UNCOVERING THE IMPACT OF EROSION CONSERVATION TECHIQUES ON SOIL ATTRIBUTES IN SHIVALIKS OF LOWER HIMALAYAS OF JAMMU

Abstract

The present study uncovering the impact of erosion conservation techiques on soil attributes in shivaliks of lower himalayas of jammu. Principle focus among land degradation concerns has been on soil erosion. Soil erosion is considered as the main cause of land degradation. Although the problem persisted on the earth for a longer period, it has become severe in recent times due to increased man-environment interactions. The study was conducted in the Merth village of Jammu and Kashmir, India, which is situated in the Kathua district. The catchment area investigated had a clay loam texture and a slope gradient of 3-6%, with a total area of 24.8 acres. The result shows that mean value of bulk density under various erosion control techniques was highest in overgrazing prevention (1.40g cm^{-3}) followed by perimeter runoff control, terrace farming and contour plowing and was lowest in cover crop (1.33g cm^{-3}). The carbon content also increased with the use of resource conservation techniques which is very good indicator as carbon act as bridge between nutrient, water and soil. The study strongly recommends adoption of resource conservation techniques for reducing soil erosion & water conservation in submontane *Shivaliks*.

Keywords: Erosion conservation modules, bulk density, infiltration rate, water holding capacity

1. Introduction

Land degradation and its potential causes on a worldwide basis are challenging the economic and social well being of the present and future generation by declining the productivity of croplands and rangelands **(Keno & Suryabhagavan, 2014)**. Principle focus among land degradation concerns has been on soil erosion. Soil erosion is considered as the main cause of land degradation. Although the problem persisted on the earth for a longer period, it has become severe in recent times due to increased man-environment interactions, **Rasool *et al.* (2014).** Most people in the developing countries are dependent completely on agriculture for their livelihood, so it has been identified as a major threat to sustainability of agriculture and economy of nations **(Gemechu, 2016)**. The continued maintenance of fertile soil is essential in order to meet basic

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human needs. In India land degradation is a common problem in the Shivaliks of Lower Himalayas of Jammu, extending from district Kathua in the southeast to Rajouri in the northwest. It is a dry semi-hilly belt, locally known as kandi. Increased human and cattle population pressure and decreased the size of land holdings in the area have resulted in the indiscriminate felling of trees, removal of bushes and grazing and browsing. It has led to unabated soil loss and land degradation. Soil erosion by water is the root cause of ecological degradation in these areas. The estimated annual soil loss from the Shivaliks or sub-montane region of Jammu is more than 80 tonnes ha^{-1}. The physiographic characteristic of the area is itself a major factor contributing to the continuous degradation of these catchments. The weak lithology of the Shivaliks of Lower Himalayas consisting of rocks like sandstone, conglomerate, shale, silt stone and limestone are relatively easily weatherable and therefore prone to quick erosion. The topography of the region ranging from gently sloping to moderately-steep sloping retards the vertical development of soils. These highly erodible soils are poor in nutrients and low in organic carbon **(Sharma et al., 2009)** contributing to poor physical attributes and poor productivity. Therefore different resource conservation techniques are necessary in these areas to limit the soil loss to a tolerable limit. The different resource conservation techniques are designed to intercept sediments, reduce runoff velocity, facilitate infiltration of runoff water, transmit runoff at non erosive power and reduces sedimentation of waterways, streams, and rivers **(Blanco and L al, 2008).** Beside this, these play a significant role in improving the physico-chemical attributes and nutrient status of the soil.

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2. Materials and Methods.

Study Area: The study was conducted in the Merth village of Jammu and Kashmir, India, which is situated in the Kathua district. The catchment area investigated had a clay loam texture and a slope gradient of 3-6%, with a total area of 24.8 acres. The geographic location of the study area is between 32^{o} 17’ to 32^{o} 55’ North latitude and 75^{o} 70’ to 76^{0} 16’ East longitude.

Erosion Control Techniques: The erosion control techniques employed in maize-wheat cropping system of the study area included:

- Terrace farming
- Perimeter runoff control

- Cover crop (Black gram, *var*. Uttara)
- Agrostological measures (Bhabar, Khus-khus, Bermuda grass, Agati, Elephant grass
- Overgrazing prevention

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DISTRICT KATHUA, J&K

Fig 1: Location of study area

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Method of implementation of resource conservation techniques:

- Start by identifying the contour lines of the slope. This can be done using a topographical map or by visually observing the slope.
- Next, construct terrace farming structures parallel to the contour lines. The terraces should be leveled and should have a slight slope to allow for water drainage.
- Construct perimeter runoff control structures such as bunds, trenches, and ditches along the contour lines to control the flow of water and reduce soil erosion.
- Plant cover crops parallel to the contour lines. The cover crops should be planted in rows and should be spaced at regular intervals.
- Plant agrostological measures such as grasses, shrubs, and trees parallel to the contour lines. The plants should be spaced at regular intervals to provide maximum coverage.
- Implement overgrazing prevention measures such as limiting the number of livestock that graze on the land. This can be achieved by constructing fences or by providing alternative grazing areas.

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If they are used by the population, show how they use them by taking photographs on the field.

The composite surface soil samples were collected randomly from the watershed areas by using GPS. Collection of soil samples were based on the different types of erosion control modules used. The collected soil samples were then air-dried, mixed well and passed through a 2 mm sieve for the analysis of selected soil physical attributes.

Analysis of soil samples

Table 1 Methods employed for the determination of various soil physico-chemical attributes and their initial values:

Parameters	Methods	References	Initial values
Texture	Hydrometer method	Bouyoucos, 1962	Clay loam
Bulk density (g cm^{-3})	Core sampler method	Black, 1965	1.38
Particle density (g cm^{-3})	Pycnometer	Black, 1965	2.63
Infiltration rate (cm hr^{-1})	Minidisk infiltrometer	Decagon, 2005	2.01
pH	Potentiometric method	Jackson, 1973	6.4
Electrical conductivity	Salt bridge method	Jackson, 1973	0.50

(dSm^{-1})			
Organic carbon ($g\ kg^{-1}$)	Rapid titration method	Walkley & Black, 1934	5.2
Available N ($kg\ ha^{-1}$)	Kjeldahl method	Subbiah & Asija, 1956	250
Available P ($kg\ ha^{-1}$)	Olsen's method	Olsen *et al.*,1954	11
Available K ($kg\ ha^{-1}$)	Flame photometry method	Piper , 1966	160

Analysis was done by using analysis of variance techniques (ANOVA) and by applying DMRT test. The SPSS Software version 14.0 was used for analysis.

3. Results and Discussion

Impact of resource conservation techniques on physical attributes of soil

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You do not just jump into impact of conservation techniques without telling us or showing the techniques.
You should take photos on ground to show how the population practice these techniques.

Table 2: Impact of resource conservation techniques on physical attributes of soil

RCT	BD ($g\ cm^{-3}$) (Mean ± S.E)	PD ($g\ cm^{-3}$) (Mean ± S.E)	Infiltration rate ($cm\ hr^{-1}$) (Mean)
CC	1.33 ± 0.02^{e}	2.62 ± 0.01^{a}	7.05
AM	1.35 ± 0.03^{d}	2.62 ± 0.01^{a}	6.10
TF	1.38 ± 0.02^{b}	2.63 ± 0.01^{a}	5.25
CP	1.38 ± 0.02^{b}	2.62 ± 0.01^{a}	5.20
PRC	1.37 ± 0.02^{c}	2.62 ± 0.01^{a}	4.75
OGP	1.40 ± 0.03^{a}	2.62 ± 0.01^{a}	2.75

Note: Means with the same letter are not significantly different

RCT (Resource conservation techniques), CC (Cover crop), AM (Agrostological measures), TF (Terrace farming), CP (Contour plowing), PRC (Perimeter runoff control), OGP (Overgrazing prevention)

Bulk Density

The result shows that mean value of bulk density under various erosion control techniques was highest in overgrazing prevention (1.40g cm^{-3}) followed by perimeter runoff control, terrace farming and contour plowing and was lowest in cover crop (1.33g cm^{-3}) (Fig:2). Degraded lands were found to have the highest values of bulk density. The highest bulk density of the soil in overgrazing prevention may be attributed due to low clay content and organic matter. The decrease in bulk density in cover crop might be the subsequent effects of reduced soil loss and crop residue through erosion and addition of organic matter through plants. The impact of falling raindrops also decreased under the cover crop. Decrease in bulk density in cover crop, terrace farming, contour plowing, agrostological measures have also been observed by other workers, **Franzluebbers and Stuedemann (2005); Autmong *et al.* (2009); Barreto *et al.* (2010); Singh *et al.* (2011)**. The results also confirm the findings of **Sharma *et al.* (2007)** and **Wallia *et al.* (2010).** The reduction in bulk density is related to increase of organic carbon in cover crop which results in more pore space and good soil aggregation, **Selvi *et al*. (2005); Khursheed *et al.* (2012); Yaduvanshi *et al*. (2013).**

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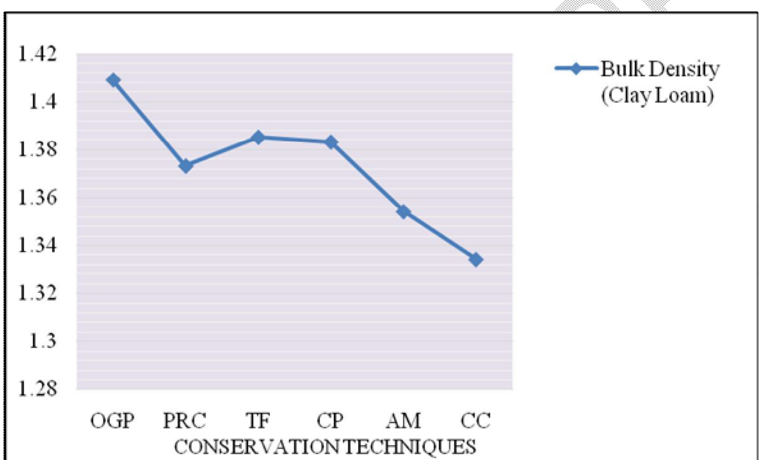

Fig 2: Impact of erosion conservation modules on bulk density in clay loam soil

Particle density (PD)

The statistical result indicated that PD did not get significantly affected by resource conservation techniques (Table 2). Particle density is an exclusive density of soil particles and excludes pore spaces. Particle density theoretically can be changed but in practical terms it need enormous amount of organic carbon/ biomass addition along with the addition of heavy minerals.

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As resource conservation techniques are effective in modifying pore space by adding organic matter and increasing microbial activity in the rhizosphere, **Chhina *et al.* (2019)** but particle density is totally independent of pore space, thus their impact on particle density was insignificant. Similar values and reasons had also been observed by **Baisden *et al.* (2002); Sollins *et al.* (2006); Rasool *et al.* (2008); Rasool and Kukal (2010); Chhina *et al.* (2019).**

Infiltration rate

Soil erosion conservation techniques significantly effected the infiltration rate. The mean value of infiltration rate was highest in cover crop and lowest in overgrazing prevention. The infiltration rate as a function of elapsed time followed the trend in different erosion conservation techniques as: cover crop > Agrostological measures > Terrace farming > contour plowing > perimeter runoff control > overgrazing prevention (Table 2). The highest infiltration rate under cover crop and other resource conservation techniques was due to the addition of organic matter, which in turn increased the total pore space of the soil. It might also be due to the loosening of the surface soil due to the lateral spread of the roots. In addition to this, infiltration rate is also affected to a great extent by the texture of the soil and in our conditions texture was coarser, resulting in higher infiltration rate, **Hadda *et al.* (2002); Hadda *et al.* (2017); Chandel and Hadda (2018)**. Cover crops neutralizes the destructing power of rain drops and suppress surface compaction, hence resulted into lesser runoff and more infiltration. Similar values were observed by **McCormack *et al.* (1982); Singh and Khera (2008); Mandal and Sharda (2011).**

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Impact of resource conservation techniques on chemical attriutes of soil

Soil pH

The soil pH in clay loam soil varies between 6.64 and 7.73, depending on the resource conservation techniques employed. Interestingly, the pH values were found to be at their lowest in areas where overgrazing was prevented, while cover crops yielded the highest pH values (Table 3). No significant difference in soil pH was noted between terrace farming and contour plowing methods. It's worth noting that the lower average pH in overgrazing prevention could be attributed to the high level of soil erosion, leading to the loss of important basic nutrients, lower base saturation percentage, and reduced soil organic matter content. Several studies by reputable researchers have confirmed that organic carbon has a positive and significant correlation with soil pH, including **Habtamu *et al.* (2009), Million (2003), Haweni (2015), Worku (2017), and Solomon *et al.* (2017).**

Soil EC

As the statistical result indicated, EC of the soils (clay loam) did not significantly affected by resource conservation techniques. Relatively high (1.33 dSm^{-1}) and low mean value of EC (0.33 dSm^{-1}) was recorded in overgrazing prevention and perimeter runoff control respectively. The high electrical conductivity value in overgrazing prevention compared to other resource conservation techniques could be due to the upward movement of the soluble salts to the surface, through capillary rise of water under prevailing hyperthermic temperature regime in submontane Shivaliks soil, **Sondhi (1992) and Nazir (1993)**. Other workers have also reported low value of electrical conductivity where resource conservation techniques were adopted in surface soil, **Burle and Mielniczuk (1997)**; **Verhulst *et al.* (2010a)**; **Verhulst *et al.*(2010b**); **Singh (2010); Baishya and Sharma (2017).**

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Table 3: Resource conservation techniques impact on soil chemical properties in clay loam soil

RCT	pH (Mean ± S.E)	EC(dSm^{-1}) (Mean ± S.E)	OC (g kg^{-1}) (Mean ± S.E)	Available N (Kg ha^{-1}) (Mean ± S.E)	Available P (Kg ha^{-1}) (Mean ± S.E)	Available K (Kg ha^{-1}) (Mean ± S.E)
CC	7.73 ± 0.12^{a}	0.44 ± 0.21^{bc}	8.25 ± 0.66^{a}	440.10 ± 74.42^{a}	30.29 ± 4.79^{a}	309.70 ± 46.60^{a}
AM	7.44 ± 0.07^{b}	0.52 ± 0.19^{b}	7.02 ± 0.41^{b}	271.25 ± 31.47^{c}	26.94 ± 3.75^{b}	273.08 ± 33.20^{b}
TF	7.18 ± 0.12^{c}	0.35 ± 0.17^{cd}	6.03 ± 0.43^{c}	310.87 ± 46.01^{b}	16.12 ± 1.95^{c}	225.50 ± 39.46^{c}
CP	7.18 ± 0.11^{c}	0.41 ± 0.19^{cd}	3.70 ± 0.97^{d}	235.66 ± 26.44^{d}	13.43 ± 1.97^{d}	160.35 ± 18.79^{d}
PRC	6.84 ± 0.98^{d}	0.33 ± 0.13^{d}	3.78 ± 0.76^{d}	223.63 ± 17.20^{d}	14.26 ± 1.82^{d}	148.85 ± 20.59^{d}
OGP	6.64 ± 0.19^{e}	1.33 ± 0.27^{a}	2.37 ± 0.55^{e}	163.67 ± 32.54^{e}	11.41 ± 1.76^{e}	126.33 ± 15.49^{e}

Note: Means with the same letter are not significantly different

RCT (Resource conservation techniques), CC (Cover crop), AM (Agrostological measures), TF (Terrace farming), CP (Contour plowing), PRC (Perimeter runoff control), OGP (Overgrazing prevention).

Soil organic carbon

According to Table 3, the mean value of soil organic carbon (OC) varied significantly among different resource conservation techniques, ranging from 8.25 g kg-1 to 2.37 g kg-1. The highest mean value was observed in the cover crop technique, while the lowest was recorded in overgrazing prevention. The presence of root biomass and leaf litter in cover crop might have contributed to the high soil organic carbon content, particularly in the subsurface layer. On the other hand, the poor growth, high runoff, and soil erosion in overgrazing prevention could have led to the lowest soil organic carbon content, as suggested **by Hassink (1995) and Sollins *et al.* (1996).**The results showed that cover crop had the highest soil organic carbon content compared to other resource conservation techniques, which is consistent with the findings of **Nagaraja *et al.* (2016)** and **Kumar *et al*.** (2018). This could be attributed to the higher amount of litter production and return under this technique. Several other studies have also reported similar results, including **Bhat *et al.* (2012), Feyissa *et al.* (2013), Du *et al.* (2014), and Araujo *et al.* (2017).**

Despite the lower value of soil organic carbon at the initial stage, its content was observed higher in cover crop as compared to other resource conservation techniques which is in agreement with other studies, **Alvarez et al. (1995)**; **Halvorson et al. (2002)**; **Alvarez and Steinbach (2009)**. The introduction of cover crops in rotation generally significantly increases soil organic matter as reported by **Smith et al. (1997)**; **Drinkwater et al. (1998)**; **Lal (2004)**. The results in our studies confirm the importance of introducing cover crops in crop rotation for maintaining or increasing soil organic carbon in loamy texture even under submontane condition. The study is in confirmative with the work of **Drinkwater et al. (1998)** and **So et al. (2001)**, that legume cover crop in a crop rotation may easily conserve or increase soil organic matter which in turn increases the soil organic carbon.

Available nitrogen

Statistically, significant difference was observed in available nitrogen under different resource conservation techniques except contour plowing and perimeter runoff control. The mean value of available nitrogen was highest in cover crop (i.e. 440.10 kg ha^{-1}) and lowest in overgrazing prevention (i.e. 163.67 kg ha^{-1}).

This increase can be attributed due to the addition of root and leaf biomass in varying degree under resource conservation techniques but comparatively more addition was observed in cover crop which indirectly through the process of mineralization increases the availability of available nitrogen, **Drinkwater *et al*. (1998); Sainju *et al.* (2008); Alvarez and Steinbach (2009)**. Our results and studies by several other researchers shows that soil organic carbon content and available nitrogen are positively correlated with each other. Beside this cover crops (Black gram etc.) also has role in biological nitrogen fixation, thus increases the pool of easily mineralized organic N as revealed by **Murrell (2011)** through its roots and root exudates.

Available phosphorous

Available P among different resource conservation techniques in clay loam was highly variable. It varied from 11.41 to 30.29 kg ha^{-1} (Table 3 and Fig. 3). The mean value of available phosphorous was found highest in cover crop and lowest in overgrazing prevention. From the studies it was Recorded that availability of phosphorous has been significantly affected by resource conservation techniques, it might be due to changes in soil pH, restoration of soil organic carbon and maintenance of externally added P by reducing soil erosion and runoff.

Accumulation of organic matter through cover crop enhances the availability of phosphorous as 30 – 35% of phosphorous comes from the organic pool of the soil, this has been documented by **Arya (2007); Cao *et al.* (2011); Arya *et al.* (2016).** Furthermore**,** addition of organic matter through incorporation of cover crop in crop rotation or recycling of crop residues in soil, influence the reaction of phosphate and its availability to plants. With the addition of organic matter the process of mineralization of phosphorous is enhanced and value of bonding energy (K) L Kg^{-1} decreased, **Arya (2007)**. By adding organic matter through various means, such as cover crops, root biomass, or composite varieties, the soil solution's inorganic phosphorous increases significantly through mineralization of organic phosphorous and solubilization of native phosphorous compounds. This phenomenon has been observed by **Vig and Chand (1993), Hiradate and Uchidia (2004), and Guppy et al. (2005)**

Available potassium

Resource conservation techniques can have a significant impact on the concentration of available potassium in clay loam soil. According to research, cover crops resulted in the highest concentration of available potassium, reaching an impressive 309.70 kg ha^{-1}. On the other hand, overgrazing prevention yielded the lowest concentration of available potassium, with only 126.33 kg ha^{-1}. The reason behind this discrepancy may be attributed to the minimal erosion impact of cover crops, as stated in a study by **Kyaruzi (2013)** which effectively control runoff and improve potassium content. Additionally, cover crops possess higher root biomass and litter fall, which indirectly enhance the availability of potassium through mineralization. Experts in the field such as **Drinkwater et al. (1998)**, **Sainju et al. (2008)**, and **Alvarez and Steinbach (2009)** have conducted studies that support these findings. So, adopting resource conservation techniques like cover crops could help improve soil fertility.

Conclusion:

From the study therefore, it can be concluded that resource conservation techniques should be adopted in submontane *Shivaliks*. As these practices not only reduces runoff and sediment yield but are also effective in maintaining the nutrient status and various physical and chemical properties of soil. Among the various resource conservation techniques used (*viz.* cover crop, agrostological measures, terrace farming, contour plowing, perimeter runoff control and over grazing prevention), cover crop was most efficient in trapping detached sediments and reducing velocity and volume of overland flow. The carbon content also increased with the use of resource conservation techniques which is very good indicator as carbon act as bridge between nutrient, water and soil. Resource conservation techniques exerts the least of soil disturbance and adds root biomass along with litter fall contributes to more soil aggregation, accumulation of nutrients and soil organic carbon, better physical condition of the soil along with good soil quality. The soils of submontane *Shivaliks* are under tremendous stress because of high soil erosivity and poor soil management practices. The study strongly recommends adoption of resource conservation techniques for reducing soil erosion & water conservation in submontane *Shivaliks*.

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