IMPACT OF RESOURCE CONSERVATION TECHNIQUES ON SOIL PROPERTIES IN SUB MONTANE NORTH WESTERN HIMALAYAS

Abstract

The present study highlights the impact of resource conservation techniques on soil properties in sub montane north western Himalayas. The continued maintenance of fertile soil is essential in order to meet basic human needs. The topography of the region ranging from gently sloping to moderately-steep sloping retards the vertical development of soils. The study was conducted in the Merth village of state J&K. The experiment was laid out to compare the impact of resource conservation techniques on the runoff and sediment yield in two different catchment areas (one with sandy loam texture and other with clay loam texture) in monsoon season. The slope of the catchment areas varies from 3-6%. The increase in available nitrogen in sandy and clay loam can be attributed because of the increase in root biomass under resource conservation techniques. Addition of root biomass and litter fall in cover crop indirectly through the process of mineralization increases the availability of available nitrogen. 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*.

Keywords: soil properties, mineralization, *Shivaliks,* available nitrogen

Introduction

Soil is considered as one of the worlds̓ limited, non-renewable resource. Under cropland conditions, it takes between 200 to 1000 years for 2.5 cm of topsoil to form **(Pimentel *et al.,* 1995).** The continued maintenance of fertile soil is essential in order to meet basic human needs. In India land degradation is a common problem in the lower Shivaliks 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 lower Shivaliks 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 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 Lal, 2008).** Beside this, these also have role in improving different properties (physical and chemical) and nutrient status of the soil.

MATERIAL AND METHOD

The study was conducted in the Merth village of state J&K. The village is situated in Kathua district, which lies between 32° 17' to 32° 55' North latitude and 75° 70' to 76^{0} 16' East longitude. The district is bound in the south by Gurdaspur district of the Punjab, in the east by Chamba district of Himachal Pradesh and in the north by Doda, Samba, and Udhampur district of J& K state. The district comprises of 5 tehsils *viz* Kathua, Hiranaga, Basohli, Billawar and Bani. Merth village comes under the tehsil Kathua. The total geographical area of Merth village is 400 ha and situated at a distance of 20 km from its district headquarter. It is located at 32º27'36.11" N latitude and 75º27'59.66" E longitude with an elevation of 425 m above mean sea level. The total area of both the investigated watershed was 49.6 acre.

Topography and agro climatic characteristics

Kathua district varies in topography and terrain. The plain areas are formed by part area of the district constituting Kathua and Hiranagar tehsils below the national highway. The area in the north side of the national highway upto Dhar – Udhampur road comprises Kandi belt whereas the remaining part of the district, constituting Billawar, Bashohli and Bani tehsils, is known as mountainous terrain. The climate of the district also varies significantly from very hot in its plain and Kandi belt to severe cold in the hills. The summer months from April to June are very hot with mercury touching even 45ºC, whereas the temperature in winter months *i.e.* during December and January ranges between 5ºC and 15ºC. The rainfall in the region is relatively poor. The monsoon reach the district between the months of June and August. The district gets maximum rainfall in the month of July and August. The average rainfall ranges between 200 and 1200 mm for different regions. Bani, Bashohli and Billawar areas receive more rainfall than other areas. The average rainfall of the Merth village is 456 mm with relative humidity of 90.66%.

Soils and vegetation

The soil of district Kathua varies between alluvial sandy loam in Plains of Hiranagar and Kathua to gravel in the Kandi area of the district. The main crops grown in the district are maize and wheat followed by paddy. Other crops grown in the district are millets, oil seeds, pulses and vegetables. Wheat and paddy constitute the staple food in plain tehsils, namely; Kathua and Hiranagar where as maize in hilly tehsils *i.e.* Billawar, Bashohli and Bani. The natural vegetation consists of trees, shrubs, climbers. The total cropped area in the district is 1.29 lakh ha. with merely 33.16% gross irrigated area.

Experimental details

The experiment was laid out to compare the impact of resource conservation techniques on the runoff and sediment yield in two different catchment areas (one with sandy loam texture and other with clay loam texture) in monsoon season. The slope of the catchment areas varies from 3-6%.

Various resource conservation techniques used in maize – wheat system

- Contour plowing
- Terrace farming
- Perimeter runoff control
- Cover crop (Black gram, *var.* Uttara)

- Agrostological measures (Bhabar, Khuskhus, Bermuda grass, Vetiver, Sesbania grandiflora, Eleplant grass
- Overgrazing prevention

Meteorological data recorded during the research programme

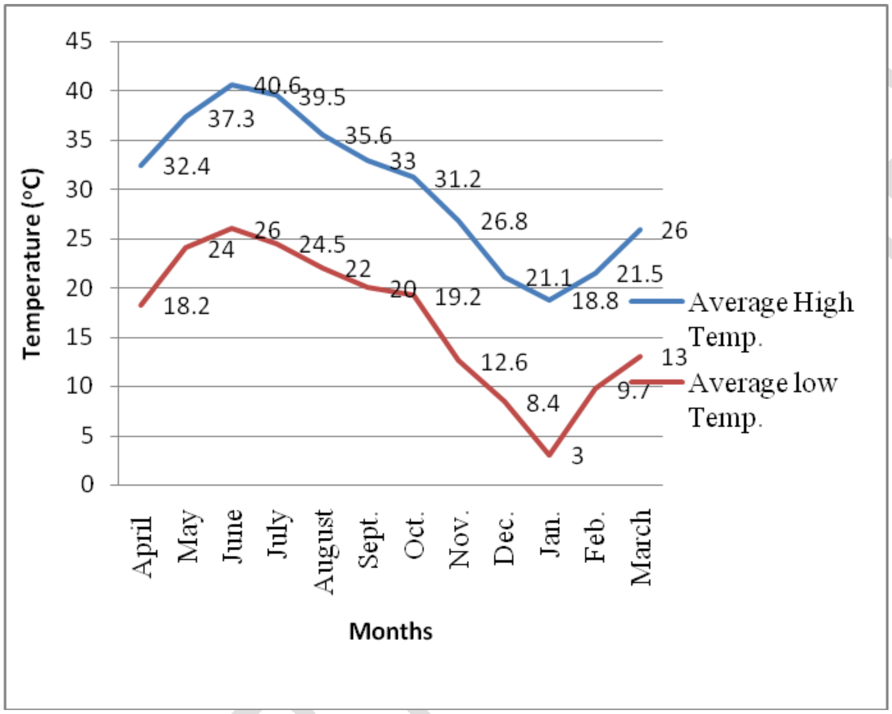

Fig: 1 Average max. and min. temperature (°c) from April 2018 – March 2019

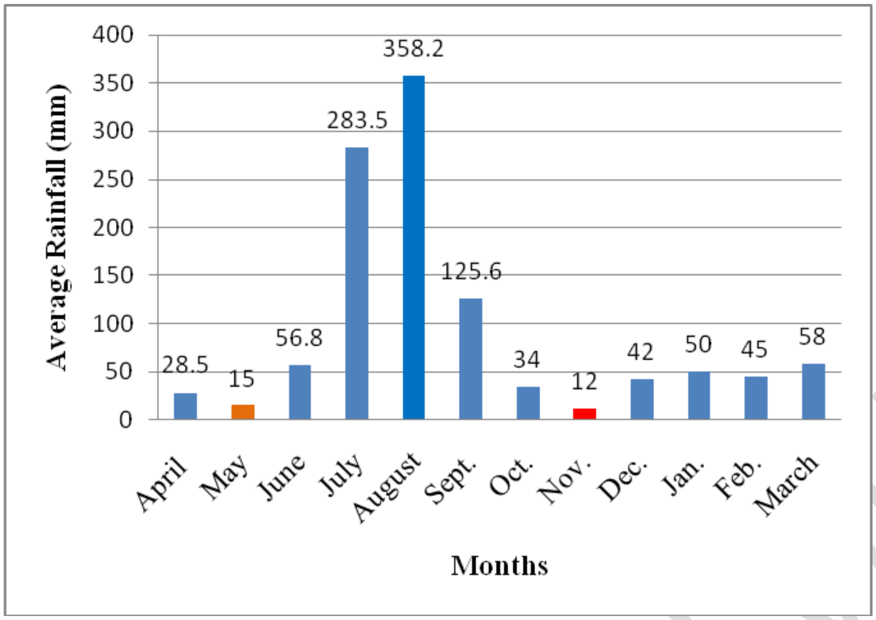

Fig 2. Average rainfall recorded from April 2018 – March 2019

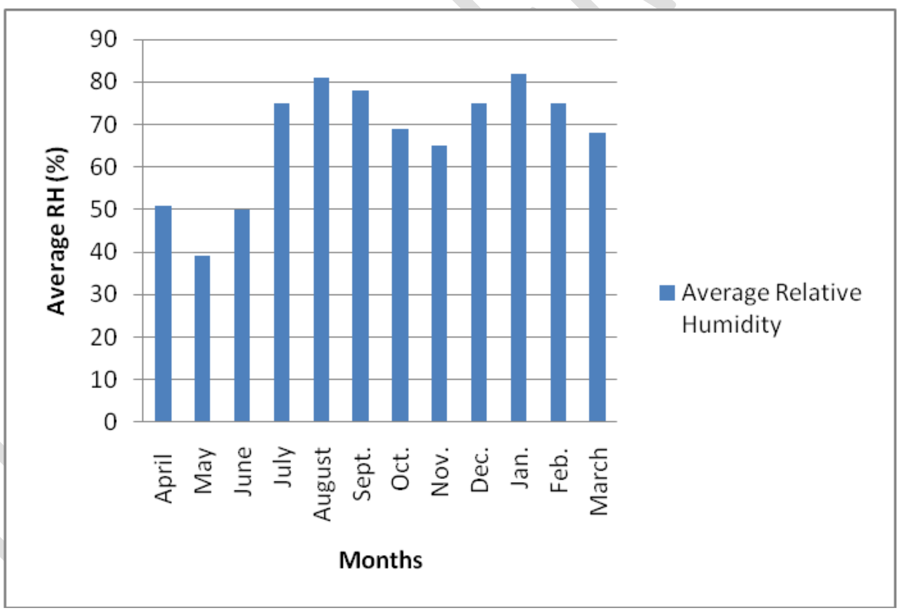

Fig.3 Average relative humidity from April 2018 – March 2019

Collection and preparation of soil samples

The composite surface soil samples were collected randomly from the both the watershed areas by using GPS. Collection of soil samples were based on the different types of conservation techniques 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 and chemical properties. Soil loss and runoff from these catchment areas was estimated through a proportionate runoff collection system during rainfall events.

Analysis of soil samples

Table 1 Methods employed for the determination of various soil physico-chemical properties

Parameters	Method	Reference
pH	Potentiometric method	Jackson, 1973
Electrical conductivity (dSm^{-1})	Salt bridge method	Jackson, 1973
Organic carbon ($g\ kg^{-1}$)	Rapid titration method	Walkley & Black, 1934
Available nitrogen ($kg\ ha^{-1}$)	Kjeldahl method	Subbiah & Asija, 1956
Available phosphorous ($kg\ ha^{-1}$)	Olsen's method	Olsen *et al.*,1954
Available potassium ($kg\ ha^{-1}$)	Flame photometry method	Piper , 1966

Table 2 Initial chemical properties of the experimental site

Parameters	Sandy loam	Clay loam
pH	7.2	6.4
Electrical conductivity (dSm^{-1})	0.60	0.50
Organic carbon ($g\ kg^{-1}$)	4.6	5.2
Available N ($kg\ ha^{-1}$)	230	250
Available P ($kg\ ha^{-1}$)	9	11
Available K ($kg\ ha^{-1}$)	140	160

3.6 Statistical analysis

For evaluating the influence of various resource conservation techniques on soil properties, 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.

RESULTS AD DISCUSSION

Effects of resource conservation techniques on selected chemical properties of soil

Soil pH

Soil pH among various resource conservation techniques in sandy loam varied between 7.33 - 7.84 and in clay loam varied between 6.64 - 7.73. In both the soils the minimum and maximum pH values were recorded from overgrazing prevention and cover crop respectively (Table 3 and 4). There was no significant difference in the pH values between contour plowing & terrace farming and perimeter runoff control & overgrazing prevention in sandy loam soil and between terrace farming and contour plowing in clay loam soil. The lower mean value of soil pH in overgrazing prevention could be attributed to high soil erosion which leads to loss of basic nutrients, relatively lower base saturation percentage and lower soil organic matter content. Studies by various researchers also showed that organic carbon was positively and significantly associated with soil pH, **Habtamu *et al*., 2009; Million 2003; Haweni 2015; Worku 2017; Solomon et al. 2017.**

Soil EC

As the statistical result indicated, EC of both the soils (sandy loam and clay loam) did not significantly affected by resource conservation techniques. Relatively high (1.41 dSm^{-1} in sandy loam and 1.33 dSm^{-1} in clay loam) and low mean value of EC (0.37 dSm^{-1} in sandy loam and 0.33 dSm^{-1} in clay loam) was recorded in overgrazing prevention and perimeter runoff control respectively. The high electrical conductivity values 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).**

Table 3: Resource conservation techniques impact on selected soil chemical properties in sandy 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	7.84 ± 1.21^{a}	0.46 ± 0.23^{bc}	8.14 ± 0.67^{a}	426.22 ± 75.71^{a}	28.52 ± 4.14^{a}	292.04 ± 37.34^{a}
AM	7.66 ± 0.07^{ab}	0.54 ± 0.19^{b}	6.89 ± 0.45^{b}	258.10 ± 34.81^{c}	24.43 ± 3.93^{b}	256.31 ± 34.43^{b}
TF	7.53 ± 0.07^{bc}	0.39 ± 0.19^{c}	5.87 ± 0.52^{c}	298.65 ± 49.93^{b}	14.05 ± 1.93^{c}	204.47 ± 34.63^{c}
CP	7.51 ± 0.07^{bc}	0.44 ± 0.21^{bc}	3.46 ± 1.04^{d}	216.42 ± 23.48^{d}	11.49 ± 2.02^{d}	139.89 ± 15.58^{d}
PRC	7.40 ± 0.05^{c}	0.37 ± 0.16^{c}	3.60 ± 0.71^{d}	195.45 ± 9.10^{e}	12.43 ± 1.45^{d}	125.51 ± 14.25^{e}
OGP	7.33 ± 0.13^{c}	1.41 ± 0.34^{a}	2.11 ± 0.64^{e}	148.95 ± 31.41^{f}	9.08 ± 1.36^{e}	95.08 ± 8.48^{f}

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)

Table 4: Resource conservation techniques impact on selected 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

The mean value of soil OC among different resource conservation techniques ranges between 8.14 g kg^{-1} and 2.11 g kg^{-1} in sandy loam whereas between 8.25 g kg^{-1} and 2.37 g kg^{-1} in clay loam (Table 3 and Table 4). The difference in organic carbon content in all the resource conservation techniques was statistically significant. Highest mean value of soil organic carbon a (8.14 g kg^{-1} in sandy loam and 8.25 g kg^{-1} in clay loam) was recorded in cover crop and lowest (2.11 g kg^{-1} in sandy loam and 2.37 g kg^{-1} in clay loam) in overgrazing prevention. The high value of soil organic carbon in cover crop could be attributed due to addition of root biomass and leaf litter. The root biomass might have increase the soil organic carbon accumulation in the subsurface layer. The lowest soil organic carbon content in overgrazing prevention may be due to poor growth, high runoff and high soil erosion, **Hassink (1995) and Sollins et al. (1996)**. Soil organic carbon was highest in cover crop as compared to other resource conservation techniques and results were consistent with the findings of **Nagaraja et al. (2016)** and **Kumar et al. (2018)**. This might be due to the production and return of higher amount of litter under cover crop. Similar results were also reported by **Bhat et al. (2012)**; **Feyissa et al. (2013)**; **Du et al. (2014)**; **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 in both the soil which is an 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 of the soil samples taken from the areas under different resource conservation techniques in sandy loam whereas in clay loam no significant difference was found between contour plowing and perimeter runoff control. In both sandy loam and clay loam the mean value of available nitrogen was highest in cover crop (i.e. 426.22 kg ha^{-1} in sandy loam and 440.10 kg ha^{-1} in clay loam) and lowest in overgrazing prevention (i.e. 148.95 kg ha^{-1} in sandy loam and 163.67 kg ha^{-1} in clay loam).

The increase in available nitrogen in sandy and clay loam can be attributed because of the increase in root biomass under resource conservation techniques. Addition of root biomass and litter fall in cover crop 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.

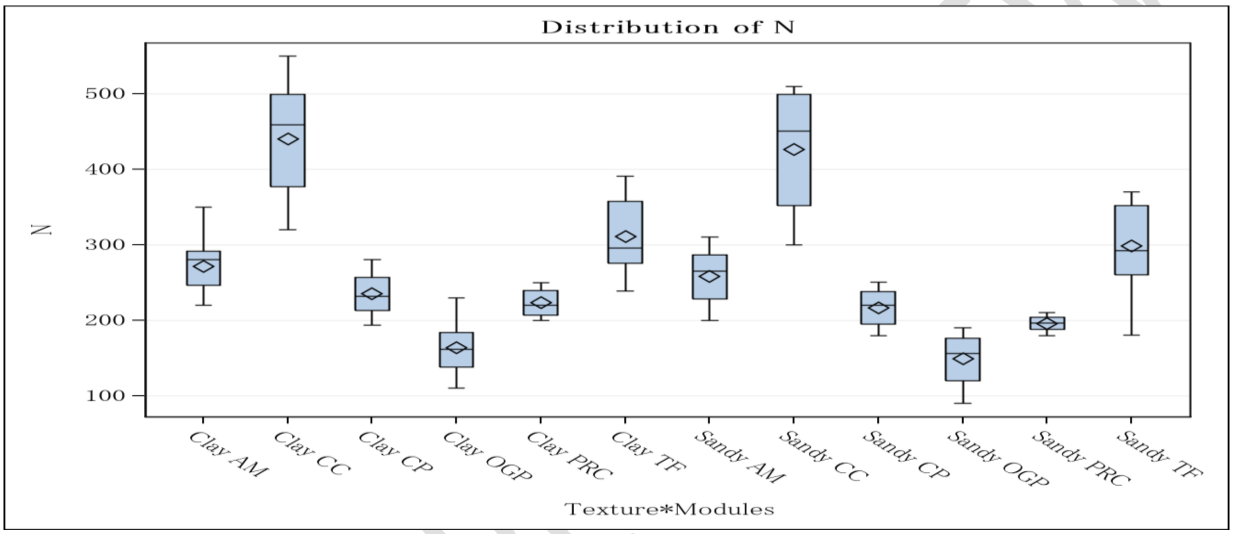

Fig: 4 Distribution of available nitrogen (kg ha^{-1}) under different conservation techniques in sandy & clay loam

Note: AM (Agrostological measures), CC (Cover crop), CP (Contour plowing), OGP (Overgrazing prevention), PRC (Perimeter runoff control), TF (Terrace farming)

Available phosphorous

Available P among different resource conservation techniques was highly variable. It varies from 9.08 to 28.52 kg ha^{-1} in sandy loam and 11.41 to 30.29 kg ha^{-1} in clay loam (Table 3 & 4 and Fig. 5). The mean value of available phosphorous was found highest in cover crop and lowest in overgrazing prevention in both sandy and clay loam soils. 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 through the organic pool of the soil, **Arya (2007); Cao *et al.* (2011); Arya *et al.* (2016).** Addition of organic matter through incorporation of cover crop in crop rotation or recycling of crop residues in the 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)**. Addition of organic matter through any mean *viz.* cover crop, root biomass, varieties, composite varieties help in the increase of soil solution inorganic phosphorous through mineralization of organic phosphorous and solubilization of native phosphorous compounds and its effect was significant, **Vig and Chand (1993); Hiradate and Uchidia (2004); Guppy *et al*. (2005).**

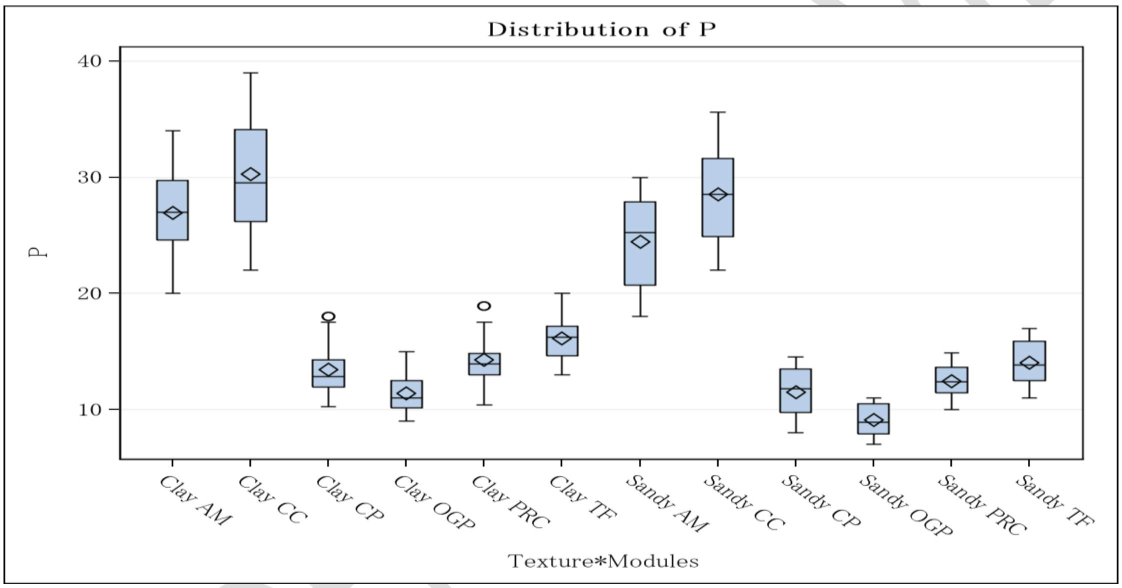

Fig 5: Distribution of available phosphorous (kg ha^{-1}) under different conservation techniques in sandy & clay loam

Note: AM (Agrostological measures), CC (Cover crop), CP (Contour plowing), OGP (Overgrazing prevention), PRC (Perimeter runoff control), TF (Terrace farming)

Available potassium

The concentration of available potassium in both sandy loam and clay loam was significantly affected by the resource conservation techniques. The highest concentration was recorded from cover crop (i.e. 292.04 kg ha^{-1} in sandy loam and 309.70 kg ha^{-1} in clay loam) and lowest from overgrazing prevention ((i.e. 95.08 kg ha^{-1} in sandy loam and 126.33 kg ha^{-1} in clay loam). This might be due to very low erosion impact in cover crop. Studies by **Kyaruzi (2013)** revealed that effective control of runoff improves the content of available potassium. This increase in cover crop could also be attributed because of the high root biomass compared to overgrazing prevention. Addition of root biomass and litter fall indirectly enhances the availability of available potassium through the process of mineralization, **Drinkwater *et al.* (1998); Sainju *et al.* (2008); Alvarez and Steinbach (2009).**

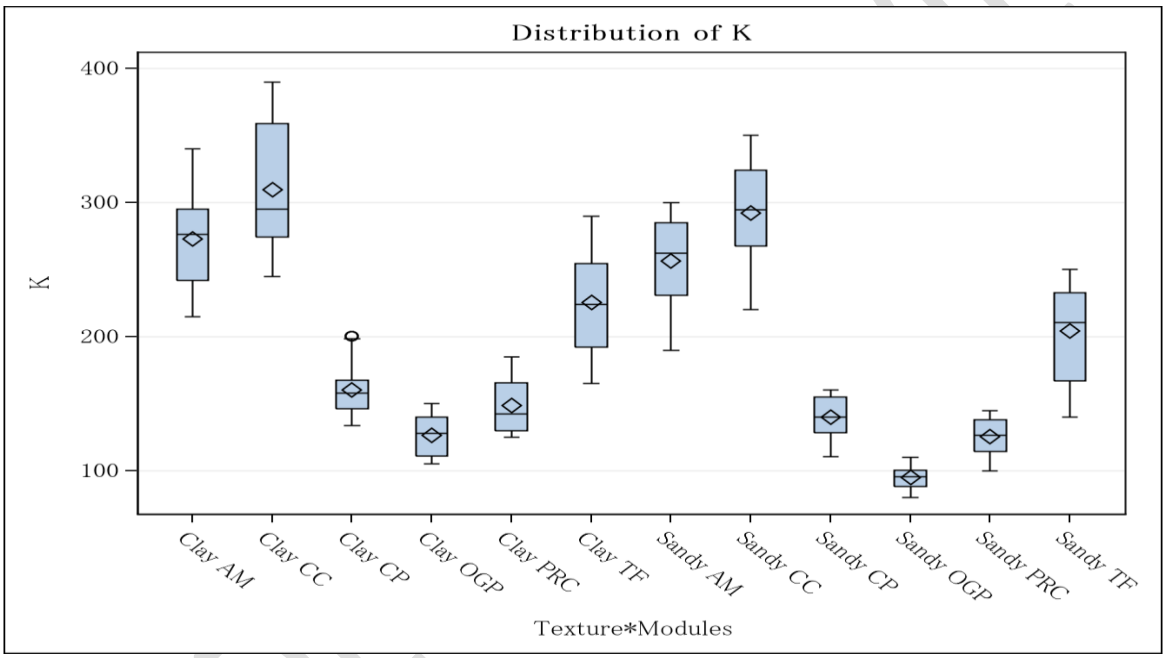

Fig 6: Distribution of potassium (K) (kg ha^{-1}) under different resource conservation techniques in sandy and clay loam

Note: AM (Agrostological measures), CC (Cover crop), CP (Contour plowing), OGP (Overgrazing prevention), PRC (Perimeter runoff control), TF (Terrace farming)

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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