J Krishi Vigyan 2021, 9 (2) : 209-213 DOI : 10.5958/2349-4433.2021.00039.8

Soil Erosion Control Through Bench Terraces in Chandel District of Manipur

Kangjam Sonamani Singh

Krishi Vigyan Kendra, Chandel 795 127 (Manipur)

ABSTRACT

This study was carried out with the objective to assess soil erosion losses after intervention of Krishi Vigyan Kendra, Chandel with modern scientific technology in the traditional conventional cultivation followed in the hilly sloping areas of the district. This is for the first time such a resource conservation technology has been demonstrated in the district of Chandel in Manipur. Bench terracing is a time-proven technology practiced across the world in sloping fields. Though construction of bench terraces is often time-consuming and laborious at the initial stage, but is worth it, given the long-lifespan and the efficacy it shows. It was demonstrated that soil retention up to a tune of 207.5 t/ ha/yr in the first year, nearly 136.5 t/ha in the second year, nearly 88.9 t/ha in the third year and almost 78.3 t/ha in the fourth year could be achieved. Thus, it was concluded that systematic and proper layout of bench terraces in the hill fields can dramatically reduce a huge amount of soil from getting eroded from the farm land of Chandel, Manipur and thus lead the tribal farmers towards sustainable existence through agriculture.

Key Words: Soil Erosion, Soil Conservation, Sustainable Agriculture.

INTRODUCTION

Agriculture is the main stay of economy in India. Over 60 per cent of Indian agriculture is dependent on rainfall mainly from South-West monsoon received during June to September and at high-risk due to vagaries of the monsoon and local meteorological conditions. Moreover, the cultivable land is deteriorating due to soil erosion followed by dwindling water resources and adverse climate change, resulted in decreased agricultural productivity (Naveena *et al*, 2019). Indigenous way of farming has been in practice by the people of the district since pre-historic days. Farmers have improvised their own skills and ideas on decisions regarding how best to grow their crops and enhance its productivity.

Excessive deforestation coupled with shifting cultivation practices have resulted in tremendous soil loss (200 t/ha/yr), poor soil physical health in this region. Studies on soil erodibility characteristics under various land use systems in Northeastern Hill (NEH) Region depicted that shifting cultivation had the highest erosion ratio (12.46) and soil loss (30.2–170.2 t/ha/yr), followed by conventional agriculture system (10.42 and 5.10–68.20 t/ha/yr). The challenge is to maintain equilibrium between resources and their use to have a stable ecosystem (Saha *et al*, 2012).

In addition, the rising population, limited land for agriculture and more food demand have led to the cultivation of crops on steep slopes vulnerable to erosion. The soils developed on hill top and escarpments are shallow to moderately deep, well drained, gravelly loamy soils with moderate to severe erosion hazards. The soils on the hilltop are strongly acidic, medium in organic matter and cation exchange capacity (CEC) with high base status. The escarpment soils are very strong to strongly acidic in reaction, medium to high in organic matter, low to medium CEC with medium base saturation (Nanda *et al*, 2018). Soil erosion is gradually becoming a serious problem in recent

Corresponding Author's Email: sonamanisingh@gmail.com

years affecting huge tracts of both cultivable as well as forest lands. Serious problems arise in agriculture and water resources management due to removal of the top fertile soil and its subsequent deposition in lakes and reservoirs.

Shifting cultivation, also known as *jhum* cultivation, is the most traditional and dominant land use system in this region. On an average, 3,869 km^2 area is put under shifting cultivation every year. Shifting cultivation in its more traditional and cultural integrated form is an ecological and economically viable system of agriculture as long as population densities are low and *jhum* cycles are long enough to maintain soil fertility. The shifting cultivation has become unsustainable today primarily due to the increase in population that led to increase in food demand. Jhuming cycle in the same land, which extended to 20–30 yr in earlier days, has now been reduced to 3–6 yr (Borthakur, 1992). Land degradation in the region is 36.64 per cent of the total geographical area, which is almost double than the national average of 20.17 per cent (Anonymous, 2000). The problem of land degradation is much serious in the states like Manipur, Nagaland, and Sikkim, where more than 50 per cent of total geographical area is defined as wastelands. Of various degradation types, water erosion, reduced infiltration, acidification, nutrient leaching, burning of vegetation, decline in vegetative cover, and biodiversity are important in context to the NE region.

MATERIALS AND METHODS

Study Area

The district has a geographical area of 3,313 sq. km and occupies the 4th position in size of the districts of Manipur . The district (23o50‘6.81”N to 24o37’54.55”N and longitude 93o46’46”12” E to 94o26.6”E approximately), is located in the south-eastern part of Manipur and it experiences hot summer and cold winter. The mean annual temperature exceeds 22˚C and experiences summer temperature to the range of 35 to 46˚C. The mean annual precipitation varies from 2000 to 2400 mm. The study was carried out at Khukhthar and Machi villages, Chandel district, Manipur. A study area of about 1.5 ha area was considered for the on-farm trial program. Continuous dilution of the forest cover in the region due to shifting cultivation, firewood, and timber collection is posing the most crucial problem resulting in poor soil health and environmental degradation in the hills. The on-farm trial was conducted on the construction of bench terrace in the sloping farms of Khukhthar and Machi villages in Chandel district, Manipur.

Bench terraces are a series of level or almost level steps constructed across the slope at vertical intervals, supported by steep intermediate risers.

Fig. 1: Bench terraces at Khukhthar and Machi villages

Bench terraces are often used for effective soil conservation measures at relatively high slope lands for farming activities. It is considered an effective engineering soil conservation practice, used to control the soil erosion from steep fields. Terracing involves cutting and filling of the soil to construct embankment or ridge like structures, across the land slope to check the velocity of surface runoff and to reduce the soil loss. Also, it reduces the length of slope by splitting the slope length in different parts.

After extensive base-line survey in the two villages, bench terraces were constructed across the hill slopes by half cutting and half filling which gives the shape of flatbeds and serve as barriers to break slope length and reduce the degree of slope (Fig 1). The risers were provided as shoulder bund for the stability of the terraces and perennial grasses were planted on the riser for its stabilization and help in filtering the silt particles. A well-established bench terrace can retain up to 98 per cent of rainfall (Singh *et al*, 2006).

The Revised Universal Soil Loss Equation (RUSLE) which was used to calculate soil erosion of the study area is represented as below:

A=R*K*LS*C*P

where,

A= Annual computed Soil Loss (ha/year)

R=Rainfall Erosivity factor

K=Soil Erodibility factor

LS= Slope-length factor

C= Crop management factor

P= Supporting Practice management factor

Rainfall Erosivity Factor (R-Factor)

R factor is the indicator for evaluating the impact of rainfall on soil separation and transportation and is used to estimate by rainfall parameters. Soil erosion is closely related to rainfall through the combined effect of detachment by raindrops striking the soil surface and by the runoff. As per RUSLE method, soil loss from the cultivated field is directly proportional to a rain storm parameter, if other factors remain constant. Rain-erosivity (*R*) is calculated as a product of storm kinetic energy (*E*) and the maximum 30 minutes rain fall intensity. This relationship helps to quantify the impact of rain drop over a piece of land and the rate of runoff associated with the rain. But In present area that kind of detailed meteorological data is not available for all the stations in the study area. The R factor was determined using formula given below (Choudhury and Nayak, 2003).

R_a=79+0.363*Xa

where,

R_a = Annual R factor,

Xa= Average Annual Rainfall in mm.

The average annual rainfall erosivity (R_a) was calculated using rainfall data of above rain gauge stations for the years (2009-2020)

Soil Erodibility (K) Factor

Soil Erodibility factor represents the soil susceptibility to detachment and transport of soil particles under an amount of runoff for specific rainfall. The K factor is rated mainly scale from 0 to 1, where 0 is for least susceptibility soil for erosion and 1 is for High susceptibility soil for erosion by water.

Slope Length and Steepness (LS) Factor

Slope and slope length (LS) are topographical factors, which mainly reflect the effects of topography on soil erosion. The slope length and slope steepness are often used in a single index, which expresses the ratio of soil loss as defined by Wischmeier and Smith (1978).

$LS = (X/22.1)^m * (0.065 + 0.045\ S + 0.0065\ S)^2$

X = slope length (m or km);

S = slope gradient (%)

Crop Management (C) Factor

The crop management factor is used to reflect the effect of cropping and management purpose on erosion rates. It represents the ratio of soil loss

Table 1. Crop Management (C) Factor values for different land use/ land cover.

Land use	Sub land use	C-factor
Agriculture	Current fallow	0.6
	Kharif + Rabi	0.6
	Kharif crop	0.5
	Plantations	0.5
Built up area	Commercial	0.2
	Industrial	0.2
	Town/Cities (Urban settlement)	0.2
	Villages (Rural settlement)	0.2
Forest	Scrub forest	0.02
Others	Prosophis	0.15
	Quarry	0.15
Wasteland	Land with scrub	0.95
	Land without scrub	0.8
	Canal	0
Water bodies	Lakes/ponds	0
	Reservoirs	0
	Rivers	0

under a given crop to that of the Base soil (Morgan *et al*, 1994). It is considered the second major factor (after topography) controlling soil erosion. An increase in cover factor indicates a decrease in exposed soil, and thus an increase in potential soil loss (Pancholi, *et al* 2015). The C (Table 1) factor is calculated depending upon different land use types as per below Table 10 (Wischmeier and Smith 1978).

Conservation Practice (P) Factor

Conservation practice factor (P) in RSLE expresses the effect of conservation practices that reduce the amount and rate of runoff, which reduces soil erosion. It is the ratio of soil loss with a support practice on croplands to the corresponding loss with up and down slope (Renard *et al*, 1997). It includes different types of agricultural management practices such as: strip cropping, contour farming, and terracing etc. In present study, P factor is derived from the land use/land cover type map. Each value of P was assigned to each land use/land cover type and slope. The value of P –factor ranges from 0 to

Table 2. Conservation Practice (P) factor on different slope gradients.

Sr. No.	Slope percentage (%)	P factor
1	0-1	0.6
2	1-3	0.6
3	3-5	0.5
4	5-10	0.5
5	10-15	0.7
6	15-35	1

Table 3. Periodic observation of soil retention.

Year-wise measurement of soil retained at the terrace	Average soil retained at the terrace (t/ha/year)
October' 2017	207.5
November' 2018	136.5
November' 2019	88.9
November' 2020	78.3

1 (Table 2), in which highest value is assigned to areas with no conservation practices. The lower the P value, the more effective the conservation practices.

RESULTS AND DISCUSSION

The present studied carried on bench terraces demonstrated that soil retention up to a tune of 207.5 t ha^{-1} yr^{-1} in the first year, nearly 136.5 t ha^{-1} yr^{-1} in the second year, nearly 88.9 t ha^{-1} yr^{-1} in the third year and almost 78.3 t ha^{-1} yr^{-1} in the fourth year could be achieved (Table 3). Thus it was observed that systematic and proper layout of bench terraces in the hill fields of Chandel can reduce soil erosion up to a great extent and thus lead the tribal farmers towards sustainable and environment-friendly and organic agriculture.

CONCLUSION

Soil erosion causes loss of fertility status which not only significantly affects the productivity of farmers' fields but also alters the chemical, physical and biological attributes and functions of soil leading to serious ecological hazards and environmental imbalance. Bench terraces in steep agricultural fields have proved to bring the soil erosion well within the permissible limits. Appropriate soil conservation measures in the hills are of dire need to enable suitable and effective strategies for sustainable and efficient use of natural resources for the present as well as future generations.

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Received on 30/04/2021 *Accepted on 20/05/2021*