suitable snake gourd varieties managing saline soil and water for coastal saline area.
b) To bring seasonally fallow land under crop production.

MATERIALS AND METHODS:

An experiment was carried out at SMRC, Batiaghata, Khulna. The experiment was laid out in RCBD design with three replications. The experiment was set up on kharif-1 season of 2018. Five hybrid varieties of snake gourd namely Asa (Rahim Afroz C I C Agro Limited), Surma (A R Malik Seeds pvt.Limited), Barnali (Mollika seed Company), Nagraj (Northern Agri science

Limited) and BARI chichinga -1 were cultivated for screening purpose. The land was prepared by three times ploughing by power tiller.Pits were made properly. Manure and basal dose of fertilizer was applied during pit preparation. Pit to pit and line to line distance was 1.50 m. Germinated seeds were sown in pit. Urea, TSP, MOP and Zinc sulphate (heptahydrate) were applied @ 80, 65, 10, 5 gm/pit, respectively. The total amount of TSP, MOP and Zinc sulphate were applied as basal. Urea was top dressed in three equal splits at 15, 40 and 60 days after sowing. Necessary intercultural operations were done as and when necessary. Fruits collection was started from 06-05-2018 and ended at 14-06-2018. Data on yield components like fruit length, fruit diameter, individual fruit weight and no. of fruits per plant were recorded from 10 randomly selected plants as per varieties and replications. After collection, the samples were analyzed statistically following MSTAT-c software.

Table: Initial status of soil in experimental plot

pH	OM (%)	K meq/100 gm soil	Total N (%)	P	S	Zn	B
				µg/g-1			
7.9	1.87	0.37	0.129	7.85	49.86	0.59	0.84
Critical level		0.12	0.12	7.00	10.00	0.60	0.20

RESULTS AND DISCUSSIONS:

Among the five varieties of snake gourd Asa gave the highest yield (19.71 t/ha) followed by Barnali (19.56 t/ha), Surma (18.43 t/ha) and BARI chichinga -1(17.87 t/ha). The lowest yield was obtained from Nagraj (6.98t/ha).

Table: Yield of bitter gourd in saline soil

Varieties	Yield (t/ha)
Hybrid (Asa)	19.71a

Hybrid (Surma)	18.43b
Hybrid (Barnali)	19.56a
Hybrid (Nagraj)	63.98c
BARI chichinga -1	17.87b
CV (%)	7.13

Table: Month wise soil salinity of experimental plot during cultivation

Year	Month wise Soil salinity (EC: dS/m)				
2018	Jan	Feb	Mar	April	May
	4.14	6.93	10.38	12.07	8.42

Soil salinity was increased from the month of January to April. The highest soil salinity was recorded in the month of April (12.07 dS/m), followed by March (10.38dS/m), May (8.42 dS/m) and February (6.93 dS/m). The lowest soil salinity was observed in the month of January (4.14dS/m).

CONCLUTIONS AND RECOMMENDATIONS:

Among these four varieties of snake gourd like Asa (Rahim Afroz C I C Agro Limited), Barnali(Mollika seed Company), Surma (A R Malik Seeds pvt.Limited) and BARI chichinga -1 may be recommended for cultivation in farmer's field under slightly to moderate soil salinity in coastal area.

Experiment No. 8: Selection of suitable kharif bottle gourd varieties in coastal saline soil

Abstract

A field experiment was carried out at Salinity Management and Research Centre, Batiaghata, Khulna during kharif 2017-2018 cropping year to select suitable bottle gourd varieties in coastal saline soil. There were four bottle gourd varieties namely Hygreen (Metal Agro limited), Diana(Laltirr Seed Limited), Chisti (Getco Agro Vision Limited) and BARI Lau were cultivated

in this study. Among the varieties statistically highest (97.36 t/ha) was obtained from Diana followed by Hygreen (94.77 t/ha) and Chisti (76.87 t/ha). The lowest yield was found from BARI Lau 4 variety which was 63.91 t/ha**.**

OBJECTIVES:

a) To select suitable bottle gourd varieties managing saline soil and water for coastal saline area
b) To bring seasonally fallow land under crop production.

MATERIALS AND METHODS:

An experiment was carried out at SMRC, Batiaghata, Khulna during kharif-2 season, 2018. The experiment was laid out in RCB design with three replications. Four hybrid varieties of cucumber (khira) namely Hygreen (Metal Agro limited), Diana (Laltirr Seed Limited), Chisti (Getco Agro Vision Limited) and BARI Lau4 were cultivated for selection of suitable variety in coastal saline soil. The land was prepared by three times ploughing by power tiller.Pits were made properly. Manure and basal dose of fertilizer was applied during pit preparation. Pit to pit and line to line distance was 2.0 m. Germinated seeds were sown in pit. Urea, TSP, MOP and Zinc sulphate (heptahydrate) were applied @ 124, 154, 17, 4 gm/pit, respectively. The total amount of TSP, MOP and Zinc sulphate were applied as basal. Urea was top dressed in three equal splits at 15, 30 and 60 days after sowing. Necessary intercultural operations were done as and when necessary. Fruits were collected after every 3 days interval. Crop harvest period was 28-08-2017 to 22-11-2017. Data on yield components like fruit length, fruit diameter, individual fruit weight and no. of fruits per plant were recorded from 10 randomly selected plants as per varieties and replications. After collection, the samples were analyzed statistically following MSTAT-c software.

Table: Initial status of soil in experimental plot

pH	OM	K	Total N	P	S	Zn	B
	(%)	meq/100 gm soil	(%)		µg/g-1		
7.2	1.13	0.23	0.103	4.43	71.86	0.52	0.95
Critical level		0.12	0.12	7.00	10.00	0.60	0.20

RESULTS AND DISCUSSIONS:

From the experiment statistically highest yield (97.36 t/ha) was obtained from the variety Diana, followed by Hygreen (94.77 t/ha) and Chisti (76.87 t/ha). The lowest yield was found from BARI Lau 4 (63.91 t/ha) which was statistically dissimilar with other varieties.

Table: Yield of sweet gourd under different varieties

Varieties	Yield (t/ha)
Hygreen	94.77a
Diana	97.36a
Chisti	76.87b
BARI Lau4	63.91c
CV (%)	5.89

During experiment period soil salinity of experimental plot was non saline condition due to rainy season.

Table: Month wise soil salinity in experimental plot

Year	Month wise Soil salinity (EC: dS/m)					
2017	June	July	Aug	Sep	Oct	Nov
	2.1	1.8	1.7	1.7	1.9	2.2

CONCLUTIONS AND RECOMMENDATIONS:

Among the four verities of bottle gourd, Diana and Hygreen may be recommended for cultivation in framers field in coastal area.

Proposed Research program (2018-19)

Expt. 1: Study on the performance of spices and vegetables under multi-layer crop production in high land of coastal saline area

Expt. 2: Study on the performance of brinjal under different ratio of manure and soil in flying bed of coastal saline area

Expt. 3: Study on the performance of tomato under different ratio of organic manure in flying bed of coastal saline field

Expt. 4: Study on the performance of chilli under different ratio of manure and soil in flying bed of coastal saline area

Expt. 5: Study on the performance of yard long bean under different ratio of manure and soil in flying bed of coastal saline area

Expt. 6: Study on the performance of yard long bean under organic agricultural system in coastal saline area

Expt. 7: Study on the performance of bitter gourd under organic agricultural system in coastal saline area

Expt. 8: Effect of integrated nutrient management on bitter gourd in plastic container

Expt. 9: Study on salt accumulation in soil by using different strength of saline water

Expt. 10: Screening of some cucumber varieties