September 2007 Volume 2 Issue 3

Environmental Science

Trade Science Inc.

An Indian Journal

Current Research Paper

ESAIJ, 2(3), 2007 [154-159]

Eco-Chemical Management Of Different Landuse In Indian Central Himalayas-A Case Study From Almora-Binsar Area

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Received: 26th June, 2007 ; Accepted: 1st July, 2007

ABSTRACT

The steep farming, smaller land holdings and other human encroachments increasingly threaten the agriculture ecosystem of the temperate hill region of Indian Himalayas. In the last few decades these are practiced as multiple uses, including the maintaining of environmental balance of the region. The present study was conducted to assess the poor traditional agriculture ecosystems and to discuss the prospects for improving their requirement by initiation of subsistence agro crop in the context of regular deterioration of these resources. A total of six trials from three traditional agriculture systems were considered for the present investigation i.e. marginal agriculture land, terraced agriculture land and irrigated agriculture land, including cash crop and non cash crop growing plots. It was obtained that the marginal agriculture land with poor-soil bunding are affected by steep ness, lower doses of fertilizer and frequent removal of grass biomass than the well-maintained bunding terraces. The results revealed that the small land holds size and marginal agriculture plot was with lowest soil moisture; organic carbon and nitrogen content and significantly varied with mentioned agriculture and irrigated plots for most of the soil characteristics. The peanut(*Arachis hypogea*) crops at marginal agriculture land enhancing one and half time farm income and more than five time for rainfed terrace agriculture, whereas the Potato(*Solunum tubersum*) cropping on and irrigated soil enhances nearly two fold in net incomes than the traditional crops cost. Moreover it augments ecological functions; carry valuable indigenous crops, retains soil moisture and provides continuous supply of organic matter and nutrients.

KEYWORDS

Rainfed agriculture;
Soil nutrient;
Practices;
Interventions;
Central Himalaya.

INTRODUCTION

The steep and small land hold size of agriculture systems of the Himalaya have under gone continuous changes during the last decades; being converted into resorting, grass cultivation and road construction. With the tremendous increase in population in the Himalayan region, the dependency for the farm based agriculture products has been retained on terrain agriculture products, beside this there is also an increase in number of jobless families, which totally depend on the aforesaid. Natural patches along the mountain slopes are removed to make use of under laying fertile soil for cultivation practices, leading to serious form of land degradation i.e. land slide, mud flow and gully erosion.

Mismanagement of these land resources by different indiscriminative activities i.e. continuous division, grand old agriculture practices, poor quality of fertilizer and lack of technical know-how, is a great threat to the Central Himalayan region of India. These activities bring changes in the crop productivity and nutrient status of the soil. The aim of the present study is to investigate the variation in soil properties and crop productivity of rain fed agriculture and irrigated agriculture ecosystems, which are under different interferences. Further, to discuss the prospects to enhance the farm economy through sustainable agro crops and improved technical know how on the soil developed over slight varied different Geomorphological conditions and the implication for income generating agro species cultivation in sandy loam to loamy sand farmland system of Almora-Binsar area of Indian Central Himalaya.

MATERIALS AND METHODS

The study area covers the agriculture land of Almora- Binsar area in mid Central Himalayas. It is located between the geographical coordinate $29^0 03'$-$29^0 55'$N Latitude and $79^0 02'$-$79^0 40'$ E Longitude. Detailed geology and physiography of the area is presented in TABLE 1. The climate of the area is temperate with pronounced summer, winter and rainy season. In general the rain fed agriculture land are often located in higher relief, part of which is recently under thorough mismanagement due multiple causes i.e. rapid migration, traditional agriculture and small land hold size as well.

The perception of the local people is that the cultivation cost of these land resources are economically higher than of the product purchased from market. The major cost items were human and animal labour used for land preparation, ploughing planting and transplanting, weeding, pruning, fertilization and harvesting, followed by the material requirements, such as seeds and planting materials, fertiliz-

TABLE 1: Catchment soil characteristics, geology of different agriculture plots

Agriculture land type	Agriculture code	Location	Physiographical and geological characteristics of the sites
Existing soil			
Marginal agriculture soil	E_1	Dina pani	AR->2000m,RR-200-300m, SR-15--20^0, Gneiss, schist and quartzite rocks. With thrust passed along the catchment area, inclined and vertical joints
Terraced agriculture soil	E_2	Najweula	AR- 1800-2000m, RR-200-300m, SR-10-15^0, Gneiss, schist and quartzite rocks with Inclined and vertical joints
Irrigated soil	E_3	Jweula	AR- 1800-200m, RR- 300-4000m SR-5-10^0, Gneiss, schist and quartzite rocks Inclined and vertical joints
Intervened soil			
Marginal agriculture soil	I_1	Barsimi	AR-1800-2000 m, RR=-200-300m SR-15-20^0, Schist and quartzite rocks with Sheer zone passes along the catchment area, inclined and vertical joints
Terraced agriculture soil	I_2	Manan	AR- 1600-1800m, RR-200-300m SR-10-15^0, Schist and quartzite rocks with inclined and vertical joints
Irrigated soil	I_3	Ranman	AR- 1400-1600m, RR-200-300m, SR-5-10^0, Schist and quartzite rocks with inclined and vertical joints

E_1-E_3= Existing soil, I_1-I_3= Intervened soil, AR-Absolute relieves, RR-relative relieves, SR=slope range ers, insecticides, pesticides and so on. The estimation of labour cost was based on the local wages rates. In general, a male labour in the study area is paid Rs.100/days(IC) and a women labour is paid Rs.70/-(IC). Similarly animal labour is paid at the rate of Rs.250/-to 400/-(IC) pair of oxen/day(for approx 500m^2 or 0.05ha land ploughing). Thus, aforesaid problems are great challenges in maintain the agriculture land and high yield as well. Under these practices such valuable land underestimate for its negative impacts on soil characteristics of these land ecosystems. The study estimates the effect of different of practices i.e. improper management; grand old practices and other soil deteriorating facts on soil characteristics and production of these farming lands.

Geology

The study area lies in the central part of the Kumaon lesser Himalaya covered by Almora nappe of Precambrian crystalline rocks. All three agriculture plots have varied assemblages of the Precambrian sedimentary rocks injected with granite of two age under the Almora nappe, thick succession of sedimentary rocks intimately associated show different geological formation. The sedimentary rocks are divisible into the lower ferrigenous rocks and upper dominantly carbonate sediments[3]. The Almora group, that constitutes the Almora nappe, is made-up of garnetiferous mica schist interbedded with micaceous quartzites, gneisses and carbonaceous phyllites interbedded with graphitic schist. The area represents severely compressed complex folds and cuts with mica schist covered with thin layer of top-soil. The differences in sedimentary rocks contribute to influence on organic debris's and soil nutrient.

Study designed

The study was conducted during mid June to October in the year 2000 and 2001 to measure the variation in soil properties and crop productivity in rain fed and irrigated agriculture ecosystems. A total of six crop management systems were investigated, out of which the first three belongs to existing agriculture practices(two rain fed and one irrigated agriculture soil) and the last three belongs to intervened agriculture management system, at slop range i.e. 5^0-20^0. A survey for crop economic feasibility analysis was made by field visits and interaction with farmers by formal and informal meetings as well.

Soil sampling and analysis

Plot of 100m^2(0.01ha) size(n=3) were selected for representing each existing agriculture land. Keeping in view to estimate the effect of different climatic, geological and cultural practices on existing land use ecosystems, gaps between two sampling phases was maintained as one year i.e. during June-October 2000 and 2001. Soil samples were collected from 0-20cm soil depth from described plots with help of bulk density tube sampler, mixed thoroughly, dried and used for determination various physical and chemical properties. The physico-chemical characteristics of the soil have been analysed following Jackson[2] and Allen[1]. The computed mean of crop sowing and harvesting stage was computed as mean for the year 2000 and 2001. The Soil texture, WHC and soil moisture measured for crop sowing period, pH including the nutrient pool status were obtained for both of the stages. The soil varied from site to site.

Due to important role of soil moisture, an hourly variation in soil moisture have been recorded from all the sites with aid of soil moisture equipment(Trase system, USA) and a mean for each of the sampling days was calculated. For estimation of nitrogen, the samples were digested in 10ml concentrated sulfuric acid and catalyst(5gm potassium sulphate +0.1gm copper sulphate) at 420^{0}C in an aluminum block digester. The samples were then analysed in K-JELTEC, auto 1030 analyzer (TECATOR, Sweden) for total nitrogen. Available phosphorus was determined by Bray extract method, by chlorostannous-reduced molybdophosphoric blue colorimetric method using 5 gm soil sample extracted with 50ml Bray extract. Available potassium was estimated using a flame photometer. Data were analyzed statistically[4]. Relationship between crop management in existing and intervened systems of various parameters(average) developed has been subjected to analysis of variance(ANOVA).

RESULTS AND DISCUSSION

Geological, physiography and soil characteristics

The soil depth of the study area vary from 0.50m-1.50m due to variation of parent material viz. gneiss, schist and quartzite having different degree of weathering and relief. Thus the biomass accumulation and nutrient mineralization rate was varying from site to site. In the irrigated soil highest moisture content, organic matter accumulation and higher C:N ratios were recorded in comparison to rainfed sites. Thus in the above geological formations, the soil moisture favoring higher rate of organic matter accumulation contribute, differential biomass accumulation and sequestering of soil nutrients due to spatial variation in chemical and mineral soil attributes[5].

The soil colour varies from light gray to dark brown whereas the soil texture ranges from sandy loam to loamy sand type. The marginal agriculture plot has higher silt and clay content. The water holding capacity(WHC) increases with an increase of the silt and clay percentage and organic matter content of soil as well. The soil moisture was higher in the irrigated soil, which increases with the soil texture and managed terraces for irrigated soil(TABLE 2).

The results revealed that crop sowing stage(SS) for all the cropping management system the soil pH varies from 6.83-7.19. The organic matter and organic carbon varies from 2.04-3.74% to 1.18-2.16% respectively. The irrigated soil has higher organic matter and carbon, this probably due to lower erosional losses and comparatively higher farmyard manure. The total nitrogen is higher irrigated 0.197% and lowest in the marginal agriculture terraces. The C:N ratio comparatively higher for marginal agriculture probably due to the slow rate of mineralization in upper relief. The valley location and well maintained terraces for irrigation are instrumentals for higher organic matter decomposition and higher rate of mineralization. The available P is higher 22.17kg/ha in intervened terrace soil followed by terrace agriculture plot. It might be due to less grass and biomass produced under higher erosional and leaching losses from sandy loam soils, causing less absorption of P from the soil. The available K was recorded lower for marginal agriculture 231kg/ha.

Crop type and soil management

TABLE 2: Soil physical characteristics of agriculture plots in Almora-Binsar area(n=3)

Parameters	Period	Existing agriculture crops			Intervened crops		
		Marginal agriculture soil	Terraced agriculture soil	Irrigated soil	Marginal agriculture soil	Terraced agriculture soil	Irrigated soil
Soil Colour	SS	10YR5/3	10YR5/2	10YR5/5	10YR5/4	10YR5/3	10YR4/3
Soil texture(Clay+Silt)	SS	33	39	47	35	38	45
W.H.C(%)	SS	34.2±1.20	56.05±1.40	71.2 ±2.20	38.05±2.10	52.05±2.02	82.05±2.02
Moisture(%)	SS	19.42±1.80	23.20±2.00	30.42±1.80	22.20±3.35	24.20±3.15	36.10±3.25
pH	SS	6.83±0.10	6.92±0.06	7.19±0.08	6.42±0.04	6.3±0.02	7.12±0.07
	HS	6.87±0.06	6.80±0.08	7.05±0.10	6.60±0.07	6.44±0.09	7.22±0.05
O.M (%)	SS	2.04±0.28	2.68±0.30	3.74±0.80	2.19±0.50	2.47±0.31	3.64±0.44
	HS	1.57±0.16	1.69±0.18	2.45±0.62	1.81±0.28	1.87±0.26	2.48±0.35
O.C.(%)	SS	1.18±0.17	1.55±0.21	2.168±0.51	1.269±0.33	1.432±0.17	2.110±0.24
	HS	0.91±0.12	0.98±0.19	1.42±0.22	1.05±0.14	1.08±0.17	1.44±0.26
Tot. N(%)	SS	0.115±0.004	0.164±0.006	0.197±0.010	0.133±0.008	0.127±0.011	0.188±0.016
	HS	0.095±0.006	0.117±0.005	0.129±0.012	0.106±0.005	0.111±0.010	0.156±0.013
C:N ratio	SS	15.1±1.01	9.47±1.20	11.00±3.20	9.54±2.1	11.27±2.30	11.17±2.60
	HS	9.50±1.22	8.37±1.08	11.00±2.85	9.90±1.87	9.73±2.34	9.20±2.46
Available P kg/ha	SS	19.45±0.98	22.14±1.02	20.10±1.13	17.14±2.10	19.44±1.12	22.17±1.44
	HS	14.95±0.72	19.08±1.11	16.34±1.37	15.98±1.81	17.54±1.34	18.14±1.28
Available K Kg/ha	SS	195±05	212±0.08	231±12	187±16	219±08	204±07
	HS	191±03	209±0.05	2291±09	189±12	214±07	201±04

Note: SS= Sowing stage, HS=Harvesting stage, WHC=Water holding capacity

A wide variation of soil properties of different crop and soil types (TABLE 2) was noticed in the study area. The statistical analysis(analysis of variance, ANOVA) of the irrigated soil significantly varies from the other soil in most of the studied parameters($P<0.05$). The water holding capacity of all the agriculture soil significantly varies from site to site. The moisture content insignificantly varies in between the irrigated soil. A significant variation in soil pH is recorded for the irrigated and rainfed soil. The organic matter, organic carbon and nitrogen content are found to be insignificant for the marginal terraced soil and intervened marginal terraced soil. The C:N ratio insignificantly varied for the existing and intervened soil. The available P shows entirely different behavior to other soil properties. The available P also found to be insignificant in between the existing and intervened soil, whereas available K proves insignificant for the studied sites and in between the cropping practices.

Soil pH, nutrient pools and cropping stages

All the selected sites have a wide variation slope range, crop composition, terraces bunding and in vegetal biomass species. Among the studied sites, the soil pH marginally varied from site to site but the nutrient concentration significantly varied in between the sites. Further, the pH slightly varied for two studied stages, however the nutrient pools i.e. O.M., O.C, total N(%) and available P significantly varied in sowing and harvesting stage. The available K marginally varied in between the two phases, TABLE 2.

Existing and intervene soil

The survey revealed that the peanut and potato cropped soil with two to three fold increase in crop productivity than the existing cropped soil(TABLE 3). In general the intervened crops begets quite higher cash than the traditional cropping systems and reduced the workload of the farmers who recently adopted the practices in the study area. Beside, this

TABLE 3: Crop cost-benefit analysis in existing and intervened soil (n=3)

Details of crop cultivation	Marginal agriculture soil	Terraced agriculture soil	Irrigated soil	Marginal agriculture soil	Terraced agriculture soil	Irrigated soil
Name of crop grown	E Coracana	O.Sativa/E.coracana, G.Max, D.Uniflorus and P.radiates in an alternate year	O.sativa	Arachis hypogea	Arachis hypogea	Solanum tebersum
Total crop production (t/ha)	1.70t/ha	2.5t/ha E.Coracana 1.2 t/ha lentil 2.0 t/ha O.sativa	4.5t/haO.sativa	1.1.0t/ha	2.7t/ha	12.00t/ha
Ploughing cost (@ Rs per ha)	3000/-	5000/-	6500/-	3200/-	3200/-	5400/-
Weeding and harvesting cost (in terms of the farm holder labour)	2400/-	4000/-	7000/-	3500/-	3500/-	3500/-
Total cultivation cost (Rs.)	**5400/-**	**9000/-**	**13500/-**	**6700/-**	**6700/-**	**8900/-**
@Rs per kg	4/- per kg E.Coracana 10/- per kg G.Max, D.Uniflorus and P. radiates	4/-per kg E.Coracana =10000/- 10/-G.Max, D.Uniflorus and P.radiates =12000/- 12/-per kg paddy	12/-per kg O.sativa =54000/-	28/-per kg =30800/-	28/-per kg =75600/-	7/-per kg =84000/-
Total product selling cost (Rs.)	**6800/-**	**24000/-**	**54000/-**	**30800/-**	**75600/-**	**84000/-**
Total benefit (Rs.)	2400/-	1000/-to 13000/-	40500/-	24100/-	69900/-	73100/-

the increase nutrient pools for next traditional crops of wheat in all categories of land. The intervened sites show significant variation in WHC, moisture content, organic matter and organic carbon and soil nutrients from the existing sites.

CONCLUSION

The traditional framing systems have not been adequate for crop productivity and present level of food requirement in the study area. The available alternatives for subsistence hill farmers to increase farm income are limited. The soil nutrient management and cost benefit analysis indicated that improvement of the existing agriculture practices ensure greater economic benefits than the traditional agroforestry system based on cereal crop production and is useful for environmental and livelihood perspectives. Further, the study also showed that the intervened agriculture sites were more profitable than the existing systems. According the farmers, multiple factors, such as insecure land tenure, land fragmentation, limited technical know how, poor extension services are discouraging for the hill agriculture. Beside this, the insufficient marketing information, inadequate technical support and treatment against different crop diseases are the limiting factors. Thus there is a need for the farmers to adopt the cooperative farming in such eco-geological conditions.

ACKNOWLEDGEMENT

The author is thankful of the Director of this institute to providing the facilities. My special thanks go to the progressive farmers of the study area to providing the land, labour and expenditure the for interventions.

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