গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
কৃষি মন্ত্রণালয়
মৃত্তিকা সংরক্ষণ ও পানি বিভাজিকা ব্যবস্থাপনা কেন্দ্র
মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট
মেঘলা, বান্দরবান।
www.srdi.bandarban.gov.bd

নং- ১২.০৩.২০০৩.০৮১.০৫.০০১.১৬- **১৫৩** তারিখ :- ২৫ আগস্ট, ২০২২খ্রিঃ।
১০ ভাদ্র, ১৪২৯ বাং ।

প্রতি : মহাপরিচালক
মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট
মৃত্তিকা ভবন, কৃষি খামার সড়ক
ঢাকা-১২১৫।

বিষয় : ২০২১-২০২২ অর্থ বছরের বার্ষিক **প্রতিবেদন প্রকাশের নিমিত্তে মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট**, বান্দরবান-এর **তথ্য প্রেরণ প্রসংগে।**

সূত্র : প্রধান কার্যালয়ের নং-12.03.0000.0০০.৯৯.00২.১৭-৬৪৫; তারিখঃ ০৩-০৮-20২২ খ্রিঃ।

উপর্যুক্ত বিষয় ও সূত্রের প্রেক্ষিতে অত্র গবেষণা কেন্দ্রের ২০২২-২৩ অর্থ বছরের বার্ষিক কর্মসম্পাদন চুক্তির সংস্কার ও সুশাসনমূলক কার্যক্রমের বাস্তবায়ন সংক্রান্ত কর্মপরিকল্পনাসমূহের মধ্যে তথ্য অধিকার বিষয়ে ২০২২-২০২৩ অর্থবছরের বার্ষিক কর্মপরিকল্পনা মোতাবেক বার্ষিক প্রতিবেদন প্রকাশ এর নিমিত্তে গবেষণা কার্যক্রমের প্রতিবেদন পুস্তক আকারে প্রস্তুতপূর্বক এবং কর্মকর্তা/কর্মচারীদের নাম, পদবী, ফোন/মোবাইল নম্বর, ইমেইল এড্রেস সম্বলিত তথ্য পরবর্তী প্রয়োজনীয় ব্যবস্থা গ্রহনের জন্য এতদসংগে প্রেরণ করা হলো।

সংযুক্ত :- ১। গবেষণা কার্যক্রমের প্রতিবেদন – ১ (এক) প্রস্থ।
২। কর্মকর্তা/কর্মচারীদের তথ্য- ১ (এক) প্রস্থ।

২৫ -০৮-২০২২ ইং
প্রধান বৈজ্ঞানিক কর্মকর্তা(চঃ দাঃ)
ফোন : ০৩৬১-৬২৪১২
ই-মেইল :scwmcsrdi081@gmail.com

সদয় জ্ঞাতার্থে ও প্রয়োজনীয় ব্যবস্থাগ্রহনের জন্য অনুলিপি প্রেরণ করা হলো:

১। পরিচালক, ফিল্ড সার্ভিসেস উইং,মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট, কৃষি খামার সড়ক, ঢাকা।

২। মূখ্য বৈজ্ঞানিক কর্মকর্তা, ট্রেনিং এন্ড কমুনিকেশন ডিভিশন, মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট, ঢাকা।

৩। অফিস কপি।

Government of the people's Republic of Bangladesh
Ministry of Agriculture
Soil Conservation & Watershed Management Center
Soil Resource Development Institute (SRDI)
Bandarban.

Government Employee Information

Sl	Name	Designation	Cell phone number	Mail ID
1.	Mr. Md. Mahbubul Islam	Principal Scientific Officer (Additional charge)	01712527742	mahbubsrdi@gmail.com
2.	*Md. Shahinul Islam*	Assistant Cartographer	01674064667 01558-780798	***snshaila2011@yahoo.com***
3.	Md. Salauddin	Senior Surveyor	01865399078	-
4.	Mrs. Nargis Khatun	Upper Division Assistant-cum Accountant.	01671920613	nargissrdi@gmail.Com
5.	*Md. Nazmul Islam*	Office Assistant Cum Computer Typist.	01748606420	tipuhaqe@gmail.con
6.	Md. Abu l Hashem	Driver	01820034018	-
7.	Mohammed Kamal	Security Guard	01864747557	-

25-08-2022
Principal Scientific Officer
(Additional charge)
Soil Conservation & Watershed Management Center
Soil Resource Development Institute (SRDI)
Bandarban.

GOVERMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

MINISTRY OF AGRICULTURE

Annual Research Report 2021-2022

Proposed Research Program-2022-2023

Compiled And Edited By

Md.Mahbubul Islam

PSO,SRDI,Bandarban.

SOIL CONSERVATION & WATERSHED MANAGEMENT CENTER (SCWMC)

SOIL RESOURCE DEVELOPMENT INSTITUTE (SRDI)

MEGHLA,BANDARBAN.

GENERAL INFORMATION OF THE CENTRE

AREA OF THE FARM	:	27.0 ha
DATE OF POSSESSION	:	12 TO 13TH JUNE, 1994.
LATITUDE	:	22^o 9`16'' TO 22$^o$ 10` 32'' N
LONGITUDE	:	92^o 11` 17'' TO 92$^o$ 11` 34'' e
ELEVATION	:	92.0 to 133.0 m above MSL.
LOCATION	:	VILL-TALUKDERPARA
DAG NO	:	1774 (PART)
MOUZA	:	313 BANDARBAN

The centre stands on the south of Bandarban- Chittagong road, 5 Km from Bandarban town. There is a meteorological station in the centre and two multipurpose dam at the south-western boarder of the centre.

The objectives of the centre are as follows:

1. Innovation, identification and development of appropriate technology for soil and water conservation and watershed management.

2. To introduce modern hill cultivation and suitable technology for soil and water conservation and watershed management.

3. To demonstrate appropriate technology and transfer to local farmers, extension workers and train to motivate them in this regard.

4. Appraisal of erosion problems and conservation of land & water resources under different land use systems.

EXPT. No. 1

STUDYING BROOM GRASS FOR CONTOLLING SOIL EROSION AND ITS ECONMIC VALUE AT CHT.

Abstract

Soil erosion is a major concern all over the world. Grasses are generally used to reduce soil erosion. Grasses develop rapidly and produces humus too. They can recover from damage and completer burial. Grasses are the key component in many ecosystems of the world. Broom grass *(Thysanolaena Maxima)* is a multipurpose perennial cash crop suitable for minimizing erosion hazard. It has also medicinal value as well as fuel, fodder and others domestic use. The main objectives of the research are to find out a significant source of income, to prevent frequent landslides, retain ground moisture and to increase soil fertility, to provide green forage for livestock and to rehabilitate the endangered animals and to keep ecological balance. There are two treatments. In one treatment, the saplings were planted maintaining plant to plant distance 0.50 m. and row to row distance 1.00 m. In another treatment, the saplings were planted maintaining plant to plant distance 0.50 m. and row to row distance 2.00 m. there was 1.00 m distance in between two double rows for both plots. It was observed that the average highest soil loss was 14.0 ton/ha in line to line distance 2 meter managed plot (18.65, 14.64 ,11.66 & 10.98 ton/ha/yr.) in the year of 2018-19 to2021-22 and Average lowest soil loss was 11.0 ton/ha in line to line distance 1 meter managed plot (14.43, 11.33, 9.17 & 9.05 ton/ha/yr.) in the year of 2018-19 to 2021-22. On the other hand, the height average return (1,94,000 BDT) was obtained from line to line distance 2 meter managed plot (ha/yr.) and the lowest average return (1,68,000 BDT) was obtained from line to line distance 1 meter managed plot (ha/yr) in the year of 2018-19 to2021-22. Broom Grass may open the door of enrichment for the poor hill dwellers' and be an important method for rehabilitation of land degraded by shifting cultivation or slush and burn agriculture.

Introduction

Soil erosion is accelerated due to high rainfall intensities (Keesstra et al., 2016), steep slopes (Beskow et al., 2009) and the fragile nature of topsoil (Lal, 1998; Rodrigo Comino et al., 2016; Ochoa et al., 2016). Soil erosion is a naturally occurring process on all land. Soil erosion is a major concern all over the world. It may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of topsoil (HIMCAT News Letter #2, Spring-2008). Soil loss 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). Worldwide loss of water and sediment due to soil erosion is a major environmental threat (Prosdocimi et al., 2016; Pimentel, 1993). Water erosion is the main cause of land degradation, affecting an area of about 2 billion ha throughout the world, with the largest part in tropics, and affecting the two most important natural resources, namely soil and water (Mandal and Sharda,2011a; DeOliveriaetal.,2010; Keesstraetal.,2014; Novara et al., 2011, 2016; Seutloali and Beckedahl, 2015). Water plays a vital role in the ecosystem. The precipitation over the country is not only unevenly distributed, but also uneven with regard to seasonal distribution as well as within season. Steep slope and terrain in hilly areas quickly releases the flow towards the outlet and thus creates scarcity of water. Geomorphology and the way land surface is managed, strongly influences the movement of water over and below the ground (Ashok Kumar and Bhanupriya Sharma-2017). .In our Bangladesh have high annual rainfall confined to only 4 to 5 months (June–october). During the 7–8-month dry period, scarcity of water causes a severe shortage of fodder in farmlands, which leads to an increase in grazing vpressure on forest and community lands. Vegetation resources are required for different local needs including grazing, fuel-wood, timber and non-timber forest products. These resource needs are closely linked with each other and several hot spots have been identified by Lempelius (2007). Soil conservation is an important requirement in sustainable farming. Basics of soil erosion control are to reduce detachment and transportation capacity of the eroding agents (water and wind) through different agronomic, vegetative measures generally known as conservative measures (Amatya and Shrestha, 2002). Good crop husbandry is an effective soil conserving practice (Joshi, 1992). Grasses are generally used to reduce soil erosion. Grasses develop rapidly and produces humus too. They can recover from damage and completer burial. In India most of the studies on the role of grasses as vegetative/ filter strips have been done in isolation with fewer slope categories and with limited objectives restricted to soil erosion (Njoroge and Rao, 1994).. Strategies to reverse land degradation are critical since soil is a non-renewablere source (Mandal and Sharda, 2011b; Mandal et al., 2010). Soil erosion rates more than tolerance values are considered unacceptable (Mandal and Sharda, 2013), which leads to irreversible land degradation and need to be reduced through appropriate soil conservation measures (SCMs) (Biswas et al., 2015). Generally, soil conservation planning requires knowledge of soil loss tolerance values, which show the higher limit of soil erosion rate that can be allowed without long-term land degra dation (Jha et al., 2009). Perennial grasses provide ground cover throughout the year and help in reducing runoff and soil loss when used as barriers along the contour, particularly in hill slopes (Dhruvanarayana and Rambabu, 1983). Grasses are the key component in many ecosystems of the world (ParrasAlcántara et al., 2015; Hu et al., 2016; Mekonnen et al., 2016). Soils typically account for 70–90% of the total carbon sequestered in a grassland ecosystem (Batjes, 2001). It is known from different studies conducted in India that the inclusion of grasses in the agricultural landscape often improves the productivity of system while providing opportunities to create carbon (C) sinks (Ghosh et al., 2009; Cogle et al., 2011; Huang et al., 2010; Mutegi et al., 2008).

The croplands in sloppy areas suffer from excessive soil erosion and erosion-induced nutrient depletion. Soil erosion in these areas ranges between 20 and 40Mgha−1 yr−1 as compared to the national average of 16.35Mgha−1 yr−1 (Dhruvanarayana and Rambabu, 1983). Such high rates of soil erosion result in considerable depletion of nutrients from the topsoil, which in turn causes poor productivity of crops. Research evidence from the land subjected to shifting cultivation reported that about 600Mt of soil is eroded annually, which led to losses of 258000, 73000 and 179000t of N, P2O5 and K2O, respectively (Kumar, 2011).

Thysanolaena maxima is a genus of plants in the grass family, the only genus in the tribe. It is locally known as Broom grass, Jharuful, Fuljharu, Foruin etc. It's other names are Tiger Grass, Nepalese Broom Grass, Broom stick, Nepali amliso or kuchcho, jhadu (phooljhadu) in Hindi. Broom grows well in hot and temperate climate of South Eastern Asia. It grows up-to 3 meters in height, has sharp leaves in long branches. Broom grass received its name because people construct sweeping brooms out of the large flower heads. It is a multi-purpose plant. Besides creating hillside stabilization and serving as household brooms, its leaves provide fodder for livestock during the dry season, and people can burn the stalks as fuel or use the broom grass as mulch to protect the soil.

Nepalese broom grass (Thysanolaena Maxima) is a multipurpose perennial cash crop that belongs to the family Poecea (Bisht and Ahlawat, 1998). It is found growing along steep hills, sandy banks of rivers and damp steep banks along ravines (Bisht and Ahlawat, 1998). It is widely distributed throughout Nepal but only up to an altitude of 2000 metres (Bisht and Ahlawat, 1998). The grass can be grown on severely degraded and marginal lands (SatNet Asia, 2014). Broom grass tends to grow in tussocks, with 4-5 tussocks in a 100 metre radius and is harvested during the winter seasons between January and March (Bisht and Ahlawat, 1998). 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 across Nepal (Llewellyn, 2015). 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 (Llewellyn, 2015). Broom grass has had a direct impact in preventing frequent landslides, helping retain ground moisture and fertility, and improving soil quality by reducing soil erosion (Llewellyn, 2015). Broom Grass can moderately support the soil mass by its strong and long fibrous roots. Broom Grass can bind average 3.8 cu. m. soil, and that for napier, stylo, and molasses are 0.37 cu. m., 0.45 cu. m. and 0.04 cu. m. soil respectively. Broom grass has the ability to crowd out invasive species when intercropped and is beneficial in retaining soil nutrients to regrow vegetation (Llewellyn, 2015). The grass also possesses numerous medicinal properties that are essential in subsistence communities (SatNet Asia, 2014). Gautam, 2015 wrote that it is very helpful to grow others vegetation rapidly on shushed and burnt cultivated land and thus save the endangered animals like barking dears and monkeys.The start of Nepalese farmers growing broom grass has increased the local biodiversity in the communities (SatNet Asia, 2014). Broom grass does not compete for land with cereal crops so they can be grown simultaneously (SatNet Asia, 2014). The farming of broom grass has had a sincere impact on the women in the communities (Gautam, 2015). It has helped women become more empowered by raising there financial status and lessening the burden of other tasks (Gautam, 2015).Brooms are required in most households across the world so there is a large market for the product. Producing good quality brooms at low prices gives the product a comparative advantage and makes it very marketable. In Nepal, brooms sold on the local market sell for an average of \$0.48, while in Canada it can range from \$10-20\$ (SatNet Asia, 2014). It has been noted that broom grass has been tried by paper and pulp industries to make paper, which means once that method of manufacturing becomes more popular Nepalese farmers can mass produce broom grass to be sold to these companies (Bisht and Ahlawat, 1998). The brooms can be transported quite easily as cargo because it is a finished product.

The improved varieties of grasses have a number of features that make it desirable. The densely tufted perennial clumps of grass seem not to spread or become a pest and terraces rise as the soil accumulates behind the hedges, converting erodible slopes into stabilized terraces where farming can be carried out safely without threats of erosion. Planting of improved varieties of grasses on the risers will not only bind the soil but also provide a rich source of fodder for the livestock (Pandit, 2002). The functions of the root system are Engineering (anchorage, armour, catch, reinforcement and drain) and physiological (storage, conduction, and absorption). The fibrous root system of the grasses consists of several main roots that branch to form a dense mass of intermeshed lateral roots. Anchorage is not the main function of shallow rooted species like grass. Armour is the main function and catch, reinforcement and drain (if planted accordingly) are other engineering functions of grasses (Rost et al., 1979). Plants themselves show considerable variation of rooting depth within the soil profile (Etherington, 1976). The maximum effective depth of rooting of plants, and therefore the depth to which they can reinforce or anchor the soil, is also a subject for debate in the world-wide bio-engineering literature. In exceptional cases, it is clear that certain plants can have extremely long roots. Grass clumps can sometimes send roots to four or five metres below the surface and trees can send roots even deeper (Howell, 1999). The majority of roots, especially the small absorbing roots, are located in the upper soil horizons where favourable aeration, nutrients, and moisture conditions occur (Spur and Barnes, 1980).

Nepalese broom grass *(Thysanolaena Maxima)* is a multipurpose perennial cash crop suitable for minimizing erosion hazard. It has also medicinal value as well as fuel, fodder and others domestic use. But sufficient Research is not conducted yet on this plant (Grass) in our country. Considering all, Soil Conservation and Watershed Management Centre (SCWMC), Bandarban has taken a small scientific effort in its Research Area under BandarbanSadarUpazila in fiscal year 2017-2018 to conduct a study on broom grass " Effectiveness on controlling soil erosion and economic value at CHT).

This proposed research program was designed to study the quantity of soil loss, surface run-off, nutrient status and also the yield of broom in different replication. Broom Grass may open the door of enrichment for the poor hill dwellers' and be an important method for rehabilitation of land degraded by shifting cultivation or slush and burn agriculture.

Objectives

a. To find out a significant source of income.
b. To prevent frequent landslides, retain ground moisture and to increase soil fertility.
c. To provide green forage for livestock.
d. To rehabilitate the endangered animals and to keep ecological balance.

Materials and Methods

The research was conducted near multi-fruits garden situated by the side of multi-purpose dam at the Research Area of Soil Conservation and Watershed Management Centre (SCWMC), SRDI under BandarbanSadarupazila, Bandarban. The experimental plots were selected in such a way that the area individually can be treated as a micro watershed. Prior to selection of the plots, the area was cleaned. Jungles were removed. Slope percentage of the land was measured by Abney's level. To conduct the study, two plots of 100 m^2 (5m x 20 m) each were selected on a degraded land of steep slope having 48 % slope. Brick masonry plot boundary was constructed for each plot. Contour lines were marked maintaining 1.00 m. vertical interval from a distance of 0.50 m. from the upper plot boundary. A set of multi-slot devisor was set up in connection of each plot to determine the soil loss and runoff calculation.

Prior to plantation of broom's saplings (stump), composite topsoil samples were collected from each plot has been collected for physical, chemical and mineralogical analysis to compare the soil characteristics. There are two treatments. In one treatment, the saplings were planted maintaining plant to plant distance 0.50 m. and row to row distance 1.00 m. In another plot, the saplings were planted maintaining plant to plant distance 0.50 m. and row to row distance 2.00 m. there was 1.00 m distance in between two double rows for both plots. Saplings were planted just following minimum tillage system during June-2018. Extra fertilizer or manure has not been added to the pits before or during plantation of saplings. Jungles were cleaned around the year when it was necessary.

Results and Discussion

Prior to plantation of broom's saplings (stump), composite topsoil samples were collected from each plot has been collected for physical, chemical and mineralogical analysis to compare the soil characteristics. After cultivation of broom, composite top soil samples are being taken for analysis and the result were shown in table-1. Soil loss and run-off data were collected after each and every shower. Total soil loss and runoff from 100.0 m² plot were presented in table-3 & 4 and Height Total soil loss and runoff was recorded in row to row 2m distance plot . Average plant height and number of plant per clump was recorded after winter in each year. Broom planted in 2.0 m. distance (row to row) grows better than that of 1.0 m. row to row distance (as shown in Table-6). Yield defers from row to row distance (shown in Table-7). Economical return from broom grown in 2m row to row distance plot were Tk. 1,35,500/-, Tk. 2,01,000/- Tk. 2,11,500/- & Tk 2,28,000/-per hectare per year during FY 2018-19, 2019-20, 2020-21 & 2021-22 and average return was 1,94,000/- for four years. while those were Tk. 90,000/-, Tk. 1,83,000/- Tk. 1,92,000/- and Tk 2,07,000/- during FY. 2018-19, 2019-20, 2020-21 & 2021-22 and average return was 1,68,000/- for four years when it was planted 1.0 m. row to row distance. Economical return of leaves used as fodder and residual sticks used for house activities or handicraft use and others benefits like biodiversity has not been calculated.

Table-1: Initial fertility status and fertility status after broom cultivation

Parameter	Year	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		
Broom 1 Meter	2017	4.6	4.24 H	0.212 M	2.65 VL	0.42 H	2.82 VL	1.87 H	0.29 L	5.54 O	1.98 VH	0.74 H	69.16 VH	14.27 VH
	2018	4.1	4.2 H	0.210 M	1.12 VL	0.53 VH	19.11 M	0.45 VL	0.58 O	6.16 M	2.57 VH	0.31 M	40.51 VH	15.53 VH
Broom 2 Meter	2017	5.7	4.64 H	0.232 M	0.34 M	0.54 VH	0.002 VL	2.22 H	0.34 M	7.28 H	2.35 VH	0.77 VH	81.17 VH	16.08 VH
	2018	4.1	3.8 H	0.190 M	1.05 VL	0.50 VH	17.44 M	0.28 VL	0.46 O	7.04 H	2.22 VH	0.27 L	38.68 VH	10.21 VH

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

Table-2: Soil Texture

Particulars	Soil Textural Class	Sand	Slit	Clay
		%		
Broom 1 Meter	Silt Loam	23	59	18
Broom 2 Meter	Silt Loam	20	59	21

Table-3: Soil loss under the cultivation of broom grass hill different treatments-2018-22 (t/h/y).

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total S0il loss (T/ha)	Average S0il loss (T/ha)
Broom-1 Meter	2018-19	_	_	_	_	_	3.24	3.97	2.90	1.98	2.34	_	_	14.43	11.00
	2019-20	_	_	_	_	_	1.60	5.84	1.41	1.83	0.65	_	_	11.33	
	2020-21	**-**	**-**	**-**	**-**	**0.96**	**1.05**	**1.18**	**2.36**	**1.74**	**1.88**			**9.17**	
	2021-22	**-**	**-**	**-**	**-**	**0.25**	**2.32**	**1.28**	**2.89**	**1.36**	**0.95**	**-**	**-**	**9.05**	
Broom-2Meter	2018-19	_	_	_	_	_	4.16	4.78	3.56	2.47	3.68	_	_	18.65	14.00
	2019-20	_	_	_	_	_	1.96	7.63	1.92	2.21	0.92	_	_	14.64	
	2020-21					0.94	1.31	1.63	3.33	1.69	2.76			11.66	
	2021-2022	-	-	-	-	0.32	2.86	1.54	3.45	1.61	1.20	-	-	10.98	
Rainfall	2018-19	3	0	0	67	207	607	691	256	249	266	-	14	2360.00	-
	2019-20	0	57	9	72	234	244	1024	398	411	141	43	9	2642.00	
	2020-21	40.0	-	-	133.0	217.0	297.0	380.0	410.0	361.0	405.0	23.0		2266.00	
	2021-22	-	-	-	-	108.0	545.0	531.0	585.0	376.0	203.0	-	-	2348.00	

Table-4: Run off(%) under the cultivation of broom grass hill different treatments-2018-22 (t/h/y).

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Broom 1 Meter	2018-19	-	-	-	-	-	28.87	42.38	38.46	40.12	39.56	-	-
	2019-20	-	-	-	-	-	27.56	46.67	37.72	44.93	30.72	-	-
	2020-21					**22.50**	**24.82**	**25.70**	**35.42**	**31.20**	**33.20**	**-**	**-**
	2021-22					**10.60**	**26.45**	**25.96**	**34.70**	**30.24**	**28.40**		
Broom 2 Meter	2018-19	-	-	-	-	-	31.7	45.37	43.56	41.36	44.25	-	-
	2019-20	-	-	-	-	-	32.15	51.37	41.31	48.95	34.37	-	-
	2020-21	**-**	**-**	**-**	**-**	**25.60**	**26.35**	**28.92**	**41.82**	**33.69**	**39.38**	**-**	**-**
	2021-22					**12.50**	**28.56**	**29.30**	**36.20**	**34.15**	**35.42**		

Table 5. Nutrient loss (tha^{-1}) from plots under different treatments- (2019-20).

Particulars	N	P	K	S	Zn	B	Ca	Mg	Cu	Mn
Broom 1 Meter	4.3	0.00206	0.32844	0.00618	0.00082	0.00016	1.76	0.6048	0.0004	0.0 173
Broom 2 Meter	4.3	0.00212	0.37536	0.1576	0.00164	0.00054	1.952	0.588	0.00086	0.0 179

Table: 6. Comparative growth study of the Broom grass in different treatments.

Treatment	No. of Sticks /Sheaf	Av. height of sticks (cm)	Av. Nos. of flower /Sheaf
Treatment 1. (Row to row distance 1 m)	18.00 b	146.88	11.15 b
Treatment 2. (Row to row distance 2 m)	33.33 a	148.38	22.95 a
CV (%)	12.73	12.05	12.99
CD (0.05)	11.48	NS	7.79

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability.
NS- Non –significant, CV- Coefficient of Variation, CD – Critical Difference

Statistical Analysis:

The collected data were statistically analyzed following the analysis of variance (ANOVA) using WASP 1.0 (Web based Agri Stat Package 1.0) program and means were separated by critical difference (CD) values at 5% level of significance.

Table-7: Yield and Return (BDT) of the broom grass in different treatments.

Year	Treatment-1 (1. 0 m. distance)			Treatment-2 (2.0 m. distance)			Total return in BDT. per ha/yr		Average Total return in BDT. per ha/yr	
	Nos. of sticks	Nos. of broom	Sale value	Nos. of sticks	Nos. of broom	Sale value	Treatment-1	Treatment-2	Treatment-1	Treatment-2
2018-19	960	60	900/-	1440	90	1350/-	90.000/-	1,35,500/-	**1,68,000/-**	**1,94,000/-**
2019-	1892	122	1,830/-	2085	134	2010/-	1,83,000/-	2,01,000/-		
2020-21	1994	128	1,920/-	2198	141	2,115/	1,92,000/-	2,11,500/-		

2021-22	2064	138	2070/-	2278	152	2280/-	2,07,000/-	2,28,000/-		

Conclusions

The planting of broom grass has a direct impact on preventing surface soil erosion on steep hillsides. Broom grass grows in clumps and has many tangled-up roots that grow to about one meter 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. 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. It also increases the local biodiversity in the communities. Various journals prove that 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 across Nepal. The grass also possesses numerous medicinal properties that are essential in subsistence communities. Broom Grass may open the door of enrichment for the poor hill dwellers' and be an important method for rehabilitation of land degraded by shifting cultivation or slush and burn agriculture.

References

- Amatya, S. M., and Shrestha, K. L.,(2002). Nepal Forestry Handbook. FAO, Italy, Rome.
- Joshi, R. B., (1992). Indigenous Practices of Soil and Water Conservation in Farmlands.A Case Study of Bishnu Village Development Committee, Kathmandu, Nepal.
- Pandit, K., (2002). An Evaluation of Terrace Improvement Techniques in Paundikhola Watershed of Lamjung District Nepal. A thesis submitted to Institute of Forestry Pokhara for the partial fulfillment of the bachelor degree in forestry. pp 24-31.
- Rost, T. L., Barbour M.G., Thornton, R. M., Weier, T. E., and Stocking, C. R., (1979). Botany: A Brief Introduction to Plant Biology. John Wiley and Sons.Inc, pp 84-94.
- Howell, J., (1999). Roadside Bioengineering: Reference manual. Department of Roads.His Majesty's Government of Nepal, Kathmandu, Nepal.
- Broom grass transforms lives and hillsides in Nepal,© *WWF Nepal, Hariyo Ban Program /NabinBaral.* May 12, 2017
- Bisht, N. S., &Ahlawat, S. P. (1998). Broom Grass. State Forest Research Institute, Information Bulletin, 6, 1-10.
- SATNET Asia portal. (2014, October 31). Retrieved November 24, 2015, from http://satnetasia.org/database/02-broomgrass-farming
- Llewellyn, B. (2015, November 10). 'Sweeping' Changes in These Nepali Villages Score High Marksin Soil Conservation | Frontlines September/October 2015. Retrieved November 24, 2015, from https://www.usaid.gov/news-information/frontlines/climate-change-2015/'sweeping'changes-these-nepali-villages-score-high
- Gautam, T. (2015, September 8). Broom Grass: Rehabilitation of Forests Degraded by Shifting Cultivation/Slash-and-Burn Agricult. Retrieved November 24, 2015, from http://www.wwfnepal.org/hariyobanprogram/hariyo_ban_program_publications/?252130/Bro

omGrass-Rehabilitation-of-Forests-Degraded-by-Shifting-CultivationSlash-and-Burn-Agriculture

- Step-by-Step Guide to Importing Commercial Goods into Canada. (n.d.). Retrieved November 24, 2015, from *http://www.cbsa-asfc.gc.ca/import*

- Gandhiv Kafle1 & Prof. Mohan K. Balla, Effectiveness of Root System of Grasses Used in Soil Conservation in PaundiKhola Sub Watershed of Lamjung District, Nepal PaundiKhola Sub Watershed of Lamjung District, Nepal PaundiKhola Sub Watershed of Lamjung District, Nepal. (The Initiation 2008, P-121-129).

- Uma Shankar, S. D. Lama & K. S. Bawa (2001). "Ecology and economics of domestication of non-timber forest products: an illustration of broomgrass in Darjeeling Himalaya". *Journal of Tropical Forest Science*.13 (1): 171–191.

- *Kandwal, M.K. & Gupta, B.K. (2009). An update on grass flora of Uttarakhand. Indian Journal of Forestry 32: 657-668.*

- Bisht, N.S.; Ahlawat, S.P.(1998)."Broom Grass".State Forest Research Institute (9): 1–10.

- Solid Earth, 8, 217–233, 2017 www.solid-earth.net/8/217/2017/ doi:10.5194/se-8-217-2017

- Brindle, F. A.; Use of native vegetation and bio stimulants for controlling soil erosion on steep slope terrain, Transport Res. Rec., 1, 203–209, 2003.

EXPT. No. 2

EFFECT OF PLANTATION OF BAMBOO FOR EROSION CONTROL AND ITS ECONOMICAL PURPOSES. MULI/PAIYA: *GIGANTOCHLOA ROBUSTA* AND ORA: *FARGESIA ROBUSTA.*

Abstract

The potential of bamboo in erosion control and slope stabilization has been proven worldwide. Bamboos are being used as living plants as well as construction material in different soil bioengineering techniques in many countries. Bamboo shoots are crisp, tender, and have a mild, corn-like taste. Two indigenous types of bamboo were selected so that those can be surviving with the local climatic condition. Between two, one is locally called Paiya/Muli bamboo and another is called Ora bamboo. Locally fabricated multi-slot devisor was installed at each plot for estimating Soil Loss and Runoff from those plots. It was recorded that the highest soil loss was recorded on Paiya bamboo and lowest soil loss was recorded on 0ra bamboo plot. 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. Bamboo leaves can filter air pollutants, recycle CO_2 and replenish the atmosphere with Oxygen. Bamboo is also helpful against landslides and soil loss by preventing erosion.

Introduction

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 type of land degradation, Bangladesh lost a substantial amount of production which in terms of money may be thousands of billion taka in every year (BARC, 1999). The potential of bamboo in erosion control and slope stabilization has been proven worldwide. Bamboos are being used as living plants as well as construction material in different soil bioengineering techniques in many countries. The soil and water bioengineering approach is combined with bamboo traits and mechanical properties. The existing accumulated experiences of using bamboo in soil and water bioengineering works, along with the existing standards and design guidelines, make bamboo species an essential and cost-effective material for erosion control and slope stabilization works.

Bamboo is a globally distributed group of plants with more than 1400 species distributed worldwide in tropical, equatorial and semitropical biomes. It builds important and diversified habitats with different specificities, according to the nature of the species and the general ecological conditions. Most bamboo species show a very strong development and colonization ability, determining that in some temperate habitats, they can assume an invasive character.Soil bioengineering comprises a diversified group of techniques and land management systems developed by mankind throughout the millennia to use natural systems and elements in order to ensure the safety and functionality of land uses in a context of restricted availability of materials and, particularly, energy. Soil bioengineering techniques have been used throughout the world with the available plants and construction systems, many times replicated in different continents due to its efficiency and easy construction. Only in the first decades of the twentieth century, this set of building and land management techniques has been recognized as an integrated engineering approach to many soil stabilization problems, and they started to be systematized, studied and developed.

The strength of bamboo culms and roots and their straightness, lightness combined with hardness, range and size of hollowness make them potentially suitable for a variety of both structural and nonstructural applications. With good physical and mechanical properties,

low shrinkage and good average density, bamboo is well suited to replace wood/timber in soil bioengineering applications but also to act on its own as a living material providing rapid ground coverage and sediment trapping, increasing surface roughness, increasing soil strength and decreasing pore-water pressures in the soil by evapotranspiration. The use of bamboo to make retaining structures for soil mass or for stream bank erosion control has been practiced in traditional way in various places around the world for long time. Live bamboo stakes, wattle fence, hedge brush layering techniques and bamboo crib walls are most commonly used bioengineering techniques. A live bamboo crib wall is a three-dimensional structure created from untreated bamboos, fill material and live cuttings. Morgan and Rickson [5] described the crib wall as ‘a specialized form of gravity-retaining structure using on-site fill material, held within a constructed framework, to provide most of the necessary mass to resist overturning by the weight of both the slope and the materials’.

Bamboo belongs to the grass family and has an aerial part characterized by a jointed stem called a culm. The culms are typically hollow with the exception of certain bamboo species which have solid culms. The underground part of the plant is built from rhizomes growing normally at a shallow depth (up to a maximum of 150 mm) from where the roots develop. These roots can grow deep into the soil up to 500 mm. The rhizomes are the main form of spreading of the plant by growing horizontally away from the plant and, because they have a similar structure as the culm with vegetative nodes developing either roots or buds, originate new shoots and new individuals.

Bamboo is the fastest growing perennial, evergreen, arbores cent plant with a resulting high productivity: the dry weight yield per hectare could total as much as 32–38 or even 47 tons of biomass per hectare per year but averaging 8–18 tons per ha per year in normal conditions according to the different species and locations. This productivity, expressed both for the aerial and the root parts of the plant, illustrates the ability of bamboo to cover the terrain very rapidly, to develop a dense network of sub superficial rhizome and root system which would structure and consolidate the upper soil layer.

Bamboo is globally distributed between 51°N and 47°S, particularly in subtropical, tropical and equatorial regions. It also covers a high-altitude range, reaching up to 4000 m above sea level and thriving at temperatures as low as −20°C. The main area of occurrence is Asia where the largest number of species can be found. There is also a growing interest for bamboo as an ornamental plant, which brought the spread of several species to areas outside their natural ecological areas. This also raised some problems such as turning into invasive species and threatening natural habitats. The reinforcement effect ensured by bamboo roots can be expressed in engineering terms as an ‘additional cohesion’ added to the strength of the non-rooted soil Eq. Therefore, the total cohesion of a rooted soil will be the sum of the uprooted soil cohesion plus the cohesion increase due to the presence of roots in the soil. The rooted soil strength value is then used in traditional slope stability analysis methods (e.g. limit equilibrium methods) to determine the overall slope stability:

Bamboo shoots are crisp, tender, and have a mild, corn-like taste. They’re low in fat and high in fiber and potassium. The shoots of most temperate bamboos are edible, but some are naturally sweeter (and larger) than others, and therefore need less processing. Below is a list of bamboos particularly well suited for shoot production? Bamboo shoots are best when cooked to remove trace amounts of cyanogens (as in cyanide) and other bitter compounds which make them hard to digest. As an aside, bamboo foliage is good fodder for some types of animals. We supplement our rabbit food with bamboo leaves, which they seem to love. Some farmers are feeding bamboo to their goats, sheep, cows and even llamas. The animals receive fodder and provide a useful service by eating the leaves and branches off poles which can then be used for numerous building projects or for market.

A case study conducted under a research project from the University of Natural Resources and Life Sciences Vienna (BOKU) and the Tribhuvan University Kathmandu, Nepal [44]. Bamboo made crib walls are comparatively cheaper than gabion or stone masonry wall (construction costs only ¼ of gabion and 1/5 of masonry wall) but provide the same technical stability. Experiences of using bamboo in soil and water bioengineering works, together with the existing standards and design guidelines, make specific bamboo species an essential and cost-effective material for erosion control and slope stabilization works where these species are native.

Objectives

I. Reclamation of gullied land by minimizing erosion hazard.
II. For Landscape, aesthetic and economic purposes,
III. For environmental and ecological conservation,
IV. To mitigate the demand of food and fodder,
V. To introduce handy craft as a part off-farm activities for livelihood.

Materials and Methods

Two indigenous types of bamboo were selected so that those can be surviving with the local climatic condition. Between two, one is locally called Paiya/Muli bamboo and another is called Ora bamboo whose scientific names are *Gigantochloarobusta* and *Fargesiarobusta.* The experiment was carried out non replicable condition. Two experimental plots having area of 100 sq.m (5m x 20m) each on a degraded land (very steep to extreme steep slope) were selected in the SCWMC's Research area at Bandardarban Sadar upazila, Bandarban. Bamboo seedlings were collected from the culms situated in the nearby areas and planted in the month of July- 2018 following contour lines maintaining row to row distance 2.0 m and plant to plant distance 1.0 m. Before plantation, jungles were cleaned and composite Top soil samples were taken for nutrient studying. Locally fabricated multi-slot devisor was installed at each plot for estimating Soil Loss and Runoff from those plots. The seedlings were planted by dibbling method. Only one seedling was planted in each pit. After plantation of the seedlings, intercultural operation has been done when necessary. No fertilizer and manure were applied to the seedlings.

Soil loss and run-off from each 100 sq.m (20 m. x 5 m.) experimental plot were measured after each shower throughout the rainy season. Daily and eventually monthly soil loss and run-off were estimated from each plot by processing aliquot of sample every day. Every morning (if rains previos day) amount of run-off water has been measured in multi-slot divisors and aliquot of about 2 litre of homogeneous sample has been collected from each tank. Suspended sediment in the sampled aliquot has been measured by simple lab. filtering and oven drying. Corresponding rainfall was recorded by manual type and ordinary rain gauge installed in SCWMC meteorological station where climatic data like rainfall, temperature, humidity, evaporation etc. are being recorded regularly.

Results and Discussion

Table 8. Initial soil fertility status and fertility status after crop harvest.

Parameter	Year	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		
Payia Bamboo	2017	5.4	2.76 M	0.138 L	2.65 VL	0.41 H	66.69 VH	2.50 VH	0.56 O	7.72 VH	1.53 H	0.97 VH	97.80 VH	24.54 VH
	2018	4.1	5.5 H	0.275 O	1.03 VL	0.51 VH	26.01 O	6.99 VH	0.40 M	8.93 VH	2.81 VH	3.23 VH	77.68 VH	21.39 VH
Ora Bamboo	2017	4.8	3.09 M	0.155 L	2.05 VL	0.33 O	0.001 VL	2.03 H	0.29 L	5.26 O	1.04 M	0.92 VH	92.45 VH	17.68 VH
	2018	4.1	5.8 VH	0.290 O	0.96 VL	0.47 VH	36.08 H	7.05 VH	0.16 L	7.44 H	2.00 VH	4.25 VH	66.03 VH	20.71 VH

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

Table-9: Soil Texture

Particulars	Soil Textural Class	Sand	Slit	Clay
		%		
Payia Bamboo	Silt Loam	23	62	15
Ora Bamboo	Silt Loam	28	54	18

Table 10: Soil loss under Paiya/Muli bamboo and Ora bamboo *Gigantochloa robusta* and Fargesia robusta during 2018-2019 to2021-22 (t/h/y).

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
Payia Bamboo	2018-19	-	-	-	-	-	2.35	6.93	6.97	2.81	4.22	-	-	23.28	**17.85**
	2019-20	-	-	-	-	-	1.97	6.78	4.53	3.32	1.87	-	-	18.47	
	2020-21	-	-	-	-	1.24	1.86	2.59	3.22	2.38	3.08			14.37	
	2021-22					0.25	2.25	4.65	3.74	2.52	1.87			15.28	

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
Ora Bamboo	2018-19	-	-	-	-	-	1.91	6.13	6.20	1.66	1.83	-	-	16.07	**12.65**
	2019-20	-	-	-	-	-	0.91	5.20	3.86	2.75	1.14	-	-	13.86	
	2020-21	-	-	-	=	082	1.24	1.69	2.72	1.44	2.38			10.29	
	2021-22					0.16	1.56	2.78	3.08	1.65	1.15			10.38	

Soil loss under different bamboo species on degraded and gullied plots during 2018-2019 to 2021-22sessions are being presented in table 10. Which was recorded throughout the rainy season. It was recorded that the average highest soil loss was 17.85 t/ha (23.28, 18.47, 14.37 & 15.28 ton$h^{-1}y^{-1}$ in 2018-19 to 2021-22) on Payia bamboo and lowest average soil loss was 12.65 t/ha on Ora Bamboo plot (16.07, 13.86, 10.29 & 10.38 ton $h^{-1}y^{-1}$ in 2018-19 to 2021-22). Run-off percentage under different bamboo species on degraded and gullied plots during 2018-2019 to 2021-22 sessions are being presented in table 11. Which was recorded throughout the rainy season.

Table 11 : Run-off under Paiya/Muli bamboo and Ora bamboo *Gigantochloa robusta* and *Fargesia robusta during* 2018-2019 to 2021-2022.

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Paiya Bamboo	2018-19	-	-	-	-	-	21.53	36.03	50.76	53.07	45.13	-	-	-
	2019-20	-	-	-	-	-	21.35	54.18	41.85	42.42	33.36	-	-	-
	2020-21	-	-	-	-	20.21	23.62	35.72	55.78	52.19	55.64	-	-	
	2021-22					9.58	20.60.	33.48	39.36	25.45	32.12			
Ora Bamboo	2018-19	-	-	-	-	-	21.47	33.86	58.84	50.27	38.27	-	-	-
	2019-20	-	-	-	-	-	22.64	50.83	39.73	41.92	32.08	-	-	-
	2020-21	-	-	-	-	23.50	25.68	40.18	65.23	60.82	58.70	-	-	
	2021-22					7.2	19.47	29.70	31.53	22.45	24.36			
Rainfall	2018-19	3	0	0	67	207	607	691	256	249	266	0	14	2360
	2019-20	0	57	9	72	234	244	1024	398	411	141	43	9	2642
	2020-21	40	0	0-	133	217	297	380	410	361	405	23.	0	2266
	2021-22	-	-	-	-	108	545	531	585	376	203	-	-	2348

Table 12. Nutrient loss (tha^{-1}) from plots under different land use (2018).+

Particulars	N	P	K	S	Zn	B	Ca	Mg	Cu	Mn
Payia Bamboo	5.2	0.00266	0.71944	0.00604	0.00088	0.0005	2.716	0.7776	0.00042	0.02118
Ora Bamboo	4.9	0.00208	0.30498	0.014	0.00058	0.00036	1.912	0.6	0.00034	0.01974

Table-13: Yield and Return (BDT) of the Bamboos (Payia & Ora Bamboo) .

Financial year	Stage and Yield		Economical return		Remarks
	Payia Bamboo	Ora Bamboo	Payia Bamboo	Ora Bamboo	
2018-2019	Seedling stage	Seedling stage	Seedling stage	Seedling stage	**Payia bamboo takes more time for sprouting & harvesting as compared to Ora bamboo.**
2019-2020	Growing stage	Growing stage	Growing stage	Growing stage	
2020-2021	Selection harvesting Stage	Selection harvesting Stage	Tk. 2,250/- (150 Nos. @ Tk. 15/- each)	Tk. 4,000/- (200 Nos. @ Tk. 20/- each)	
2021-2022	Harvesting Stage, 180 nos.	Harvesting Stage, 250 nos.	180 nos. x 15/- =2,700/- per plot (100m2) =2,700/- x100 =**2,70,000/-per ha**	250 nos. x 20/- =5,000/- per plot (100m2) =5,000/- x100 =**5,00,000/-per ha**	

Conclusions

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. Bamboo leaves can filter air pollutants, recycle CO_2 and replenish the atmosphere with Oxygen. Bamboo is also helpful against landslides and soil loss by preventing erosion. The soil and water bioengineering approach is combined with bamboo traits and mechanical properties. The existing accumulated experiences of using bamboo in soil and water bioengineering works, along with the existing standards and design guidelines, make bamboo species an essential and cost-effective material for erosion control and slope stabilization works.

References

[1] Guillermo Tardio1*, Slobodan B. Mickovski2, Hans Peter Rauch3, Joao Paulo Fernandes4 and Madhu Sudan Acharya3- 1 Technical Univesity of Madrid, Spanish Association of Landscape Engineering, Madrid, Spain 2 Glasgow Caledonian University, Glasgow, Scotland, UK 3 Department of Civil Engineering and Natural Hazards, University of Natural Resources and Life Sciences, Vienna, Austria 4 University of Evora, Evora, Portugal- *gtarcer@gmail.com* * The Use of Bamboo for Erosion Control and Slope Stabilization: Soil Bioengineering Works.

[2] Studer R, Zeh H. Soil Bioengineering: Construction Type Manual. Zurich: vdfHochschulverlag AG; 2014

[3] Hacker E, editor. European Guidelines for Soil and Water Bioengineering. Aachen: European Federation for Soil Bioengineering; 2015

[4] Lammeranner W, Rauch HP, Laaha G. Implementation and monitoring of soil bioengineering measures at a landslide in the Middle Mountains of Nepal. Plant and Soil. 2005; 278:159-170

[5] Sthapit KM, Tennyson LC. Bio-engineering Erosion Control in Nepal. Rome, Italy: Food and Agriculture Organization of the United Nations; 2014. Available from: http://www.fao.org/docrep/u1510e/u1510e04.htm

[6] Rauch HP, Florineth F, Lammeranner W, Wibmer S. Soil Bioengineering Slope Protection Investigations in Nepal. Final Report for the Austrian Commission of Development Research. 2002.

[7] Morgan RPC, Rickson RJ. Slope Stabilization and Erosion Control: A Bioengineering Approach. London, UK: E&FN Spon; 1995. pp. 1-47 and 221-248

[8] Stokes A, Sotir R, Chen W, Ghestem M. Soil bio-and eco-engineering in China: Past experience and future priorities. Journal of Ecological Engineering. 2010;36(3):247-257

[9] Gray DH, Sotir RB. Biotechnical and Eco-Engineering Slope Stabilization. New York: Wiley; 1996.

[10] Lammeranner W. Slope stabilization with soil-bioengineering methods in the Middle Mountains of Nepal. Suitability of plants for drainage fascines, palisades, single tree planting and grass planting in winter plantation [Master thesis].University of Natural Resources and Live Sciences, Vienna, Austria. 2002

[11] Waldron LJ. Shear resistance of root-permeated homogenous and stratified soil. Soil Science Society of America Journal. 1977;41(5):843-849

[12] Tardio G, Mickovski SB. Method for synchronisation of soil and root behaviour for assessment of stability of vegetated slopes. Journal of Ecological Engineering. 2015; 82:222-230

[13] Rauch HP, Acharya MS, Khadka P, Shakya NM. Assessment of Soil Bioengineering and Conventional Methods Used in Road Side Slope Stabilisation Work in Nepal (2008) Final Report for the Austrian Commission of Development Research. 2006

[14] Tardio G, Mickovski SB. Implementation of eco-engineering design into existing slope stability design practices. Ecological Engineering. 2016;92:138-147

[15] Zaidon A, Nazri M. Traditional treatment of Malaysian bamboos: Resistance towards white rot fungus and durability in service. Pakistan Journal of Biological Sciences. 2000;3(9):1453-1458, 2000.

EXPT. No. 3

STUDYING BRUSHWOOD CHECK DAM FOR MINIMIZING EROSION HAZARD AND RECLAMATION OF GULLIED LAND.

Abstract

Gullies are the common features throughout the areas where the land comprises with High and slopping lands all over the world. The hilly region receives a huge amount of precipitation which is not well distributed. Due to different type of land degradation by rain, Bangladesh lost a substantial amount of production which in terms of money may be thousands of billion takas in every year. Brushwood check dams made of posts and brush are placed across the gully. Check-dams are constructed across the gully bed to stop channel bed erosion. The main objectives of brushwood check dams are to reduce the velocity of run-off, to prevent deepening and widening of the gully and to collect sedimentation and recharge the water table. Its catchment area was nearly 0.12 hectares. The types of Brush wood check were double row brush-wood check dam across the gully bed. The potential of the check dam to deposit the soil was evaluated by using leveling Instrument to observe the change of gully depth, cross sectional area and soil loss data were collected. Result obtained after three years indicates that the gully bed was filled with eroded soil from its catchment area of 0.12hac is 0.628 m which is equivalent to 138.188 ton/ha. The check dam interrupt surface run-off velocity, it also increases the permeability of water in to the soil. It also very cost effective for using locally available materials which are cheap and effective to rehabilitate gully.

Introduction

Gullies are common features throughout the Highlands. Induced environmental degradation comprises not only the loss of soil volume and of arable lands, but also the triggering of landslides (Nyssen et al., 2002) or off-site sedimentation problems (Nigussie et al., 2005). The phenomenon of gully development is not restricted to Highlands, but seems to be a phenomenon on sub-continental scale all over the world (Moeyersons, 2001). Land degradation, comprising degradation of the natural vegetation cover, soil erosion, loss of soil fertility and moisture stress is a well-known problem in hilly regions of Bangladesh as well as all over the world (Herweg and Stillhardt, 1999). Land degradation, particularly by water erosion, is an important factor in both the long-term decline and the seasonal reduction in food crop production (FAO, 1986). Soil erosion in Highlands degrades the soil resources on which agricultural production are based (Hurni, 1986, Nyssen, 1995 and many others). This threat stems from the depletion and degradation of the vegetation cover of the country, especially forest and exploitative farming practices. Water plays a vital role in the ecosystem. The precipitation over the country is not only unevenly distributed, but also uneven with regard to seasonal distribution as well as within season. Steep slope and terrain in hilly areas quickly releases the flow towards the outlet and thus creates scarcity of water.

Brushwood check dams made of posts and brush are placed across the gully. The main objective of brushwood check dams is to hold fine material carried by flowing water in the gully. Small gully heads, no deeper than one meter, can also be stabilized by brushwood check dams. Brushwood check dams are temporary structures and should not be used to treat ongoing problems such as concentrated run-off from roads or cultivated fields. They can be employed in connection with land use changes such as reforestation or improved range management until vegetative and slope treatment measures become effective. Temporary physical and structural measures such as gully brushwood dam are used to dissipate the energy of runoff and to keep the gully stable. Check-dams are constructed across the gully bed to stop channel bed erosion. By reducing the original gradient of the gully channel, check-dams reduce the velocity and erosive power of runoff. Run-off during peak flow is conveyed safely by check-dams. The structures can be either temporary or permanent.

The main requirement of temporary gully control structures is that, they must be quick and easy to construct, should be made by using cheap and readily available material in nearby areas. In areas where the soil in the gully is deep enough, brushwood check-dams can be used if proper construction is assured. The gradient of the gully channel may vary from 5 to 12 percent, but the gully catchment area should not be as such huge which produces high amount of runoff volume.

Objectives

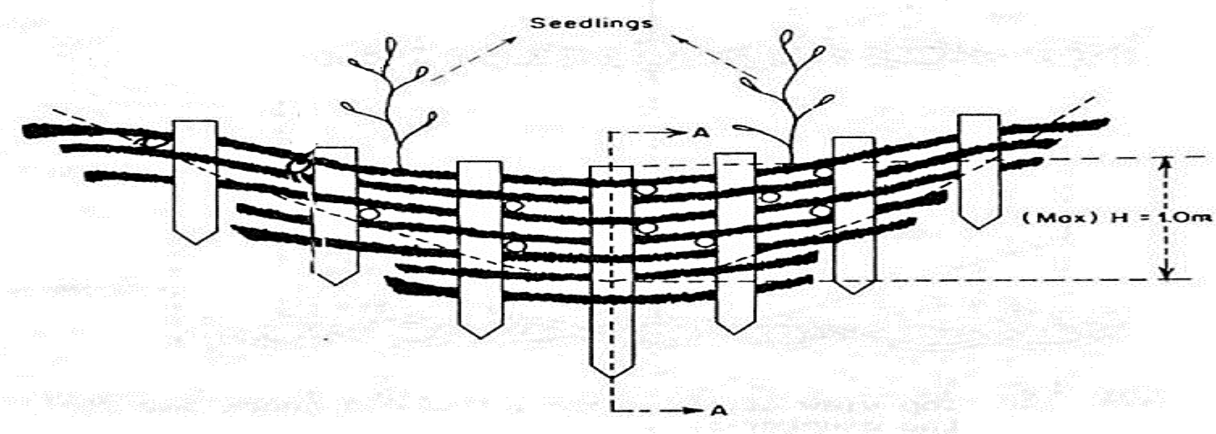
a) To reduce the velocity of run-off.
b) To prevent deepening and widening of the gully.
c) To collect sedimentation and to recharge the water table.

Materials and Methods

The study has been introduced at SCWMC research area to minimize erosion hazard and reclamation of a gully formed by the South-east side of the Administrative Building of SCWMC, SRDI, Bandarban. The length of the gully is 16.50 m. and width were variable with 1.80 m. near head and 5 m. where the Brush-wood check dams were constructed. It is situated in between two small hills. Average width of the gully in front of upper check dam is 2.30 m. Its catchment area was nearly 0.12 hectares. The gully head was very adjacent to the Administrative Building which was increasingly extending towards the Administrative Building. So, it was a future threat for the stability of the Administrative Building.

Brushwood check-dams made up of posts and brushes are placed across the gully. The main objective of brushwood check-dams is to hold fine materials carried by flowing water in the gully. Small gully heads, no deeper than one meter, can also be stabilized by brushwood check dams. Brushwood check-dams are temporary structures and should not be used to treat ongoing problems such as concentrated run-off from roads or cultivated fields. They can be employed in connection with land use changes such as reforestation or improved range management until vegetative and slope treatment measures become effective. The main requirement of temporary gully control structures is that, they must be quick and easy to construct, should be made by using cheap and readily available material in nearby areas.

There are two types of brushwood check-dams: these are single row and double row brush wood check-dams. Following the principle for construction of Brush-wood check dam, a decision had been taken to construct two nos. double row brush-wood check dam across the gully bed in series to reclamation of this gully.



The construction of the dam started with an excavation in the floor and into the sides of the gully to a depth of 0.30 m to 0.50 m. Two rows of living posts 5-10 cm in diameter and 1-20 m in length were placed into the holes maintaining a distance from post to post 0.60 m across the floor of the gully to a depth of 0.50 m to 0.60 m. The spacing between two rows was 1.00 m for upper check dam and 0.70 m for lower one. The width of the upper and lower brush wood check dam was 1.10 m. and 0.80 m, and height was 1.20. Brushwood and branches are packed between the posts. The height of the posts in the center was kept in such a way that it should not exceed the height of the spillway so that the flow would be blocked and water may be forced to move to the gully sides. The distance between upper and lower check dam was 6.00 m. Deposition of eroded soil from the catchment area is observed carefully.

Results and Discussion

Average width and length of the gully was 2.30 m. and 16.50m. adjacent to the upper Brush wood check dam. Soil deposited length in the gully was 8.20 m. and average width was 2.30 m. where the eroded soil was deposited in various depth. Soil deposition area was (8.20 m. x 2.30 m.) = 18.86 Sq.m. The Reduced Level (RL) of the gullied land wad measured by Theodolite Instrument. Before construction of the brush-wood check dam, the altitudes of the gully bed was were recorded in June-2018. Average RL of the gully was 94.102 m. (June-2018). After one rainy season during 2018-19, the RL of the gully bed was observed and it was found 94.418m. in March-2019. It was found that the average deposition height (by eroded soil from the catchment area) was 0.316 m. which is equivalent to 69.533 $tonh^{-1}y^{-1}$. After 2nd year, the average RL of gully bed was again measured and found that the average RL was 94.54 m. Hench, the deposition depth by eroded soil carried from the upper catchment was 0.122 m. which is equivalent to 26.842 $tonh^{-1}y^{-1}$., The average R.L. gully bed was measured in April-2021 and after 3rd year it was found that the average R.L. of the bed is 94.62 m. It shows that the deposition depth of eroded soil from the upper catchment is 0.080 m. which equivalent to 17.605 $tonh^{-1}y^{-1}$. Finally the average R.L. gully bed was measured in April-2022 and after 4th year it was found that the average R.L. of the bed is 94.73 m. It shows that the deposition depth of eroded soil from the upper catchment is 0.110 m. which equivalent to 24.208 $tonh^{-1}y^{-1}$. After Four years total deposition depth of eroded soil is 138.188 ton/ha. Amount of deposited soil is shown in Table-14. Weight of deposited soil was assumed to be on average 1400 kg per cubic meter.

Table-14: Amount of soil deposited by Brush wood Check Dam.

Location	Cross Sectional Area of the Gully bed (m².)	Catchment area of the gully (check dam) in hac.	RL of gully bed(m)					Depth of deposition (m)	Amount of deposited soil (m³)	Deposited amount from the catchment each year (ton)	Deposited amount $tonh^{-1}y^{-1}$	Total Deposition (ton/ha)
			June-18	March-19	April-20	April-21	April-22					
Upper check dam	8.20x2.30 = 18.86	0.12	94.102 (Initial)	94.418	94.54	94.62.	94.73	0.316 (2019)	5.96 (2019)	8.344 (2019)	69.533 (2019)	**138.188**
								0.122 (2020)	2.301 (2020)	3.221 (2020)	26.842 (2020)	
								0.080 (2021)	1.509 (2021)	2.113 (2021)	17.605 (2021)	
								0.110 (2022)	2.075 (2022)	2.905 (2022)	24.208 (2022)	

Note: Weight of 1.0 m^3 soil = 1.3 to 1.7 ton. Here considered 1.4 ton per m^3 of soil.

Conclusions

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.

As the Research Within three years, the gully bed has been raised up 0.628 m which proves that the check dam is capable to check 138.188 ton/hac sedimentation carried from the upper catchment area. Not only that, as the check dam interrupt surface run-off velocity, it also increase the permeability of water in to the soil. It also very cost effective for using locally available materials which are cheap and effective to rehabilitate gully.

References

- Agoramoorthy, Govindasamy, SunitaChaudhary&Minna J. Hsu (2008). "The Check-Dam Route to Mitigate India's Water Shortages".Natural Resources Journal.48 (3): 565–583.

- *Mississippi Department of Environmental Quality. Erosion Stormwater Manual(PDF) (4th ed.). Mississippi DEQ. pp. 4–118. Retrieved October 21, 2014.*

- Iowa Statewide Urban Design and Specifications (SUDAS) (2013). Design Manual - Erosion and Sediment Control (PDF). Ames, IA: Institute for Transportation at Iowa State University. Retrieved 28 October 2014.

- Garcia, Carmelo & Mario Lenzi (2010). Check Dams, Morphological Adjustments and Erosion Control in Torrential Streams. New York: Nova Science Publishers. ISBN 978-1-61761-749-2.

- A conceptual model of check dam hydraulics for gully control:efficiency, optimal spacing and relation with step-pools C. Castillo, R. Pérez, and J. A. Gómez from Hydrology and Earth System Sciences 18, 1705–1721, 2014

- United States Environmental Protection Agency (2014-08-06). "Water Best Management Practices: Check Dams". water.epa.gov. USEPA. Retrieved 28 October 2014.

- Mazzorana, Bruno (6 June 2014). "The susceptibility of consolidation check dams as a key factor for maintenance planning". ÖsterreichischeWasser- und Abfallwirtschaft.66 (5): 214–216. doi:10.1007/s00506-014-0160-4.1`

- Department of Environmental Quality (2005). IDEQ Stormwater Best Management Practices Catalog: Check Dams BMP 32 (PDF). State of Idaho. pp. 106–108. Retrieved 28 October 2014.

- Rickard, Charles & Rodney Day, Jeremy Purseglove (2003). River Weirs – Good Practice Guide (PDF). UK: Environment Agency. p. xi. Retrieved 4 November 2014.

- Sustainable Technologies Evaluation Program. "Check dams".Low Impact Development Stormwater Management Planning and Design Guide.Retrieved 28 March 2018.

- Agoramoorthy, Govindasamy, and Minna J. Hsu (2008). "Small Size, Big Potential: Check Dams for Sustainable Development". Environment.50 (4): 22–34. doi:10.3200/envt.50.4.22-35. Retrieved 28 October 2014.

- http://www.bebuffered.com/downloads/ManualonGullyTreatment_TOTFinal_ENTRO_TBIWR DP.pdf

- http://www.fao.org/docrep/006/ad082e/AD082e03.htm

- http://info.water.gov.my/attachments/article/324/GuidelineCheckDamsComplete Set.pdf

- http://www.brbuffered.com/downloads/ManualonGullyTreatment TOTFinal ENTRO TBIWRDP.pdf
- http://www.forestrynepal.org/wiki/346
- FAO (Food and Agriculture Organization of the United Nations), 1986. High lands reclamation Study– Ethiopia. Final report, volumes 1 and 2.Food and Agriculture Organization, Rome.
- Herweg K and Stillhardt B., 1999. The variability of soil erosion in the Highlands of Ethiopia and Eritrea.Research Report 42. Centre for Development and Environment University of Berne Switzerland.
- Moeyersons J. 2001. Deforestation, gully development and desertification in sub-Saharan tropical and subtropical Africa. Poster presented at Second International Conference on Tropical Climatology.
- Nyssen, J., 1995. Soil erosion in the Tigray Highlands (Ethiopia): I. Natural and human environment in its relationship to soil erosion. Geo-Eco-Trop 19, 51– 82.

EXPT. No. 4

EFFECT OF INDIGENOUS &ZERO TILLAGE CULTIVATION METHODS OF PINEAPPLE ON SOIL EROSION, RUN OFF, NUTRIENT MINING IN HILLY AREAS.

Abstract

The study was conducted at the Soil Conservation and Watershed Management Centre (SCWMC), Soil Resource Development Institute (SRDI), Bandarban . The present research work was undertaken to introduce a eco-friendly productive crop production system that is zero tillage cultivation system in sloping lands of CHT which will mitigate the process of land degradation due to digging up cultivation as well as take care of food security of Hill people. The main objectives of the research are to estimate & compare soil loss, runoff and nutrient mining under indigenous and zero tillage cultivation systems of pineapple, to calculate effect of soil loss on soil chemical properties and to create awareness about soil conservation & watershed management among hill dwellers. There are four treatments such as (1) Digging up across the slope (2) Digging up along the slope (3) Zero tillage across the slope and (4) Zero tillage across the slope. Measurement of soil loss and run-off was carried out by established and locally fabricated multi-slot divisors. Nutrient loss was calculated in every experimental plot from eroded soil. The lowest soil loss recorded in practicing zero tillage cultivation method across the hill slope and the highest soil loss recorded in digging up along the slopes. This research improves soil healthy by reducing soil erosion hazard, enhances crop production and encourages the hill dwellers to adopt the cultivation system to losing zero tillage across the hill slope in contour.

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 (Das gupta 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.

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.

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. 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.

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

Objectives

i. To estimate & compare soil loss, runoff and nutrient mining under indigenous and zero tillage cultivation systems of pineapple.
ii. To calculate effect of soil loss on soil chemical properties.
iii. To create awareness about soil conservation & watershed management among hill dwellers.

Materials and Methods

The experiment was carried out under non-replicated condition. Four experimental plots of 100 sqm.(5 m x 20 m) on steeply (32%) were selected in the SCWMC, Bandarban. There are four treatments such as (1) Digging up across the slope (2) Digging up along the slope (3) Zero tillage across the slope and (4) Zero tillage across the slope. Pineapple suckers are inserted in double row. The distance between single row to row was 30 cm and double row to row was70 cm. Fertilizers were applied as per recommendation of soil test value. Cultural operations were done as usual in all the plots. Measurement of soil loss and run-off was carried out by established and locally fabricated multi-slot divisors. 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. Different agronomic practices were done when it was necessary. Nutrient loss was calculated in every experimental plot from eroded soil.

Results and Discussion

Table 15. Initial soil fertility status and fertility status after crop harvest.

Parameter	Year	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		
Digging Up Across	2017	5.1	3.56 H	0.178 L	9.82 L	0.39 H	0.001 VL	1.41 O	0.19 L	3.81 M	0.78 M	0.79 VH	65.00 VH	28.38 VH
	2018	4.0	4.2 H	0.210 M	1.05 VL	0.44 H	11.15 L	0.38 VL	0.53 O	4.30 O	1.15 O	0.33 M	47.27 VH	10.50 VH
Digging Up Along	2017	5.7	3.63 H	0.182 M	3.48 VL	0.37 H	0.002 VL	4.18 VH	0.17 L	3.60 M	0.77 M	0.83 VH	66.46 VH	34.02 VH
	2018	4.1	3.5 H	0.175 L	1.07 VL	0.46 VH	22.30 O	0.27 VL	0.30 L	8.01 VH	0.88 M	0.18 L	39.80 VH	11.48 VH
Zero Tillage Across	2017	6.0	3.50 H	0.175	1.63 VL	0.36 O	0.001	6.30 VH	0.15 VL	4.34 M	0.86 M	1.04 VH	65.00	28.84 VH
	2018	4.0	4.3 H	0.275 L	1.21 VL	0.55 VH	18.53 M	0.50 L	0.60 O	6.52 H	1.59 H	0.25 L	37.55 VH	12.69 VH
Zero Tillage Along	2017	5.7	3.90 H	0.195 M	3.21 VL	0.42 H	1.15 VL	5.75 VH	0.26 L	5.18 O	0.93 M	0.84 VH	93.90	33.84 VH
	2018	4.0	5.5 H	0.275 O	1.04 VL	0.52 VH	17.54 M	1.17 M	0.32 M	5.92 O	1.79 H	0.56 M	50.15 VH	18.18 VH

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

Table-16: Soil Texture

Particulars	Soil Textural Class	Sand	Slit	Clay
		%		
Digging Up Across	Silt Loam	15	57	28
Digging Up Along	Silt Loam	18	56	26
Zero Tillage Across	Silt Loam	17	57	26
Zero Tillage Along	Silt Loam	18	56	26

The highest soil loss recorded in digging up along the slope were 68.59, 60.19, 52.55 & 40.21 ton/ha/yr. in the year of 2018-19,2019-20 ,2020-21 & 2021-22 respectively and finally the average highest soil loss was 55.38 ton/ha/yr. The lowest soil loss recorded in practicing zero tillage cultivation method across the hill slope were 8.69 ,7.48 , 6.45 & 6.21 ton /ha/yr. in the year of 2018-19, 2019-20 ,2020-21 & respectively and finally the average lowest soil loss was7.20 ton/ha/yr. On the other hand, soil loss recorded in digging-up across the slope were 52.04, 49.91, 43.35 & 34.12ton/ha/yr. in the year of 2018-19, 2019-20, 2020-21 & 2021-22 respectively and average was 45.0 ton/ha and zero tillage cultivation method along the hill slope were 14.48, 13.19 ,12.41 & 11.38 ton/ha/yr in the year of 2018-19, 2019-20, 2020-21 & 2021-22 respectively and average was 12.86 ton/ha.

Table 17. Total Soil Loss (ton/ha/yr) under indigenous & Zero Tillage cultivation methods of Pineapple for 2018-19, 2019-2020 , 2020-21 and 2021-2022.

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Average
Digging up Across	2018-19	-	-	-	-	-	6.83	15.52	11.85	10.27	8.16	-	-	52.63	**45.00**
	2019-20	-	-	-	-	-	4.12	22.38	8.89	10.12	4.40	-	-	49.91	
	2020-21	-	-	-	-	3.5	5.12	6.13	10.64	8.55	9.26	-	-	43.35	
	2021-22					1.5	6.85	7.69	8.08	5.76	4.24			34.12	
Digging up Along	2018-19	-	-	-	-	-	7.71	19.83	16.25	14.83	9.97	-	-	68.59	**55.38**
	2019-20	-	-	-	-	-	4.84	27.69	9.52	11.91	6.23	-	-	60.19	
	2020-21	-	-	-	-	4.2	7.68	8.04	11.50	10.05	11.0	-	-	52.55	
	2021-22					2.8	8.79	8.23	9.49	6.65	4.25			40.21	
Zero tillage Across	2018-19	-	-	-	-	-	0.96	3.49	2.29	0.72	1.23	-	-	8.69	**7.20**
	2019-20	-	-	-	-	-	0.85	2.83	2.29	0.82	0.69	-	-	7.48	
	2020-21	-	-	-	-	0.6	0.89	1.25	1.46	0.77	1.37	-	-	6.45	
	2021-22					0.2	1.32	0.94	1.66	1.25	0.84			6.21	
Zero tillage Along	2018-19	-	-	-	-	-	1.4	6.22	3.57	1.76	1.53	-	-	14.48	**12.86**
	2019-20	-	-	-	-	-	0.87	6.62	2.81	2.28	0.61	-	-	13.19	
	2020-21	-	-	-	-	1.1	1.56	2.34	2.95	1.33	3.09	-	-	12.41	
	2021-22					0.3	2.64	2.39	3.11	1.70	1.24			11.38	
Rainfall (m/m)	2018-19	3	0	0	67	207	607	691	256	249	266	0.	14	2360	-
	2019-20	-	57	9	72	234	244	1024	398	411	141	43	9	2642	
	2020-21	40	-	-	133	217	297	380	410	361	405	23	-	2266	
	2021-22	-	-	-	-	108	545	531	585	376	203			2348	

Table-18: Run off (%) under the cultivation indigenous & Zero Tillage cultivation methods of Pineapple.

2018-19, 2019-2020 , 2020-2021 and. 2021-22.

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Rain fall (m/m)
Digging up Across	2018-19	_	_	_	_	_	29.48	61.10	61.12	63.39	63.36	_	_	_
	2019-20	_	_	_	_	-	40.78	51.99	50.26	44.28	34.37	_	_	_
	2020-21	_	_	_	_	26.49	42.45	46.54	45.65	30.56	68.95		_	_
	2021-22					11.35	23.56	21.45	24.75	22.45	20.12			
Digging up Along	2018-19	_	_	_	_	_	27.26	59.24	68.66	65.75	57.15	_	_	_
	2019-20	_	_	_	_	-	45.01	53.75	53.50	47.42	38.03	_	_	_
	2020-21	_	_	_	_	28.42	45.25	49.37	46.10	33.82	70.38	_	_	_
	2021-22					12.4	30.25	28.70	31.32	27.85	23.54			
Zero Tillage Across	2018-19	_	_	_	_	_	25.78	56.77	65.75	53.93	54.05		_	_
	2019-20	_	_	_	_	-	33.39	49.72	46.38	38.64	30.72		_	_
	2020-21	_	_	_	_	19.43	23.90	37.03	39.99	26.23	57.62		_	_
	2021-22					9.4	22.70	20.45	23.20	19.80	18.50			
Zero Tillage Along	2018-19	_	_	_	_	_	26.52	55.53	57.15	58.66	50.94	_	_	_
	2019-20	_	_	_	_	_	36.56	51.24	50.91	41.15	32.55	_	_	_
	2020-21	_	_	_	_	23.36	39.76	41.11	43.76	29.14	60.16	_	_	_
	2021-22					10.5	24.30	22.8	26.80	21.64	19.60			
Rain Fall(m/m)	2018-19	3	0	0	67	207	607	691	256	249	266	0.0	14	2360.00
	2019-20	_	57	9	72	234	244	1024	398	411	141	43	9	2642.00
	2020-21	40	-	-	133	217	297	380	410	361	405	23	-	2266
	2021-22	-	-	-	-	108	545	531	585	376	203	-	-	2348

Rainfall and its pattern have a vital role on surface run off and soil loss hazard. Annual rainfall was measured by manual type rain gauge. Total Annual Rainfall was 2360 mm, 2642 mm 2266 & 2348 mm in the year of 2018-19, 2019-20 ,2020-21 & 2021-22 respectively. 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.

Table.19. Nutrient loss (tha^{-1}) from plots under different land use (2019)

Particulars	N	P	K	S	Zn	B	Ca	Mg	Cu	Mn
Digging up Across	4.0	0.00384	0.2737	0.00264	0.00216	0.0007	1.912	0.4656	0.00096	0.0291
Digging up Along	4.4	0.00502	0.3128	0.0059	0.00224	0.00084	2.072	0.4752	0.001	0.03164
Zero tillage Across	3.0	0.00222	0.1955	0.00198	0.00064	0.00024	1.328	0.3072	0.00038	0.02242
Zero tillage Along	3.6	0.00284	0.24242	0.00258	0.00128	0.0004	1.64	0.4152	0.00062	0.022852

It was observed that highest nitrogen loss i.e. 4.4 tha^{-1}occurred from Digging up Along the plot and the lowest (3.0tha^{-1}) from Zero tillage Across the plot along with other nutrient elements. In case of Digging up Across and Zero tillage Along the plot nitrogen loss was 4.0 and 3.6 tha^{-1} along with other nutrient elements.

Table.20. Yield Study of Pineapple under different Cultivation Practices:

Cultivation practices	Yield per Plot (Nos)				Fruit Size	Sale Value per plot / Total Earning (tha^{-1})				Average Earning for 4 yrs.(tha^{-1})
	2018	2019	2020	2021		2018 - 19	2019 -20	2020 -21	2021-22	
Digging up Across	12	187	214	225	**Standard size**	216/-	3366/-	3,852/-	4050/-	**2,87,100/-**
						21,600/-	3,36,600	3,85,2 00	4,05,000/-	
Digging up Along	10	190	196	200	Comparatively smaller	150/-	2850/-	2,940/-	3000/-	**2,23,500/-**
						15,000/-	2,85,000 /-	2,94,0 00	3,00,000/-	
Zero tillage Across	15	255	270	280	Comparatively bigger	300/-	5,100/-	5,400/-	5,600/-	**4,10,000/-**
						30,000/-	5,10,000 /-	5,40,0 00/-	5,60,000/-	
Zero tillage Along	13	205	212	228	Standard size	234/-	3690/-	3,816/-	4104/-	**2,96,100/-**
						23,400/-	3,69,000 /-	3,81,6 00/-	4,10,400/-	

For judging economic viability, the input & output cost of pineapple cultivation in different practices are also being studied. It was observed that the height average return comes from Zero tillage Across the slope 4,10,000/- and the lowest average return comes from Digging up Along the slope 2,23,500/- for four years. On the other hand, average return comes from Zero tillage Along the slope was **2,96,100/-** and digging-up across the slope was **2,87,100/-** for four years.

Conclusions

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 research improves soil healthy by reducing soil erosion hazard, enhances crop production and encourages the hill dwellers to adopt the cultivation system to losing zero tillage across the hill slope in contour.

References

- *Palis, R.G., C.W. Rose, and P.G. Saffigna. 1997. Soil erosion and nutrient loss. IV. Effect of slope length on runoff, sediment yield, and total nitrogen loss from steep slopes in pineapple cultivation. Australian Journal of Soil Research 35:907-913.*
- *Wan, Y.E.-S., S A. 1999. Runoff and soil erosion as affected by plastic mulch in a Hawaiian pineapple field. Soil and Tillage Research. Sept., 1999 52 (1-2): 29-35.*
- *Singh, D.B. 1997. Double fruiting in pineapple: A rare phenomenon. Journal of the Bombay Natural History Society 94:600-601*
- *Singh, H.P., I.S. Yadav, and S. Uma. 1999. Current status of tropical fruits in India. Indian Journal of Agricultural Sciences 68:494-507*

- *Wan, Y.E.-S., S A. 1999. Runoff and soil erosion as affected by plastic mulch in a Hawaiian pineapple field. Soil and Tillage Research. Sept., 1999 52 (1-2): 29-35.*

- *Pokharkar, S.M., and S. Prasad. 1998. Water desorption isotherms of osmotically concentrated pineapple. Journal of Food Science and Technology 35:518-520.*
- *Sarma, N.N., J.K. Dey, D. Sarma, D.D. Singha, P. Bora, and R. Sarma. 1995. Improved practice in place of shifting cultivation and its effect on soil properties at Diphu in Assam. Indian Journal of Agricultural Sciences 65:196-201.*
- *Sarah, J.L., B. Osseni, and R. Hugon. 1991. Effect of soil pH on development of Pratylenchusbrachyuruspopulations in pineapple roots. Nematropica 21:211-216.*
- *Craswell, E.T., A. Sajjapongse, D.J.B. Howlett, and A.J. Dowling. 1998. Agroforestry in the management of sloping lands in Asia and the Pacific. Agroforestry Systems 38:121-137.*
- Banzai,K.et al.(1995): Measurement of soil erosion in reclaimed land with optical land surverying.SoilPhys.Cond.Plant Growth,Jpn,71,53-56[In japanese]
- Hu.S.C. &Lee,S.W.(1995): Erosion control practices for steep upland fields in Taiwan.Food Fert.Technol.Cent.Ext.Bull.,401,1-12.
- McPhee,P.J.,Hartmann,M.O. &&Kieck,N.F. (1983): Soil erodibility and crop management factors of soils under pineapple production.Am.Soc.Agric.Eng.,Paper No.-83-2073,1-17.
- Valentin,C. &Roose,E.J.(1981): Soil and water conservation problems in pineapple plantations of south Ivory Coast.In Soil Conservation – Problems and Prospects. ed.Morgan, R.P.C.,John Wiley & Sons,Chichester,239-246.
- Kazuo SUGAHARA[1],Yoshinari OHWAKI[2] and Kenji BANZAL,Erosion control in pineapple fields on the island of ishigaki,okinawa subtropical station,Japan international Research center for Agricultural Sciences (ishigaki,okinawa,907-0002 Japan);JARQ 35(2),91-96 (2001).
- Annual Report (2015-2016);Soil conservation and watershed management center, SRDI, Bandarban.

EXPT. No. 5

STUDYING EFFECT OF NATURAL VEGETATIVE STRIP (NVS) FOR MINIMIZING SOIL EROSION IN CULTIVATION OF VEGETABLES.

Abstract

Natural Vegetative Strips (NVS) are narrow strips of naturally growing grasses and herbs intentionally left unplowed along the contours of slope land farms. These strips serve as buffers that prevent the soil from eroding during heavy rains and intensive cultivation. Over time, these strips form stable terraces along the contours. , The specific objectives of the present study were-To examine the effect of NVS on the maintenance of soil fertility and reducing soil erosion in moderate hill slope, to examine the effect of NVS on vegetables productivity in hill slope. The test crops of the experiment were Okra and yard long bean. There were four treatments and these were as: T_1 = Okra in Natural vegetative strip, T_2 = Okra in control (no NVS), $T_{3=}$ Yard long bean in Natural vegetative strip, T4 = Yard long bean in Control (no NVS). Soil erosion was measured through Spike layout method. The topsoil loss was the highest in Yard long bean in Control (29.22 t ha^{-1})which was significantly different from the NVS used plots. Among the NVS applied plots, soil erosion was the lowest in Okra in Natural vegetative strip plot (10.69 t ha-1).Soil loss from the Okra in control plot was 28.95t $ha^{-1}$and Yard long bean in Natural vegetative strip plot was 11.03t ha^{-1} .The highest yield (8.993 t/ha) was obtained in Okra in NVS managed plot and the lowest yield (6.007 t/ha), was observed in Okra in Control managed plot. On the other hand the highest yield (9.593 t/ha) was obtained in Yard long bean in NVS managed plot and the lowest yield (6.606 t/ha), was observed in Yard long bean in Control managed plot.

Introduction

The CHT covers an area about 13,181 km^2 and occupies about 76% of total 12% upland areas of the country (Khisa.2006) endowed with natural beauty and economic potentiality.Jhum, the dominant form of land use in CHTs, widely practiced by tribal communities and remain as major source of livelihood for most of the hill people. About 1.0 million peoples in CHT of which 13 different ethnic groups are directly or indirectly depend on Jhum (Shoaib,2000).Generally, after one year harvest in general, sometimes two year, the land was left fellow for 20-30 years, which at present has been shorten to 3-4 years (DANIDA,2000).It is estimated that1,02,468 areas (4.3 percent area of the CHT) is cleared every year for jhum cultivation.Gafur*et al*.(2003) cited approximately 2.5% area of CHT remains under jhum in each year. Soil erosion is an important social and economic problem and an essential factor in assessing ecosystem health and function. When runoff occurs, less water enters the ground, thus reduces the crop productivity. Soil erosion

also reduces the levels of the basic plant nutrients needed for crops, trees and other plants and decreases the diversity and abundance of soil organisms(Olson et al.1999;Schumacher et al.1999; Irvine and Kirkby2004).Effective control of soil erosion lies in reducing direct impact of rain drops, maintaining maximum soil infiltrability by decreasing surface sealing, increasing the surface storage,imporving soil structure and decreasing the velocity and transport capacity of runoff, which can only be achieved through good land use management.Joshi et al.(2004) reported that the grass cultivation on barren terraces and bund of agriculture land proved effective in reducing erosion hazards for hill farming to maintain the nutrient balance under different land use systems.

The physical and chemical properties of soils are significantly affected by the land use patterns.. One of the best ways of solving those problems could be adoption of Natural Vegetative Strip during crop cultivation. Natural Vegetative Strips (NVS) are narrow strips of naturally growing grasses and herbs intentionally left unplowed along the contours of slope land farms. These strips serve as buffers that prevent the soil from eroding during heavy rains and intensive cultivation. Over time, these strips form stable terraces along the contours. Natural Vegetative strips are easy to establish. They are incorporated during land preparation, and thus require minimal labor. They do not entail additional cost as there is no need for additional planting materials, since the grasses naturally grow on the farm. The strips filter pesticides, nitrates and soluble phosphorus, thus prevent runoff. They control soil erosion by more than 90%.They improve water infiltration during heavy rains. Subsequently land preparation and crop management become easier. Farmers are provided with food foundation, and farms evolve into complex agro forestry systems, thereby increases the productivity. The NVS reduces the available cropping area by about 10 to 15%.However; the cropping area utilized for strips basically depends on the steepness of the slope. The steeper slope used the greater of area for strips. Basically, the strips do not cause weed problems as long as the farmers regularly maintain the NVS area and about 50 cm of its surrounding through continuous cultivation. If farmer-maintenance is good, no weed problems will occur.

Minimization of soil through (NVS) is an indigenous technology which used by the hill dwellers since time immemorial. In the rural areas the poor, who struggle for survival, cannot be expected to pay heed to the conservation strategy unless their daily needs of food, fiber and fuel are met. Still a more urgent need is for assured and full employment for all the peoples. Though soil erosion in Chittagong Hill Tract is a great threat for crop cultivation, the practice of Natural Vegetative Strip application is still very limited. In this manner a land use system should be developed to control soil erosion and sustain crop productivity and aware the people as well as the peoples who involved develop the people of this remote area. So, the specific objectives of the present study were as follows:

- **To examine the effect of NVS on the maintenance of soil fertility and reducing soil erosion in moderate hill slope.**
- **To examine the effect of NVS on vegetables productivity in hill slope.**

Materials and Methods

The experiment was conducted in the experimental farm of the Soil Conservation and Watershed management Center (SCWMC); Soil Resource Development Institute (SRDI), Bandarban. The site was located in south-southeast hilly region of Bangladesh. The location of the site is between $22^0$09´16 to $22^0$10´32 north latitude and $92^0$11´17 to $92^0$11´34 east longitudes with an elevation 92-133 m above mean sea level (SRDI,2005).The experiments were set up on the 26% hill slope areas. The climate of the experimental site is sub-tropical characterized by heavy rainfall during May to September and scanty rainfall during rest of the year. The area has an erratic monsoon climate, with periodic flooding in the valleys and drought in the mountains, hot rainy summer and a pronounced dry season in the cooler months. January is the coolest month of the year and April is the warmest one. The detail records of air temperature, humidity and rainfall for the study period were collected from meteorological station of Soil Conservation and Watershed Management Center, Bandarban.The mean annual rainfall of the study site was 3000 mm and monthly mean air temperature ranged from 25 to 34 ^{0}c and mean relative humidity was 79.3%.

The test crops of the experiment were Okra and yard long bean. There were four treatments and these were as: T_1 = Okra in Natural vegetative strip, T_2 = Okra in control (no NVS), $T_{3=}$Yard long bean in Natural vegetative strip, T4 = Yard long bean in Control (no NVS).The experiment was laid out in Randomized Complete Block Design (RCBD) with 3 (three) replications. The treatments were randomly allotted in each block. The dimension of each plot was 20m x 5m (100 m^2).The seeds were sown in following dibbling method . Necessary agronomic management practices for all crops were followed. Plots were prepared manually. Intercultural operations like weeding and fertilizer application were done equally in all treatments to get better results. In every plot after 4 meter intervals a 1 m width NVS were made naturally. So, there were four NVS in each plot. In Natural Vegetative Strips area there were different types of shrubs and grasses, which were germinated and developed naturally. The area of NVS was kept just to leave the cultivated area in cropping time without cleaning.

Soil erosion was measured through Spike layout method. In every plot, four spikes were inserted-two were near upper side (top of the plot) and another two were near bottom side of the plots. The spikes were made by mule bamboo and these were colored by normal paints. These bamboo spikes were divided into two parts by using two different colors (red and white).

Different intercultural operations like –weeding, insect and disease control, harvesting were done properly and timely for successful completion of the experiments.

Composited Soil samples were collected and just before land preparation to determine the physical and chemical properties of the experimental field. Soil samples were also collected treatment-wise after the final harvest of the crop. The collected samples were air-dried, grained and passed through a 2 mm sieve for physical and chemical analysis. Soil samples were analyzed following standard analysis method in central laboratory of SRDI.

Results and Discussion

Table 21. Initial soil fertility status and fertility status after crop harvest.

Parameter	Year	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		
NVS Okra	2017	6.7	3.09 M	0.155 L	26.81 VL	0.30 O	0.003 VL	1.52 O	0.30 L	3.42 M	0.69 L	0.82 VH	80.62 VH	42.11 VH
	2018	6.1	3.6 H	0.180 L	30.57 VH	0.37 H	7.58 L	6.48 VH	0.30 L	2.78 L	1.11 M	2.77 VH	37.16 VH	18.50 VH
Control Okra	2017	6.3	3.16 M	0.158 L	17.89 O	0.38 H	0.30 VL	1.60 O	0.23 L	5.29 O	1.16 O	0.81 VH	67.90 VH	37.68 VH
	2018	4.0	3.6 H	0.180 L	5.20 VL	0.43 H	11.59 L	0.52 L	0.03 VL	2.67 L	1.39 O	0.40 M	40.45 VH	16.61 VH
NVS Yard long bean	2017	6.1	3.50 H	0.175 L	0.54 VL	0.54 VH	31.69 H	1.71 O	0.26 L	4.80 O	1.33 O	0.77 VH	63.90 VH	42.32 VH
	2018	4.0	4.0 H	0.200 M	2.02 VL	0.9 VH	4.38 VL	0.39 L	0.30 L	3.12 M	1.81 H	0.38 M	55.67 VH	17.23 VH
Control Yard Long bean	2017	5.9	3.70 H	0.185 M	9.08 L	0.50 VH	7.99 L	1.91 H	0.35 M	4.21 M	1.25 O	0.73 H	66.23 VH	41.56 VH
	2018	4.0	4.2 H	0.210 M	1.73 VL	0.86 VH	3.60 VL	0.48 L	0.14 VL	3.36 M	1.94 VH	0.35 M	41.28 VH	13.37 VH

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

Table-22: Soil Texture

Particulars	Soil Textural Class	Sand	Slit	Clay
		%		
NVS Okra	Silt Loam	23	59	18
Control Okra	Silt Loam	22	60	18
NVS Yard Long Bean	Silt Loam	20	62	18
Control Yard Long Bean	Silt Loam	23	59	18

Soil erosion is considered as one of the most important parameters as well as the main constraints for crop production in slopping lands. In this study, the soil erosion parameter was assessed based on the soil losses or washed out (eroded) at a given (prefixed) location of the study area. The total soil erosion based on the loss of top soil (i.e depth created due to erosion) in the experimental treatments as shown in table 23& 24. The soil loss varied considerably with the use of NVS systems. The topsoil loss was the highest in Yard long bean in Control (29.22 t ha^{-1})which was significantly different from the NVS used plots. Among the NVS applied plots, soil erosion was the lowest in Okra in Natural vegetative strip plot (10.69 t ha-1).Soil loss from the Okra in control plot was 28.95t $ha^{-1}$and Yard long bean in Natural vegetative strip plot was 11.03t ha^{-1} This statement was supported by Paningbatan and Rosario (1990) who observed that alley cropping with mulching contouring and minimum tillage greatly reduced surface run-off and soil losses and erosion rates ranging from 36 to 200 t/ha on erosion plots cultivated up and down the slope. The surface cover crop barriers do not channelize runoff, as do engineered systems. Woo and Luk (1990) observed that if the vegetative cover decreases both the interception and infiltration decreases which increase the overland flow and soil loss.

Table 23: Soil loss under the cultivation of Okra in Natural vegetative strips

Treatments	Average soil loss in mm	Total soil loss (ton/ha)
Okra in NVS	0.8220 b	10.69 b
Okra in Control	2.227 a	28.95 a
CV (%)	26.04	2.98
CD (0.05)	1.40	4.79

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability. CV- Coefficient of Variation, CD – Critical Difference

Statistical Analysis:

The collected data were statistically analyzed following the analysis of variance (ANOVA) using WASP 1.0 (Web based Agri Stat Package 1.0) program and means were separated by critical difference (CD) values at 5% level of significance.

Table 24: Soil loss under the cultivation of Yard long bean in Natural vegetative strip.

Treatments	Average soil loss in mm	Total soil loss (ton/ha)
Yard long bean in NVS	0.8487 b	11.03 b
Yard long bean in Control	2.248 a	29.22 a
CV (%)	11.32	5.31
CD (0.05)	0.62	8.67

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability. CV- Coefficient of Variation, CD – Critical Difference

Statistical Analysis:

The collected data were statistically analyzed following the analysis of variance (ANOVA) using WASP 1.0 (Web based Agri Stat Package 1.0) program and means were separated by critical difference (CD) values at 5% level of significance.

Mean performance of NVS on yield & yield component of Okra.

Fruit Length: All the treatments significantly influenced fruit length of Okra cultivation. The height fruit length (18.60cm) was obtained in Okra in NVS managed plot. The lowest fruit length (14.47cm), was observed in Okra in Control managed plot (Table 25).

Fruit Weight: All the treatments significantly influenced fruit weight of Okra cultivation. The height fruit weight (18.24gm) was obtained in Okra in NVS managed plot. The lowest fruit length (12.46gm), was observed in Okra in Control managed plot (Table 25).

Table 25: Mean performance of NVS on yield & yield component of Okra.

Treatments	Fruit length (cm)	Fruit weight (gm)	Fruit/plant	Plot Yield (kg)	Yield(t/ha)
Okra in NVS	18.60 a	18.24 a	16.10 a	59.76 a	8.993 a
Okra in Control	14.47 b	12.46 b	12.27 b	47.78 b	6.007 b
CV (%)	1.73	5.09	4.90	2.551	7.591
CD (0.05)	1.00	2.75	2.44	4.814	2.005

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability. CV- Coefficient of Variation, CD – Critical Difference

Statistical Analysis:

The collected data were statistically analyzed following the analysis of variance (ANOVA) using WASP 1.0 (Web based Agri Stat Package 1.0) program and means were separated by critical difference (CD) values at 5% level of significance.

Fruit per Plant: The height fruit /plant (16.10) was obtained in Okra in NVS managed plot and the lowest fruit /plant (12.27), was observed in Okra in Control managed plot (Table 25).

Plot Yield (Kg): The Maximum plot yield (59.76 kg) was obtained in Okra in NVS managed plot. The lowest plot yield (47.78 kg) was observed in Okra in Control managed plot (Table-25).

Yield (t/ha): All the treatments significantly influenced yield of Okra cultivation. The highest yield (8.993 t/ha) was obtained in Okra in NVS managed plot and the lowest yield (6.007 t/ha), was observed in Okra in Control managed plot (Table 25).

Mean performance of NVS on yield & yield component of Yard long bean

Pod Length: All the treatments significantly influenced pod length of Yard long bean cultivation. The height pod length (50.65 cm) was obtained in Yard long bean in NVS managed plot. The lowest pod length (40.57cm), was observed in Yard long bean in Control managed plot (Table-26).

Pod diameter: All the treatments significantly influenced pod diameter of Yard long bean cultivation. The height pod diameter (0.9900 cm) was obtained in Yard long bean in NVS managed plot. The lowest pod diameter (0.8967 cm), was observed in Yard long bean in Control managed plot (Table -26).

Table 26: Mean performance of NVS on yield & yield component of Yard long bean

Treatments	Pod length (cm)	Pod diameter (cm)	Pod wt. (gm)	No. of pod/ plant	No. of seed/ Pod	Plot Yield (kg)	Yield (t/ha)
Yard long bean in NVS	50.65 a	0.9900 a	18.91 a	20.17 a	19.00 a	66.20 a	9.593 a
Yard long bean in Control	40.57 b	0.8967 b	13.53 b	14.00 b	12.67 b	54.86 b	6.606 b
CV (%)	3.35	0.26	3.64	1.13	2.09	1.94	2.206
CD (0.05)	5.38	0.01	2.07	0.67	1.17	4.13	0.625

In a column means having dissimilar letter(s) differ significantly as per 0.05 level of probability.
CV- Coefficient of Variation, CD – Critical Difference

Statistical Analysis:

The collected data were statistically analyzed following the analysis of variance (ANOVA) using WASP 1.0 (Web based Agri Stat Package 1.0) program and means were separated by critical difference (CD) values at 5% level of significance.

Pod wt.: The height pod wt. (18.91 gm.) was obtained in Yard long bean in NVS managed plot and the lowest pod wt. (13.53 gm), was observed in Yard long bean in Control managed plot (Table 26).

No. of pod/ plant: The height No. of pod/ plant (20.17.) was obtained in Yard long bean in NVS managed plot and the lowest No. of pod/ plant (14.00), was observed in Yard long bean in Control managed plot (Table-26).

No. of seed/ pod: The height No. of seed/ pod (19.0) was obtained in Yard long bean in NVS managed plot and the lowest No. of seed/ pod (12.67), was observed in Yard long bean in Control managed plot (Table-26).

Plot Yield (Kg): The Maximum plot yield (66.20 kg) was obtained in Yard long bean in NVS managed plot. The lowest plot yield (54.86 kg) was observed in Yard long bean in Control managed plot (Table-26).

Yield (t/ha): All the treatments significantly influenced yield of Yard long bean cultivation. The highest yield (9.593 t/ha) was obtained in Yard long bean in NVS managed plot and the lowest yield (6.606 t/ha), was observed in Yard long bean in Control managed plot (Table-26).

Conclusions

Minimization of soil erosion through natural vegetative strip (NVS) is an indigenous technology which used by the hill dwellers since time immemorial. Use of natural vegetative strip (NVS) has created positive effect on the morphological and reproductive characteristics as well as at the yield of crops. Natural vegetative strip (NVS) always plays a vital role on plant growth, crops productivity, fruit length & weight as well as minimizing of soil erosion. More yields were gained from the managed plots by NVS, though the number of total plant was comparatively less in those plots than the controlled one. 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 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.

References

1. Atta-krah, A.N. and J.E.Submerg, 1988 Studies with Glericidiasepum for crop-livestock production system in West Africa, agroforestry systems 6:97-118.
2. Attah-krah,A.N.,J.ESumberg.and L.Reynolds.1986.In potential of forage legume in farming System of Sub Saharan,Africa.InI.haque,S.Jutzi and P.J,H Neate (eds) 307-329.ILCA,ADDIS ABABA.
3. DANIDA, 2000 Interim Planning Mission, Watershed Development Project, Chittagong Hill Tracts (CHT), Bangladesh (draft).
4. Gafur,A,O,KBorggaard,J.R.Jensen and L.Petersen.2000.Changes in soil nutrient content under shifting cultivation in the Chittagong Hill Tracts Of Bangladesh. Danish J.Geogr.100:37-46.
5. Irvine,B and M.Kikby,2004,Land Degradation risk and off site impact of soil erosion at the European scale. Geophy. Res. Abstracts 6 (03669).
6. Joshi,B.K,P.KVerma and B.P.Kothyari.2004.Erosion studies under different land use systems in Bhetagad watershed of central Himalayas.IndianJ.Soil Cons.32(2):139-142.
7. Kang,B.T.H. Grimme and T.L.Lawson.1985.Plants and Soils 85:267-276.
8. Khisa, S.Kanti, J.U.M Shoaib, and K.N.Ahmed.2006. Selected natural resources conservation approaches and technologies in Chittagong Hill Tracts Bangladesh.Bangladesh Conservation Approaches and Technology (BANCAT).

9. Miah, M.G.1993 Performance of selected multipurpose tree species and field crops grown in the association as affected by tree branch pruning. A Ph.D dissertation research (Crop Science-Agronomy). CLSU.Philippines.

10. Nair, P.K.R.1990.The prospect of Agro forestry in the tropics.(ed.P.K.R. Nair).Kluwer Academic Publisher London, pp.12-18.

11. Olson, K.R.., Mokma, D.L.R.Lal, T.E.Schumcher and M.J.Lindstrom.1999.Erosion impacts on crop yield for selected sois of the North Central United States.In:R.Lal (ed.) Soil Quality and Soil Erosion, CRC Press, Boca Raton, FL.pp.259-283.

EXPT. No. 6:

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. 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. 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.

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.

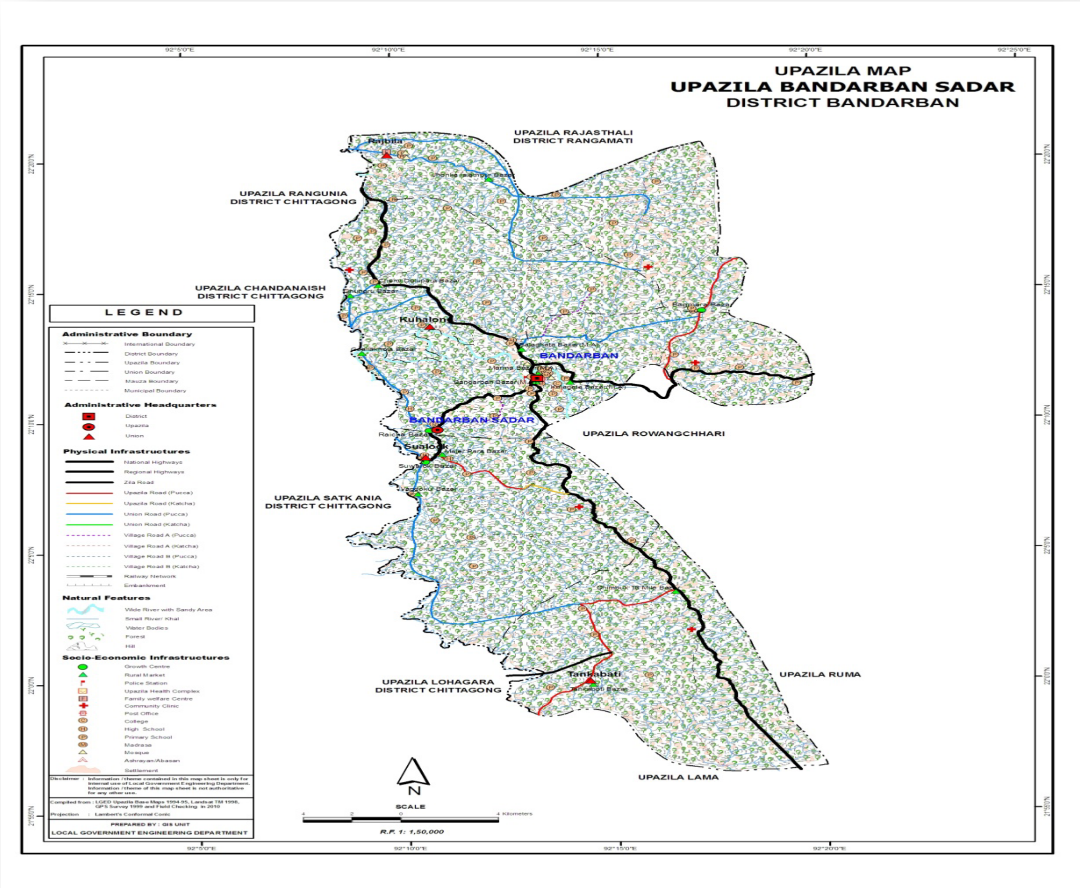


Figure 2: Map of the study area

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 (*Eupatoriumodoratum*), 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.Patibetis 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 quantity 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 lands 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 where the plants growth of the second plot is satisfactory and green to dark green in colour. The plants of the lower plot were healthier and vigorous than second plot with dark green in colour. There was a significant change of appearance, leaf per plant, height and plant diameter depending on the location of the plats (shown in table-27). Yield difference was also observed in different plots. Total **Average return (in BDT)** in financial value was recorded Tk. **625**-, Tk. **1158**/- and **1543**/- from upper, middle and lower plots for 1700sft. jhiri land from 2018-19 to 2021-22. (shown in table -27). The immediate lower plot's response better than that of upper one.

Table 27: Comparative growth Study & return from *MURTA*/ PATIBET plants in different plot in different elevation.

Plot No	Year	Appearance	Av. plant Height	Av.plants Diameter (mm)	Av. Leaf per plant (Nos.)	Av. Plants per Culm (Nos.)	Return (in BDT)	Average Return (in BDT)	Remarks
1. Upper	2017-18	Yellowish green	1'-6" to 2'-0"	4- 6	4 to 6	7 to 9	-	625	
	2018-19	Green	3'-6" to 6'-6"	8- 20	8 to 12	12 to 16	300/-		150 sticks @ Tk.2/- each
	2019-20	Green	3′-6′′ to 7′-0′′	10 - 22	11-20	16-20	625/-		250 sticks @ Tk.2/50 each
	2020-21	Green to dark green	3′-6′′ to 7′-0′′	12 - 26	11-25	18-26	750/-		300 sticks @ Tk.2/50 each
	2021-22	Green to dark green	3′-6′′ to 7′-0′′	14-28	12-24	20-28	825/-		330 sticks @ Tk.2/50 each
2. Middle	2017-18	Green	3'-0" to 4'-0"	5 - 8	5 to 9	10-14	-	1158	-
	2018-19	Green	4'-0" to 7'-0"	10- 22	8 to 14	15- 20	700/-		280 sticks @ Tk.2/50 each
	2019-20	Green to dark green	3′-6′′ to 7′-6′′	10-22	12-22	16-25	1,170/-		390 sticks @ Tk.3/- each
	2020-21	Green to dark green	3′-6′′ to 7′-6′′	14-28	14-28	16-30	1,320/-		440 sticks @ Tk.3/- each
	2021-22	Green to dark green	3′-6′′ to 7′-6′′	15-30	16-30	18-32	1440		480 sticks @ Tk.3/- each
3. (Lower)	2017-18	Dark green	4'-0" to 5'-0"	7 -12	9 to 14	12- 16	-	1543	-
	2018-19	Dark Green	4'-0" to 7'-0"	12 -22	10 to 16	20- 22	1250/		417 sticks @ Tk.3/- each
	2019-20	Dark green	4′-0′′ to 7′-6′′	10-24	14-24	24-36	1,710		570 sticks @ Tk.3/- each
	2020-21	Dark green	3′-6′′ to 7′-6′′	14-28	14-28	18-35	1,530/-		510 sticks @ Tk.3/- each

	2021-22	**Dark green**	**4´-0´´ to 8´-7´´**	**16-32**	**18-30**	**20-38**	**1680**		**560 sticks @ Tk.3/- each**
								Total Taka for 1700 sft. =	**3,326/-**

Table 28: 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 29: Variation in price for different products from producer to retailer

Articles	**Selling Price (US$)**				**Difference between Artisan and Retailer (US$)**
	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-30: Chemical properties of Soil 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						
Experimental Plot	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-31: Soil Texture

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

Conclusions

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.

References

- Al-Hadi AH. Sylhet District In Islam S (ed.),Banglapedia Multimedia CD.Dhaka, Bngladesh : Asiatic Society of Bangladesh;2004
- Anon. Wealth of India(Raw Materials), Vol.II. New Delhi: Council of Scientific and Industrial Research;1950:427
- Anon. Working Plan for the Forest of Sylhet Division for the Period 1963-64 to 4982-83, Vol.1. Dhaka,Bangladesh: East Pakistan Government Press;1970:215
- Ara R, Merry SR, Paul SP and Siddiqi NA. Effect of Fertilizer on the Yield of Patipata, Schumanniannthusdichotoma.Bangladesh Journal of Forest Science 2000;29(1):67-8
- Arnold JEM. Socio-Economic Benefits and Issues in Non-wood Forest Products Use. In Report of the International Expert Consultation on Non-wood forest products. Non-wood Forest Products 3,Rome: FAO;1995:89-123
- Bakht Z. Entrepreneurship in Bangladesh rural industries, Bangladesh Development Studies 1984;XII(1& 2): 25-58
- BanikRL. Economic Importance and Future of Rattan and Patipata in Bangladesh. In Roshetko M and Bose SK (eds), Propagation and Cultivation of Rattan and Patipata in Bangladesh. Proceeding of Training Courses held at the Bangladesh Forest Research Institute (BFRI), Chittagong Bangladesh;2001;25-8
- BBS(Bangladesh Bureau of Statistics),Bangladesh Population Census 2001 Preliminary data for Sylhet Division Ministry of Planning, Government Republic of Bangladesh, Dhaka, Bangladesh;2001
- BBS(Bangladesh Bureau of Statistics),Statistical Year Book of Bangladesh (Thana series). Ministry of Planning, Government Republic of Bangladesh, Dhaka; 2006
- Chowdhury D and Konwar BK. Morphology and karyotype study of Patidoi (Schumannianthusdichotoma (Roxb.) Gagnep. synonym ClinogynedichotomaSalisb.) , a traditional plant of Assam.Current Science 2006;91(5):648-51
- Chowdhury MSH. Uddin MS, HaqueF,Muhammed N and Koike M. Indigenous Management of Patipata(Schumannianthusdichotoma) plantation in the rural homesteads of Bangladesh. Journal of sub-tropical Agriculture Research and Development 2007;5(1);202-7
- FAO. Non-wood forest products for rural income and sustainable forestry 7. Reprinted in 1999. Rome;FAO;1995:1-2
- Fernandes W and MenonG. Tribal women and forest economy;New Delhi: Indian Social Institute;1987
- FMP. Forestry master plan, forest production, Dhaka;UNDP/FAO BGD 88/025;1992;147
- Gunatilake HM, Senaratime DMAH and AbeygunawardenaP.Role of Non-timber forest products in the economy of peripheral communities of Knuckles National Wilderness area of Sri Lanka,Economic Botany 1993;47(3);275-81
- Hecht SB, Anderson A and May P. The subsidy from nature;shifting cultivation, successional palm forests and rural development. Human Organization 1988;47(1);25-35
- Hooker JD, Flora of British India, vol.VI,Kent,UK;I.Reave and Co.;1892;257-8
- Islam ANMF,The role of Murta-Based Cottage Industry in Socio-Economic Development of Rural People; A Case Study from Sylhet District, Bangladesh, A Project Paper.

Department of Forestry; Shahjalal University of Science and Technology;Sylhet,Bangladesh;2005;47

- Liedhomam C and Mead DC.The structure and growth of micro-enterprises in southern and eastern Africa.
- GEMINI Working paper No.36, Bethesda, MA: Growth and Equity through micro enterprise investments and institutions (GEMINI);1993
- Merry SR, Ara R and Siddiqi NA. Raising Seedlings of Patipata Schumannianthusdichotoma). Bangladesh Journal of Forest Science 1997;26(1):74-5
- Merry SR. Propagation Technique of Patipata. In Roshetko JM and Bose SK (EDS), Propagation and Cultivation of Rattan and Patipath in Bangladesh. Proceeding of Training Course held at the Bangladesh Forest Research Institute (BFRI),Chittagong,Bangladesh;2001:22-4
- Mohiuddin M and Rashid MH. Survival and growth of vegetative grown pati-pata (Schumannianthusdichotoma): an exploratory study. Bangladesh Journal of Forest Science 1988;17 (1&2):20-5
- Nair CTS. Income and employment from non-wood forest products. In Durst PB and Bishop A(EDS), Proceeding of Regional Expert Consultation: Beyond Timber; Social Economic and Culture Dimensions of Non-wood Forest Products in Asia and the Pacific Rome: FAO/RAP;1995:87-95
- PrainD.Bengalplants,Vol.II Dehra Dun,India;Bishen Singh &Mahendra Pal Singh;1903;1048
- Rao AS and Verma DM. Materials towards a monocot flora of Asam-II (Zingiberaccae&Marantaceae), Bull.Bot,Sur,India 1972;14:114-43
- Rashid MH, Merry SR,Ara , Mohiuddin M and Alam MJ. How to Cultivate Rattan and Patipata (in Bengali), Bulletin 6, Minor Forest Products Series, Bangladesh Forest Research Institute. 1993;8-12
- Sharma P,Non-wood forest prodicts and integrated mountain development; Observations from Nepal, In Report of the Expert consultation on Non-wood Forest Products,Yogykarta,Indonesia, Non-wood Forest Products 3, Rome:FAO;1995
- Siddiqi NA,Ara R and Merry SR. Survival and intial growth of Schumannianthus dichotoma (Marantaceae) from four different propagating materials. Indian Forester 1998;124(8):619-24
- Warner AT. Marketing, Valuation and Pricing of NWFPS. In Durst PB and Bishop A(eds),Proceeding of Regional Expert Consultation : Beyond Timber; Social, Economic and Cultivation Dimensions of Non-wood Forest Products in Asia and Pacific Rome:FAO/RAP;1995-97-107

EXPERIMENT- 07

UP SCALING 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. The hill dwellers generally practiced shifting cultivation in the same area with a fallow period of 15–20 years in the past. But now a days the jhum cycle is reduced in 3-4 years, sometimes it is even 1 year too. The experiment was conducted in moderate hill slope of Soil Conservation and Watershed Management Center, SRDI, Bandarban. The main objective of the research is to evaluate the soil erosion hazard, productivity, economic return & fertility status practicing jhum under different treatment having the land abandoned for 3 years. Experimental site comprised of four plots- QSMAS model, modern Jhum with hedge row, traditional Jhum and control (secondary forest). It was observed that system productivity of QSMAS was much higher than that of Jhum with hedge row and traditional Jhum in the year of 2020 &21. Total soil loss and surface run off was much lower in QSMAS model than Jhum with hedge row and traditional Jhum. The lowest total soil loss was observed in control plot (secondary forest). As the research is in the primary stage, now it is not possible to compare with the previous research. But all the data like soil fertility status, soil loss, surface run off, crops' yield etc. are in conformity with the previous research.

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.

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

Objectives:

I. To evaluate the soil erosion hazard, productivity, economic return & fertility status practicing jhum under different treatment having the land abandoned for 3 years.
11. To create awareness about soil conservation and watershed management among hill dwellers.

Materials and Methods

The hill dwellers generally practiced shifting cultivation in the same area with a fallow period of 15–20 years in the past. With the rapid growth in population, the fallow period has been dramatically reduced to 3–4 years. Moreover, now a day, it is observed that jhum is being practiced even in every year in the same land. In this circumstance, a land having abandoned for 3 years was selected for this research at SCWMC Research Area.

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 will be evaluated for three cropping season from 2020. All the data like soil fertility status, soil loss, surface run off, crops' yield etc are being observed and recorded. Finally, all these will be compared and evaluated with the same of the year 2015, 2016 and 2017.

Results and Discussion

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 32). Physical analysis was done to determine the soil texture (Table 34). 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 32). Whereas, CEC was reduced in Jhum with hedge and Traditional Jhum system.

Table 32. 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	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

Table33. 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

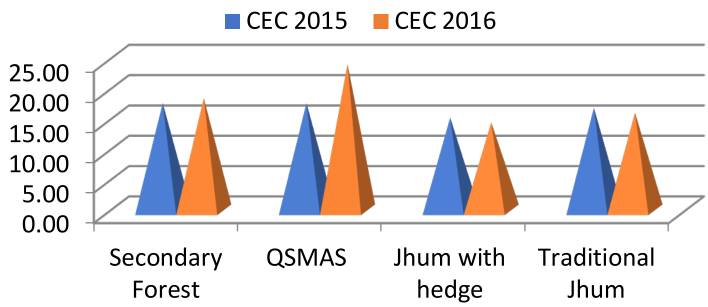


Figure : Comparative CEC data of experimental plots over time

Table 34. 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 35,36,37,38 &39).

Table 35. 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 36. 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 37. 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	-	5.00	7.00	10.00	50.00	50.00	30.00	
					Total =	**1699.00**	**2171.00**	**2912.00**	

Table 38. Yield (kg/100 sqm) and return (BDT) of crops harvested from experimental plots (2020).

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)	11.00	10.00	5.00	25.00	275.00	250.00	125.00	QSMAS model out yielded all the other plots
2	Maize (local)	1.80	3.00	3.00	60.00	108.00	180.00	180.00	
3	Sesame	0.70	0.80	0.90	80.00	56.00	64.00	72.00	
4	Millet	0.75	0.70	0.50	90.00	67.50	63.00	45.00	
5	Sweet gourd	2.50	3.50	3.50	30.00	75.00	105.00	105.00	
6	Chilly	0.50	0.40	0.30	140.00	70.00	56.00	42.00	
7	Marpha	2.00	1.50	1.50	40.00	80.00	60.00	60.00	
8	Yardlongbean	4.00	4.50	3.00	40.00	160.00	180.00	120.00	
9	Countrybean	-	-	5.00	60.00	-	-	300.00	
10	Cotton	0.80	1.00	1.50	200.00	240.00	200.00	300.00	
11	Ginger	2.00	3.00	3.50	80.00	160.00	240.00	280.00	
12	Turmeric	7.00	10.00	9.50	20.00	140.00	200.00	190.00	
13	Papaya							-	No fruiting was observed
14	Banana							-	
15	Pineapple							-	

					Total =	**1431.50**	**1578.00**	**1822.00**	

Table 39. Yield (kg/100 sqm) and return (BDT) of crops harvested from experimental plots (2021).

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)	12.00	10.50	6.00	26.00	312.00	273.00	156.00	QSMAS model out yielded all the other plots
2	Maize (local)	2.00	1.80	3.00	65.00	130.00	117.00	195.00	
3	Sesame	0.60	0.50	0.80	80.00	48.00	40.00	64.00	
4	Millet	0.60	0.75	0.80	95.00	57.00	71.25	76.00	
5	Sweet gourd	2.80	3.60	3.80	35	98.00	126.00	133.00	
6	Chilly	0.30	0.40	0.50	120.00	36.00	48.00	60.00	
7	Marpha	2.20	2.00	2.50	45.00	99.00	90.00	112.50	
8	Yardlongbean	3.00	3.20	4.00	45.00	135.00	144.00	180.00	
9	Countrybean			5.00	50.00	-	-	250.00	
10	Cotton	0.60	0.80	0.70	250.00	150.00	200.00	175.00	
11	Ginger	2.00	2.50	2.50	85.00	170.00	212.50	212.50	
12	Turmeric	6.00	8.50	8.00	20	120.00	170.00	160.00	
13	Papaya							-	No fruiting was observed
14	Banana							-	
15	Pineapple							-	
					Total =	**1355.00**	**1491.75**	**1774.00**	

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. 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 (2015-2017) 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.

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 40: 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**

Table 41: Total soil loss from experimental plots (t ha^{-1} y^{-1}) in 2020 & 2021.

Particulars		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total (t $ha^{-1}y^{-1}$)
Control	**2020-21**	**-**	**-**	**-**	**0.48**	**0.97**	**1.45**	**2.09**	**2.66**	**2.52**	**2.98**	**-**	**-**	**10.33**
	2021-22	**-**	**-**	**-**	**-**	**0.45**	**2.10**	**1.35**	**1.95**	**1.39**	**0.90**	**-**	**-**	**8.14**
QASMAS	**2020-21**	**-**	**-**	**-**	**0.76**	**1.45**	**2.66**	**3.38**	**3.52**	**3.21**	**3.78**	**-**	**-**	**18.76**
	2021-22	**-**	**-**	**-**		**0.57**	**3.31**	**3.25**	**4.83**	**2.80**	**1.42**	**-**	**-**	**16.18**
Jhum with hedge row	**2020-21**	**-**	**-**	**-**	**0.89**	**1.88**	**3.44**	**3.98**	**4.41**	**4.07**	**4.55**	**-**	**-**	**23.22**
	2021-22	**-**	**-**	**-**	**-**	**0.79**	**4.16**	**3.92**	**5.59**	**3.16**	**2.52**	**-**	**-**	**20.14**
Traditional Jhum	**2020-21**	**-**	**-**	**-**	**1.63**	**3.57**	**5.83**	**6.34**	**7.16**	**6.57**	**7.35**	**-**	**-**	**38.45**
	2021-22	**-**	**-**	**-**	**-**	**3.12**	**6.82**	**7.50**	**7.90**	**5.45**	**4.86**	**-**	**-**	**35.65**
Rainfall (mm)	**2021-22**					**108**	**545**	**531**	**585**	**376**	**203**	**-**	**-**	**2348**

Runoff and sediment load

The total runoff per hectare during 2015, 2016 , 2017, 2020 & 2021 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 42 & 43 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).

Table -42. 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	-

Table- 43. Total surface run off (%) from experimental plots in 2020 & 21

Particulars		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Control	**2020-21**	-	-	-	**5.87**	**24.54**	**28.62**	**35.71**	**38.39**	**32.48**	**41.54**	-	-
	2021-22	-	-	-	-	**5.20**	**35.92**	**34.60**	**42.70**	**22.70**	**18.20**	-	-
QASMAS	**2020-21**	-	-	-	**7.45**	**31.62**	**34.44**	**41.44**	**48.88**	**39.53**	**46.67**	-	-
	2021-22	-	-	-	-	**7.12**	**39.54**	**37.65**	**50.85**	**25.64**	**20.52**	-	-
Jhum with hedge row	**2020-21**	-	-	-	**6.39**	**34.72**	**37.44**	**39.67**	**52.48**	**46.33**	**55.23**	-	-
	2021-22	-	-	-	-	**6.54**	**41.44**	**40.39**	**55.36**	**30.87**	**23.49**	-	-
Traditional Jhum	**2020-21**	-	-	-	**8.85**	**38.15**	**39.24**	**43.36**	**54.81**	**51.46**	**57.29**	-	-
	2021-22	-	-	-	-	**8.30**	**46.91**	**45.72**	**60.85**	**32.94**	**26.85**	-	-

CONCLUSION

The research is going on from two years past. As the research is in the primary stage, now it is not possible to compare with the previous research. But all the data like soil fertility status, soil loss, surface run off, crops' yield etc. are in conformity with the previous research. 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 in 2020 & 2021. The lowest total soil loss was observed in control plot (secondary forest).

REFERENCES

- Hossin, M. A., Hossain, M.F., Islam, M. M., Introduction of Quesungual Slash and Mulch Agro-forestry System(QSMAS) for Enhancing Crop yields and Soil Quality in Chittagong Hill Tracts.www.itspoa.com/journal/as. Page-28-40, volume-1, 2017
- Asian Development Bank (ADB) (2001). Chittagong Hill Tracts region development plan. Final report, ADB TA no. 3328, Rangamati, Bangladesh.
- Bangladesh - Household Income and Expenditure Survey.2005. (BGD) HIES v01 M. Bangladesh Bureau of Statistics, Sept 29, 2011.
- Banglapedia(2009).Population-Banglapedia. ttp://en.banglapedia.org/index.php?title=Population
- Borggaard, Ole K., Gafur, A. and Peterson, L. (2003) Sustainability appraisal of shifting cultivation in the Chittagong Hill Tracts of Bangladesh. Ambio. 32 (2), 118-123.https://doi.org/10.1579/0044-7447-32.2.118
- Brammer H (1986) Reconnaissance soil and land use survey: Chittagong Hill Tracts (1964–1965). Soil Resources Development Institute, Bangladesh
- Chakma, A. S. and Nahar, B. S. (2012). Jhum cultivation influences the degradation of hilly environment. Journal of Environmental Science & Natural Resources, 5(2), 339-344. www.banglajol.info/index.php/JESNR/article/view/14840
- Dasgupta, S. and Ahmed, F. U. (1998). Natural resource management by tribal community: a case study of Bangladesh. pp. 52-55.
- de Rouw, A. 1995. The fallow period as a weed-break in shifting cultivation (tropical wet forests). Agric. Ecosyst. Environ. 54: 31–43. https://doi.org/10.1016/0167-8809 (95)00590-O
- Dewan (2008). Conducted a survey work to analyze the socio-economic status of 70 jhum cultivators. This was quoted by Chakma,AS and Nahar,BS 2012 in their publication but I failed to loacte original paper, so please drop this statement along with reference.
- Dingkuhn, M., Johnson, D. E., Sow, A. and Audebert, A. Y. (1999). Relationships between upland rice canopy characteristics and weed competitiveness. Field Crops Res. 61, 79-95.
- Gafur, A., Borggaard, O.K., Jensen, J.R., Peterson, L. 2003. Run off and loses of soil and nutrients from watershed under shifting cultivation (Jhum) in the Chittagong Hill Tracts of Bangladesh. J. Hydrol., 279:293-309. https://doi.org/10.1016/S0022-1694 (03)00263-4
- Gafur A (2001) Effects of shifting cultivation on soil properties, erosion, nutrient depletion, and hydrological responses in small watershed of the Chittagong Hill Tracts of Bangladesh. PhD Dissertation, The Royal Veterinary and Agricultural University, Copenhagen Household Income and Expenditure Survey Analysis Report. 2005. Bangladesh Bureau of Statistics, Dhaka, Bangladesh.
- Gary, W. C. and Carmen, V.: Impacts of land use changes on runoff generation in the east branch of the brandywine creek watershed using a GIS-based hydrologic model, Middle 15 States Geographer, 40, 142–149, 2007.
- Hartantoa, H., Prabhub, R., Widayat, A., and Asdakd, C.: Factors affecting runoff and soil 30 erosion: plot-level soil loss monitoring for assessing sustainability of forest management, Forest Ecol. Manag., 180, 361–374, 2003.
- Jamaluddin, M., Hassan, M. K. & Miah, M. M. 2010. Identifying livelihood patterns of ethnic minorities and their coping strategies different vulnerabilities situation in Chittagong

hill tracts region, Bangladesh. Final Report. National Food Policy Capacity Strengthening Programme Food Planning and Monitoring Unit (FPMU), Ministry of Food and Disaster Management. Government of Bangladesh. p. 53.

- Lakaria, B. L., Mandal, D., Biswas, H. 2010. Permissible soil erosion limits under different landscapes of Chhattisgarh. Indian Journal of Soil Conservation 2010 Vol. 38 No. 3 pp. 148-154
- Miah MAM, Islam SMF (2007) Shifting cultivation and its alternatives in Bangladesh: productivity, risk and discount rates. SANDEE working paper no. 24-07, Nepal
- Pathak, P., Wani, S. P., Singh, P., and Sudi, R.: Sediment flow behavior from small agricultural watersheds, Agr. Water Manage., 67, 105–117, 2004.581
- Rasul, G. and Thapa, G. B. (2002). State plicies, praxies and land use in chittagong hill tracts of Bangladesh, Regional and Rural Development planning, School of Environment, Resource and Development, Asian Institute of Technology, Thailand, Bangkok.
- Riessen AV (2000) Chittagong Hill Tracts region development plan. Interim report no. 7. Sociology and Indigenous People, Asian Development Bank, Bangladesh
- Shoaib, J.U., Mostafa, G., Rahman, M. 1998. A Case Study on Soil Erosion Hazard in Hilly Regions of Bangladesh, Annual Report, SRDI. Dhaka.
- Tripura, P. and Harun, A. (2003). Parbotto Chattagrame Jum chash.
- Ullah, M. M., Malek, M. A., Karim, M. M. & Ali, M. S. (2012). A report on jhum research in CHT. Hill Agriculture Research Station, Bangladesh Agricultural Research Institute, Khagrachhari Hill District. p. 31.
- Van, K. K. (2003). On-farm agronomic diagnosis of transitional upland rice swidden cropping systems in northern Thailand. Louvain: KUL. p. 220.

EXPT. No. 08

STUDYING PERFORMANCE OF WATER MELON IN RAINY SEASON AT HILL SLOPES USING SOIL CONSERVATION TECHNIQUE.

Abstract

A study on performance of Watermelon in rainy season at hill slope using Soil Conservation Technique has been taken by Soil Conservation and Watershed Management Centre, Bandarban on its own research area. Its main objective is to find out the sustainability and challenges of cultivation of watermelon on sloping lands during rainy season. Three types of sloping land like gentle, moderate and steep sloping has been selected for this study. There were three plots on three sloping lands having an equal area. Soil conservation technique like pineapple hedge and Vetiver hedge were introduced following contour.. Bamboo made colored pegs were inserted into the soil to estimate the soil erosion hazard. Local bamboos made platforms (Macha) were used for cultivation of watermelon during rainy season. Maximum soil loss 20.734 ton/ha.y^{-1} was recorded at controlled plot on steep slope where as minimum soil loss was 8.834 ton/ha.y^{-1} at pineapple hedge plot on gentle slope. Maximum yield was12.844 ton/hac.y^{-1} at pineapple hedge plot on gentle slope and minimum yield was 8.505 ton/hac.y^{-1} at controlled plot on steep slope .

Introduction

Watermelon (*Citrullus lanatus*) belongs to the family Cucurbitaceae. It is one of the most widely cultivated crops in the world with global production reaching about 89.9 million ton per year. Its centre of origin has been traced to both Kalahari and Sahara desert in Africa and these areas have been regarded as point of diversification to other parts of the world. The crop has wide distribution as a garden crop while as a commercial vegetable production; its cultivation is confined to drier Savanna region of the Nigeria. It is horticultural crop that provide high return and has relatively low water requirement compared to other crops. It is traditional food plant in Africa with potential to improve nutrition, boost food security, foster rural development and support sustainable land cares. Smallholder farmer in different semi-arid zones of the world grow watermelon mostly under rainfed conditions and to lesser suplimental furrow irrigation. Now a day the demand of watermelon is increasingly growing up day by day. *Citrullus lanatus* is an important Cucurbitaceous Vegetable/Fruit in our neighboring country India. It is an excellent desert fruit and its juice contains 92% water along with proteins, minerals and carbohydrates. Now it is going to be extended day by day. In India, Watermelons are mainly cultivated in Maharashtra, Karnataka, Tamil Nadu, Panjab, Rajasthan, Madhya Pradesh and Uttar Pradesh.

The growth and development of watermelon describes the sequential order of the different stages of growth attained by this crop. The growth phase of watermelon includes the emergence stage, vegetative stage, flowering stage, yield formation stage and the ripening stage. However, crop growth and development depends largely on climatic factors such as precipitatin, relative humidity, solar radiation, evaporation etc. Each of these climatic factors affects the growth of crops, most especially in the tropics. For instance, the presence or absence of precipitation will have either positive or negative impact on the crop growth and productivity. Climate is also responsible for seasonal variation in the tropic.

A well drained soil of loamy type is preferred for Watermelon. It is important that soil should be fertile and rich in organic matter. The most suitable P^H range is between 6.0 and 7.0. It is noted that soil should not be water logged in the rainy season. Watermelon is warm season crop and do not withstand even light frost and strong wind. Seed do not germinate below 11^0 C , optimum germination occurs at 18^0 C and germination increases with the rise of temperature till 30^0 C. Watermelon grows best at temperature 18^0 C - 24^0 C. It prefers tropical climate with high temperature during fruit development with day temperature of 35^0 C-40^0 C. But excess chillness occures hamper. Cool nights and warm days give better quality fruits in watermelon.
There are many varieties of watermelon like Seminis Apoorva Watermelon, Mayco Super Sakkar Watermelon,, Suger Pack Watermelon, Aishwariya Watermelon, Anmol Yellow Watermelon, Arun Watermelon, Dragon King Watermelon, Black Magic Watermelon, NS 292 Watermelon, Jaguar F1 Watermelon etc. The crop duration ranges from 55 days to 120 days depending on the varieties.

Chittagong Hill Tracts Comprising the three districts of Bandarban, Rangamati and Khagrachari has an area of 13,181 Sq. Km. endowed with natural beauty and high economic potentiality. The tribal along with the Bengali people are living there for long maintaining their district socio-cultural identities and harmony. The area is hilly with mild to very steep (15% to over 70%) often breaking or ending cliffs. More than 90% of the area is covered by hills with only 1'29'000 ha. of cropped land. About 87% of the land is covered with forest mostly owned by the Government (Dasgupta and Ahmed. 1998). According to Banglapedia (2009) about 20,000 hectares of land are being brought under jhum cultivation each year.

Jhum cultivation, sloppiness, heavy rainfall and improper management of soil enhanced nutrients 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 a small watershed under shifting cultivation in CHT. Borggaard et al. (2003) carried out a study to analyze the sustainability 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 Tract region is of great importance for various crops which are different from the plains. But unfortunately few eco-friendly sustainable practices for CHT has so for been developed.

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). Erosion hazard caused by water in the rainy season is one of the mostly responsible for land degradation in Bangladesh. In the hilly region of Bangladesh received huge amount of rainfall in this time. This amount of excess rainfall drains out along with eroded soil materials through numerous channels, canals and rivers of the hilly regions without natural or artificial obstacle. Thus following heavy downpour of the rainy season, the area suffers from severe draught and water scarcity in the dry season. Vegetation and land use play an important role controlling the intesity and frequency of overland flow and surface erosion (Mitchel, 1990; Gafur el at 2001b). Cultivation of watermelon in the rainy season using hedge of different species established across the slope could be introduced to mitigate the demand of food, to improve the socio-economic status of the hill dwellers and to minimize the land degradation.

In these circumstances, a very little scientific effort has been taken in hand to study the performance in cultivation of watermelon in the rainy season using soil conservation technique at the Research Area of Soil Conservation and Watershed Management Centre, SRDI, Bandarban. If the challenges along with other difficulties can be overcome, it would be a mile stone of eco-friendly sustainable agriculture of this hilly region.

Objective:

a. To find out the suitability of water melon without irrigation (rainy season) at hill slopes.

b. To compare soil loss, runoff and nutrient mining under different hedge species & different slopes.

c. To find out a significant source of income.

Materials and Methods

The research was conducted at the Research Area of Soil Conservation and Watershed Management Centre (SCWMC), SRDI under Bandarban Sadar upazila, Bandarban. Three types of slopping land like Gentle, Moderate and Steep Slopes were selected for this research to have comparative data. There are 3 plots in every individual slopping land having an area of 100 m^2 (5m x 20 m) for each plot. Total area of each slopping land was 300 m^2. The experimental plots were selected in such a way that the area individually can be treated as a micro watershed. Prior to selection of the plots, the area was cleaned. Jungles were removed. Slope percentage of the land was measured by Abney's level. To conduct the study, 3 plots of 100 m^2 (5m x 20 m) in each slopping land were selected for applying different soil conservation technique. Among the three plots- one was controlled and remaining others two were pineapple hedge and vetiver hedge. Slope gradient of the selected three types of sloping lands were: 12%, 26% and 36% respectively. Each plot is separated by plot boundary in such a way that runoff from one plot can not enter to another plot. On 25th of April-2021, Pineapple and Vetiver hedge in single row were established following contour at 5.0 m horizontal interval in each plot. There are four lines of hedge row in each plot. A number of bamboo made pegs painted by different colors were inserted in to the soil plot to determine the soil loss.

On 5th May-2021, seeds of watermelon placed in soil filled poly packet for germination and to have seedlings. Digging up pits for transplantation of watermelon seedlings were started from 7th of May-2021. Prior to Digging up pits, composite topsoil samples were collected from each plot has been collected for physical, chemical and mineralogical analysis to compare the soil nutrients status. Pit size was 15″x15″ having 1′-0″ depth. During preparation of pits, at least one kg of dried cow dung along with 100 gr. TSP and 50 gr. MOP (Murat of Potash) were applied in each pit. Hill method or raised bed was practiced to avoid excess amount of water which causes root rot diseases. On 29th of May-2021, the seedlings of watermelon (having the seedlings age at 21 days) were transplanted from poly packs to pits. Two seedlings were planted in each pit/bed. In the rainy season, weeding is very necessary as this season promotes weed growth and the incidence of pest and diseases. When 25 to30 days has passed after plantation of the seedling, 2nd dose of fertilizer @50 gr. urea, 100 gr. TSP and 50 gr. MOP was applied in each pit.

Intercultural operation was done when necessary. Mulching practice around the plant was applied to prevent the rainwater from splashing soil onto the plants, reducing the chance of bacterial or fungal infection that might come from the soil. Bamboo made platform (Mancha) was placed for climbing up the plants and to protect melon bursting for excess water. During the fruiting time of the watermelon 3rd dose of fertilizer @ TSP 125 gr. and MOP 50 gr. in each pit was applied.

To estimate the soil loss on different slopping land under different treatment peg method was followed. In this practice, each plot was divided into three parts namely- Upper part, middle part and lower part. At the beginning of the monsoon, 9 nos. bamboo made pegs having marked by different color of paint were inserted in the soil for each part. Soil loss near each peg was measured by using leveling instrument and recorded. Average of nine pegs was calculated for each part. Insecticides, Pesticides and fungicides were applied depending upon the symptom of the plants at 3rd week, 5th week, 7th week, 9th week and 11th week after planting. When the fruits were in growing stage, those were supported to hang from the platform by using cotton made net bags.

Results and discussion

. Maximum soil loss 20.734 ton/ha.y^{-1} was recorded at controlled plot on steep slope where as minimum soil loss was 8.834 ton/ha.y^{-1} at pineapple hedge plot on gentle slope. On field yield data was recorded. Only the ripen watermelon those were collected from field was included in yield data. Maximum number of fruits (76 nos.) with maximum weight (Average 1.69 Kg) was recorded on pineapple hedge plot on gentle slope. On the other hand, minimum number of fruits (63 nos.) with average minimum weight (1.35 kg) was recorded at controlled plot on steep slope. Maximum yield was 128.44 kg/plot *i.e.*12.844 ton/hac.y^{-1} at pineapple hedge plot on gentle slope and minimum yield was 85.05 kg/plot *i.e.* 8.505 ton/hac.y^{-1} at controlled plot on steep slope for the year 2021-22.

Table-44: Yield of the Watermelon in different treatments in financial year 2021-22

Sl. No.	Slope Class	Treatments	Number of fruits (Nos.)	Av. weight per fruit (Kg)	Yield per plot (Kg.)	Yield per hectare (Ton)
1	Gentle	Pineapple hedge	76	1.69	128.44	12.844
		Vetiver Hedge	75	1.65	123.75	12.375
		Controlled	73	1.61	117.53	11.753
2	Moderate	Pineapple hedge	74	1.64	121.36	12.136
		Vetiver Hedge	72	1.62	116.64	11.664
		Controlled	70	1.56	109.20	10.920
3	Steep	Pineapple hedge	74	1.50	111.00	11.100
		Vetiver Hedge	73	1.45	105.85	10.585

		Controlled	63	1.35	85.05	8.505

Table-45: Soil Loss under the cultivation of Watermelon in different treatments & different slope for the year 2021-22.

Year.	Slope Class	Treatments	Average soil loss in each row (mm)			Average Soil Loss of all row (mm.)	**Total soil loss (ton/ hac)**
			Upper Row	Middle Row	Lower Row		
2021-22	Gentle	Pineapple	0.585	0.623	0.685	0.631	8.834
		Vetiber	0.600	0.684	0.720	0.668	9.352
		Controlled	0.690	0.75	0.810	0.750	10.500
	Moderate	Pineapple	0.695	0.790	0.840	0.775	10.850
		Vetiber	0.780	0.864	0.914	0.853	11.942
		Controlled	1.000	1.100	1.20	1.100	15.400
	Steep	Pineapple	1.140	1.200	1.260	1.200	16.800
		Vetiber Hedge	1.190	1.243	1.32	1.251	17.514
		Controlled	1.410	1.470	1.563	1.481	20.734

Conclusion

The research is going on from one-year past as the research is in the primary stage. Hedge always plays a vital role on plant growth, crops productivity, no of fruit & weight as well as minimizing of soil erosion. Height yields and lowest soil loss were gained from the managed plot by pineapple hedge and gentle slope. Lowest yields and Height soil loss were gained from the control plot and steep slope. soil conservation technique is must for any agricultural practice on the slopping land. Fungal, bacterial and virus diseases are more during rainy season which affects badly on growing watermelon and its yields and quality. Attract of white flies hampers the production of watermelon during rainy season.

Refferences

1. Schipper RR (2000), African Indigenous Vegetables, An Overview of the Cultivated Species, N.R/ACO, EU pg no. 56-60, Chatthan, UK.
2. Ufoegbune GC, Fadip OA, Belloo NJ, Eruola AO, Makinde AA and Amori AA, Department of Water Resources Management and Agrometeorology, Federal University of Agriculture, Abeokuta, Nigeria. Journal of Climatology Forecasting: Development of Watermelon in Response to Variation of Rainfall.
3. FAO (2003) World Agriculture towards 2015/2030. Summary Report, Rome.
4. Jarret B, R Bill, W Tom and A Garry (1996), Cucurbits Germplasm Report, Watermelon National Germplasm System, Agricultural Service, page no. 29-66, U.S.D.A.
5. Anons (2006), Nasarawa State Agricultural Development Programme, Annual Crop Area

and Yield Survey (CAYS), Lafia, Nasarawa State.

6. Dane F, Lui J, Zhang C (2007) Phylogeography of the bitter apple, Citrulus Colocythis, Genet. Resour. Crop Evol. 54, 327-336.

7. Toth Z, Gyulai G, Szabo Z, Horvath L,Heszky L (2007), Watermelon (Citrulus lanatus) Production in Hungary from the Middle ages (13^{th} Century). Hungarian Agric. Res. 4, pg. no. 14-19.

8. Wang Y, Xie ZK, Lim F, Zhang Z (2004). The effect of Supplemental Irrigation on Watermelon Citrulus lanatus) production in gravel and sand mulched fields in the loess Plateau of north China Agric. Water Manage. 69; pg. no. 29-41.

EXPT. No. 9:

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. 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. 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 have 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 has 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 Discussion

Soil loss by peg method was studied for 2016-2017 to 2020-2021. 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 soil loss of all rows (in mm)** were 0.715 mm, 0.63 mm, 0.56 mm ,0.503mm & 0.45mm for the year of 2016-17, 2017-18,2018-19, 2019-20 & 2020-21 respectively. The total soil loss soil loss was calculated assuming 1mm depth soil loss is equal to13.70 ton/ha. Finally, Total Soil loss was recorded 9.796 ton/ha, 8.631ton/ha, 7.672 ton/ha, 6.891ton/ha ,6.16,& 5.89 ton/ha for the year of 2016-17, 2017-18,2018-

19, 2019-20 , 2020-21 & 2021-22 respectively. Total soil loss data (ton/ha per year) from 2016-17 to 2020-21 has been shown in Table-46. Average Economical return shown in Table-47.

Table 46: Soil Loss under pineapple-based Jackfruit orchard on steep slope:2016-2022

<table>
<tr><th rowspan="3">Location of peg</th><th colspan="6">Average soil loss in mm</th><th colspan="3">Average soil loss of all rows (in mm)</th><th colspan="5">Total soil loss (ton/ hac)</th><th></th></tr>
<tr><th rowspan="2">2016-17</th><th rowspan="2">2017-18</th><th rowspan="2">2018-19</th><th rowspan="2">2019-20</th><th rowspan="2">2020-21</th><th rowspan="2">2021-22</th><th>2016-17</th><th>2018-19</th><th>2020-21</th><th rowspan="2">2016-17</th><th rowspan="2">2017-18</th><th rowspan="2">2018-19</th><th rowspan="2">2019-20</th><th rowspan="2">2020-21</th><th rowspan="2">2021-22</th></tr>
<tr><th>2017-18</th><th>2019-20</th><th>2021-22</th></tr>
<tr><td>Upper row</td><td>0.655</td><td>0.60</td><td>0.51</td><td>0.45</td><td>0.39</td><td>0.36</td><td rowspan="2">0.715</td><td rowspan="2">0.56</td><td rowspan="2">0.45</td><td rowspan="3">9.796</td><td rowspan="3">8.63</td><td rowspan="3">7.67</td><td rowspan="3">6.89</td><td rowspan="3">6.16</td><td rowspan="3">5.89</td></tr>
<tr><td>Middle row</td><td>0.710</td><td>0.62</td><td>0.54</td><td>0.50</td><td>0.45</td><td>0.46</td></tr>
<tr><td>Bottom row</td><td>0.780</td><td>0.67</td><td>0.62</td><td>0.56</td><td>0.51</td><td>0.48</td><td>0.63</td><td>0.50</td><td>0.43</td></tr>
</table>

Table-47: Yield and return from pineapple-based Jackfruit orchard on steep slope:

Financial year	**Yield (main and associated crop)**		**Economical return (in BDT)**			
	Pineapple	Jack Fruit	Pineapple	Average **(in BDT)**	Jack Fruit	Average**(in BDT)**
2016-2017	Initial stage	Initial stage	Initial stage		Initial stage	
2017-2018	Flowering stage	Growing stage	1000/- (Expected)		Growing stage	
2018-2019	Fruiting stage	Primary fruiting stage	Tk. 9,000/- (500 Nos. @ Tk. 18/- each)	5,380/-	Tk. 600/- (15 Nos. @ Tk. 40/- each)	2,093/-
2019-2020	Matured Stage	Fruiting Stage (Partly)	Tk. 7,200/- (400 Nos. @ Tk. 18/- each)		Tk. 2,280/- (57 Nos. @ Tk. 40/- each)	
2020-2021	Matured Stage	Fruiting Stage	Tk. 4,320/- (288 Nos. @ Tk. 15/- each)		Tk. 3,400/- (85 Nos. @ Tk. 40/- each)	
2021-2022	Matured Stage	Fruiting Stage	Tk. 3,150/- (210 Nos. @ Tk. 15/- each)	4,934/-	Tk.5,000 /- (125 Nos. @ Tk. 40/- each)	2,820/-

Conclusions

- ✓ Jack fruit, the main horticultural crop takes more time for its optimal stage than pineapple, the secondary crop.
- ✓ Farmers can be financially benefited by using short term secondary crops with long term horticultural crops and erosion hazard is comparatively lessened than pure horticulture as the secondary crops interrupt the surface runoff when planted following contour line.

References

1. DANIDA.2000.Interim Planning Mission,Watershed Development Project, Chittagong Hill Tracts (CHT), Bangladesh (draft).
2. Gafur,A.,J.R. Jensen,O.K. Borggaard and L. Petersen.2001b.Runoff and losses of soil and nutrients from small watersheds under shifting cultivation (Jhum) in the Chittagong Hill Tracts of Bangladesh.J.Hydrol.(Not yet published).
3. Khisa; S.Kanti,Shoaib,M.Jalaluddinand K.N.Ahmed.2006.Selected natural resources conservation approaches and technologies in Chittagong Hill Tracts Bangladesh. Bangladesh Conservation Approaches and Technology(BANCAT)
4. Lal,R. 1983. No-tillage farming. Soil and water conservation and management in the humid and sub-humid tropics-iiTA Tech.Monograph2.64.
5. Mitchell,D.J.1990.The use of vegetation and land use parameters in modeling catchment sedimentyields. In:J.B.Thornes(Ed.).Vegetation and Erosion, Processes and Environments. Wiley, Chichester,pp.289-314.
6. Soil Conservation and Watershed Management Center (SCWMC),2004. Annual Report, Soil Conservation and Watershed Management Centre,SRDI,Bandarban,Pp.7-8.
7. Shoaib.2000.Development of sustainable cultivation practices for minimizing soil erosion on hill slope. Soil Resource Development Institute (SRDI).
8. Soil Resources Development Institute(SRDI).1986. Reconnaissance Soil and Land Use Survey: Chittagong Hill Tracts.Forestal,Canada 1964-1965.Soil Resources Development Institute, Dhaka. 206 p.
9. Khybri,M.L.1983.Soil erosion problems and soil conservation in India. Watershed management. Bhatt.P.N.(ed.).pp.6-13.

EXPT. No. 10:

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

Abstract

The study involving White Gourd conducted at the Soil Conservation and Watershed Management Centre (SCWMC), Soil Resource Development Institute (SRDI), Bandarban to investigate the 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: *Vatiber* 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 gradient. 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 *Gliricidiasepium* 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 *Leucaenaleucocephala, Gliricidiasepium, Vatibertysmani, Fleminigiaspp*, and *Desmodiumrensonii* etc. and two grass species *Vetivierazizanoides* 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

i. To compare soil loss, runoff and nutrient mining in cultivating White Gourd under different hedge species.

ii. 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; *Vatiber* and *Pineapple*. Hedge species were planted in 2013 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. Pits were dug 1.80 m c/c in rows maintaining contour. Total number of pits in each plot was 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 seedlings 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. White Gourd was selected as a test crop. Different agronomic practices were done when it was necessary.

Results and discussion

Soil loss under different hedge species in gentle slope at White Gourd growing plot during 2020-21 sessions is presented in table 45. Soil loss under White 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 (16.04,13.14, & 16.98 t/ha in the year of 2019-20 ,2020-21& 2021-22 respectively.) where no hedge species were used, followed by *Vatiber* hedge species used plot (9.06, 8.13 & 9.26 t/ha in the year of 2019-20 ,2020-21 & 2021-22 respectively) and pineapple hedge species used plot (5.46, 5.16 & 6.45 t/ha in the year of 2019-2020 ,20-21 & 21-22 respectively).

Table 48: Soil loss under the cultivation of different hedge species in 2019-20 to 2021-22 (t/ha/y).

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Vativer	2019-20	-	-	-	-	0.85	1.94	2.57	1.45	1.63	0.62	-	-	9.06
	2020-21	-	-	-	-	0.65	0.84	0.95	2.35	1.32	2.02	-	-	8.13
	2021-22	-	-	-	-	0.52	2.30	1.94	2.10	1.25	1.15	-	-	9.26
Pineapple	2019-20	-	-	-	-	0.61	1.19	1.80	0.69	0.41	0.96	-	-	5.46
	2020-21	-	-	-	-	0.42	0.56	0.79	1.23	1.05	1.11	-	-	5.16
	2021-22	-	-	-	-	0.31	1.26	1.94	1.34	1.24	1.41	-	-	6.45
Control	2019-20	-	-	-	-	1.83	3.36	3.81	1.73	3.68	1.63	-	-	16.04
	2020-21	-	-	-	-	1.43	1.72	1.95	3.47	2.15	2.42	-	-	13.14
	2021-22	-	-	-	-	1.11	4.23	2.74	3.60	3.98	1.32	-	-	16.98
Rainfall	2019-20	-	57	9	72	234	244	1024	398	411	141	43	9	2642
	2020-21	40	-	-	133	217	297	380	410	361	405	23	-	2260
	2021-22	-	-	-	-	108	545	531	585	376	203	-	-	2348

Table 49: Run off under the cultivation of different hedge species in 2019-20 & 2020-21.

Particulars	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Vativer	2019-20	-	-	-	-	7.07	41.14	28.41	19.21	25.30	22.41	-	-
	2020-21	-	-	-	-	25.19	27.48	31.08	34.67	35.52	36.50	-	-
	2021-22	-	-	-	-	8.20	52.30	40.32	42.40	38.50	25.40	-	-
Pineapple	2019-20	-	-	-	-	6.39	36.69	26.32	18.17	17.19	16.85	-	-
	2020-21	-	-	-	-	22.30	25.56	36.79	38.25	39.42	40.89	-	-
	2021-22	-	-	-	-	24.70	38.20	39.50	40.60	41.90	42.52	-	-
Control	2019-20	-	-	-	-	9.77	44.79	33.64	22.34	31.29	29.80	-	-

	2020-21	-	-	-	-	28.65	30.58	40.25	42.79	46.82	50.60	-	-
	2021-22	-	-	-	-	10.20	50.60	42.60	45.40	35.62	52.70	-	-

Conclusions

1. Use of different hedge has created positive effect on the morphological and reproductive characteristics as well as at the yield of White 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.

References

I. Annual Report, 2010. Soil Conservation and Watershed Management Centre, SRDI, Bandarban. pp.

II. Khisa, S.K. 2001. Contour hedgerow inter-cropping agroforestry technology for degraded hill side farms in Chittagong hill tracts. Proc. National Workshop on agroforestry research, Gazipur, September 16-17. pp. 179-184.

III. Khisa, S.K.; M.K. Alam and N.A. Siddiqi. 1999. Broom grass (Thyanolaena maxima) Hedgerow : A Bioengineering Device for Erosion and Slope Stabilization. Proc. First Asia-Pacific Conference on.

IV. Ground and Water Bioengineering for Erosion and Slope stabilization, April 19-21, 199, Manila, The Philippines International Erosion Control Association. pp. 172-177.

V. Khisha, S.K., J.U.M. Shoaib and N.A. Khan. 2002. The experience of promoting slope agricultural land technology for hillside farms in the Chittagong Hill Tracts. In : “Farming Practices and Sustainable Development in the Chittagong Hill Tract” (N.A. Khan et al., Eds.). CHTDB and VFFP, Intercooperation , pp. 114-115.

VI. Khisa, S. Kanti, J.U.M. Shoaib, and K.N. Ahmed. 2006. Selected natural resources conservation approaches and technologies in Chittagong Hill Tracts Bangladesh. Bangladesh Conservation Approaches and Technology (BANCAT).

VII. Khybri, M.L. 1983. Soil erosion problems and soil conservation in India. Watershed management. Bhatt. P.N. (ed.). pp. 6-13.

VIII. Lal,R. 1993. No-tillage farming. Soil and water conservation and management in the humid and sub-humid tropics. iiTA Tech. Monograph2:64.

IX. Singh, G.S., G. Shastri and S.P. Bhardwaj. 1990. Watershed response to conservation measures under different agro-climatic regions of India. Indian J. Soil Conservation. 18 (3): 16-22.

X. Shoaib. 2000. Development of sustainable cultivation practices for minimizing soil erosion on hill slope. Soil Resource Development Institute (SRDI).

XI. Uddin, M.S. and Z.A. Firoz. 2001. Yield of lemon and guava as influenced by hill slope and hedgerow plants. Proc. National workshop on agroforestry research, Gazipur, September 16-17. pp. 196-198.

TRANSFERABLE TECHNOLOGY / ADAPTIVE RESEARCH

PROGRAME-1

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.

Justification:

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

Justification:

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

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.

Justification:

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.

PROGRAME-4

TITLE: GULLY CONTROL BY GABION CHECK DAM & VEGETATIVE MEASURES FOR THE RECLAMATION OF DEGRADED LANDS IN THE HILLS OF CHT.

Objectives

1) To check widening & head extension of gully.
2) To reduce runoff and subsequently retain washed out sediments/debris at the gully head and increase filtering effect of the run-off sediment.

To rehabilitate/reclaim the degraded land.

Justification:

Construction of Gabion check dam needs no high-tech technology. Locally available materials can be used for construction of gabion. Others high tech construction materials except 10 SWG and 22 SWG GI wire are not required for Gabion. So, it can be constructed even at remote areas. After achieving the target, the used materials can be shifted to another place without any wastage. As this structure is considered as a flexible structure, there is a less possibilities to be damaged except scouring. If the well graded local stone bolder is used in gabion, it works well to check the sediments carried with and is finally very good for rehabilitation of degraded land by plugging the gully head.

PROGRAME-5

INTRODUCTION OF HALF-MOON TERRACE, STAGGERED TRENCHING, CONTOUR GRASSED WATERWAYS, AND CONTOUR TRENCHING IN FARMER'S FIELD.

Objectives

I. To minimize the soil erosion hazard.
II. To increase the optimum soil moisture capacity.
III. To convert the eroded land in to productive.

IV. To divert the excess water causing no damages in the rainy season.
V. To rehabilitate the degraded land.
VI. To provide facilities for applying fertilizers, manure and irrigation on the sloping land.

Justification:

HALF MOON TERRACE

Half-moon terrace is a kind of terrace used for planting of fruit and horticultural purposes. It is called the Half Moon Terrace for its shape. Construction of Half Moon Terrace is easier than others. It is made by cutting the upside soil of the plant in half moon shape to create a circular level bed having 1.0-1.5 m. diameter. The dug-out soil is deposited on down side of the plants to make ridges for retaining moisture. Mulch materials are used in the terraced area which will add organic matter in to the soil. It also provides facilities for all

intercultural operation like application of fertilizer and manure along with irrigation in the drought. This type of terrace is generally made just before the end of monsoon when the soil is saturated. It also helpful for healthy growth of plants.

STAGGERED TRENCHING

The staggered trenches are constructed for shorter length, as compared to the graded trenches. These trenches are arranged in staggered form (i.e. not in straight line). Staggered trenches are generally constructed at the land slope greater than 33% receiving high rainfall to prevent erosion and absorb rain water for horticulture and forestry land . The trenches run level for distance of maximum 90 to 120 m, than on the gradient increasing from 1 in 500 to 1 in 300 at the outlet. The bunds are constructed at closer interval about 3 to 5 m. The important points about this type of trench are as follows:

The trenches have shorter length; and are arranged in the row along the Contour with interspace between them.

a) The vertical interval between two successive trenches is decided on the basis of expected runoff from the area, above,
b) In staggered sequence, the alternate rows trench are located directly below one another;
c) The length of row and slope between them are fixed based on the Concept that there should be greater length of unprotected or uninterrupted slope to cause unexpected runoff and erosion.

CONTOUR GRASSED WATERWAYS

A grassed waterway is a natural or constructed channel that is shaped or graded to carry surface water at a nonerosive velocity to a stable outlet. The required dimensions are those needed for the waterway to convey runoff from the design storm, generally the 10-year, 24-hour storm. The grassed waterway is designed to ensure that the velocity of runoff water is not excessive.

The primary purpose of a grassed waterway is to convey runoff from terraces, diversions, or other areas of water concentration without causing erosion or flooding. Another purpose is to improve water quality. Grassed waterways are natural drainage ways that are graded and shaped to form a smooth, bowl-shaped channel. They are seeded to sod-forming grasses. Runoff water that flows down the drainage way flows across the grass rather than tearing away soil and forming a larger gully. An outlet is commonly installed at the base of the drainage way to stabilize the waterway and to keep a new gully from forming. The most critical time for successful installation of a grassed waterway is immediately following construction, when the channel is bare and unprotected from runoff. Waterways are generally planted to perennial grass and then mulched with straw. In some areas silt fences or straw bales in the waterway reduce the velocity of the runoff, thereby reducing the risk of gully formation in the new waterway.

A grassed waterway provides a vegetative strip that benefits the environment in several ways in addition to the primary benefit of providing a non-erosive waterway. These additional benefits include diversity of wildlife habitat, corridor connections, vegetative diversity, non-cultivated strips of vegetation, and improved esthetics. An additional grassed width on each side of the grassed waterway allows the waterway to better serve as a conservation buffer.

Contour Trenching

Contour trenching is excavating trenches along a uniform level across the slope of the land in the top portion of catchment. Bunds are formed downstream along the trenches with materials taken out of them. The main idea is to create more favorable moisture condition and thus accelerate the growth of vegetation.

Contour trenches break the velocity of runoff. The rain water percolates through the soil slowly and travels down and benefits the better types of land in the middle and lower section of the catchment. Where the lower fields are bunded, these trenches also protect the bunds from the runoff from the upper portion of the catchment. It also traps and stores the soil particles carried from the upper ends with runoff.

PROGRAME- 6

GULLY CONTROL BY BRUSHWOOD CHECK DAM FOR MINIMIZING EROSION HAZARD AND RECLAMATION OF GULLIED LAND.

Objectives

I. To reduce the velocity of run-off.
II. To prevent deepening and widening of the gully.

III. To collect sedimentation and to recharge the water table.

Justification:

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 built easily. But it needs for regular maintenance and repairing.

THE END