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SOIL EROSION, RUN OFF AND NUTRIENT LOSSES UNDER DIFFERENT VEGETATIONAL AND SOIL CONSERVATION MEASURES

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ABSTRACT

An experiment was conducted at the Horticultural Research Station, Kodaikanal for a period of one year from June, 1991 to study the influence of vegetation on soil erosion, run off and nutrient loss under different vegetational cover. The soil conservation methods of bench terraces and contour stone wall were compared with plantations without any conservation measure. The plantations were apple, eucalyptus and acacia besides plots of seasonal crops of vegetables and geranium. Under each ecosystem, plots with and without natural soil cover were compared. The results revealed that the loss through soil erosion in terms of sediments (1115 kg/ha/yr) and run off water (9.09 lakh l/ha/yr) and also nutrient loss through them were quite high (86-4.7-64.5 NPK kg/ha/yr) in the eucalyptus plantation on cleared ground without any conservation measure. The above losses were found to be low under apple planted on bench terraces with natural grass as soil cover. The contour stone wall was effective in checking the erosion related problems though not to the extent of bench terraces.

KEY WORDS : Soil Erosin, Run-off, Nutrient Loss, Vegetation Conservation

Soil erosion due to excessive rainfall is very damaging to soil fertility owing to the removal of nutrient rich top-soil consisting of clay and organic matter. Though in humid climate, abundant vegetation ought to protect the soil, natural vegetation had been slowly removed and substituted by several types of cultivated plantations. This aggrevates soil erosion further aided by heavy rainfall. An attempt was made in this investigation to study the sediment loss as influenced by natural soil cover, seasonal and perennial vegetation and different soil conservation measures under Kodaikanal hill soils.

MATERIALS AND METHODS

An experiment was laid out with three methods of soil conservation, two different vegetations under each method and also adoption of soil conservation in combination with and without natural ground cover. The selected treatment combinations of six vegetational ecosystem were tried. Two constructed conservation measures, *viz.*, bench terraces and contour stone wall were included in comparison with 'check' without any conservation to protect the soil. The natural soil cover of grass was cleared in vegetable (beans) growing in bench terraces, geranium by contour stone wall and eucalyptus plots without any conservation measures. In bench terraching method of soil conservation, perennial (apple) as well as seasonal crops (vegetables) were compared. Under contour stone wall, acacia and geranium were included. The plantation of eucalyptus without any conservation measure was treated as absolute 'check'. Thus there were six ecosystems under comparative treatments.

1. Uncleared eucalyptus; 2. Cleared eucalyptus; 3. Uncleared acacia plantation; 4. Cleared geranium crop; 5. Apple uncleared plantation; 6. Cleared vegetable plot

In every treatment area the run off pits (15 x1x0.5 m) as standarised by Wischmeier and Smith (1978) were laid out at the lower most slope and lined with polyethylene sheets (800 gauge). These studies were conducted with a plot size of 20 cents. After every effective rain (above 10 mm/day) the run off water was measured by quantifying the water collected inside the pit. Similarly, the weight of soil lost during every rain was also monitored. The nutrient loss through eroded soil and run off water was computed by analysing the nutrient contents in the composite samples of run off water.

RESULTS AND DISCUSSION

The soil loss through erosion ranged from 42 to 93 kg/ha/month. This loss varied widely among plots under different crops as well as conservation measures. The highest loss observed during October was a reflection of a high monthly rainfall.

Table 1. Initial soil sample analysis of run off plots under different vegetation and conservation measures

Particulars	No conservation		Contour stone wall		Bench terraces	
	Uncleared Eucalyptus	Cleared Eucalyptus	Uncleared Acacia	Cleared Geranium	Uncleared Apple	Cleared vegetable
Mechanical abalysis						
Clay (%)	28.46	29.31	24.53	23.48	25.41	20.20
Silt (%)	7.60	13.43	11.43	12.43	11.46	1320
Fine sand (%)	29.28	27.54	30.17	28.16	28.46	30.62
Coarse sand (%)	34.66	29.72	33.87	35.94	34.67	35.98
Apoarent specific gravity (g cm)	1.03	1.07	1.09	1.00	1.06	1.82
True specific gravity (g cm^{-3})	1.65	1.63	1.45	1.74	1.33	1.67
pH	5.60	5.63	5.60	5.20	5.18	5.61
EC (m.mhos/cm)	0.10	0.21	0.11	0.15	0.30	0.60
Organic carbon (%)	4.53	4.16	4.04	5.40	3.53	3.70
Nutrient elements (kg/ha)						
Total N	2760	2430	2844	2520	2036	2052
Total P	2852	2582	2936	2638	2116	2135
Total K	1682	1538	1435	1689	1012	1214
Available N	623	533	661	583	488	435
Available P	16	15	14	15	14	14
Available K	122	132	82	108	146	129

As could be expected, the eroded soil loss was found to be low during January which had also the lowest rainfall. The apple plantation on bench terraces with grass cover had appreciably low rate (42 kg/ha/month) of erosion as compared to the vegetable plot on bench terraces (59 kg/ha/month) and tree species of eucalyptus and acacia. This might be due to the effectiveness of bench terrace and grass cover as conservation measures (Barnett *et al.*, 1972; Kannan, 1990). It was observed that natural grass cover had an effective role and this was distinct from the influence of constructed conservation measures and other vegetational covers. For instance, in the presence of natural

Table 2. Sediment (kg/ha) and run off water (1000 l/ha) loss under different vegetation and conservation measures

	No conservation				Contour stone wall				Bench terraces			
	Uncleared Eucalyptus		Cleared Eucalyptus		Uncleared Acacia		cleared Geranium		Uncleared Apple		Cleared vegetable	
	S	R	S	R	S	R	S	R	S	R	S	R
June 91	116	84	130	109	80	73	92	81	57	52	67	62
Jully 91	54	77	63	43	38	33	42	37	22	20	31	30
Aug. 91	62	44	70	49	42	37	50	42	26	25	32	32
Sep. 91	111	65	129	169	85	73	94	77	66	55	64	65
Oct. 91	261	201	281	246	176	177	222	187	143	133	162	158
Nov. 91	119	98	140	119	82	82	103	91	63	83	75	73
Dec. 91	34	25	45	29	24	22	29	24	13	12	19	19
Jan. 92	10	8	13	8	7	6	8	7	4	5	6	5
Feb. 92	-	-	-	-	-	-	-	-	-	-	-	-
Mar. 92	-	-	-	-	-	-	-	-	-	-	-	-
Apl. 92	58	50	79	57	46	44	57	46	35	28	38	40
May 92	138	119	166	140	116	100	123	109	76	64	90	91
Total	936	754	1115	969	697	646	821	702	499	46	586	573
Mean	80	63	93	81	58	53	68	59	42	38	49	47
S.D.	75	59	82	77	52	51	64	55	42	39	47	46

S : Sediment; R : Run off Inter.

Table 3. Nutrient loss (kg/ha) under different vegetation and conservation measures

	No conservation						Contour stone wall						Bench terraces					
	Uncleared Eucalyptus			Cleared Eucalyptus			Uncleared Acacia			Cleared Geranium			Uncleared Apple			Cleared vegetable		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
June 91	8.7	0.31	8.5	8.0	0.25	8.9	8.0	0.19	6.3	8.3	0.22	6.8	6.6	0.17	5.1	7.2	0.18	5.7
Jully 91	4.0	0.15	2.9	5.2	0.17	3.1	3.8	0.15	2.4	3.9	0.16	2.8	3.1	0.12	2.1	3.4	0.14	2.0
Aug. 91	3.1	0.13	2.0	4.3	0.15	2.2	2.9	0.14	1.7	2.9	0.15	1.8	2.3	0.12	1.3	2.6	0.12	1.4
Sep. 91	9.4	0.45	10.5	12.3	0.50	10.5	9.1	0.44	9.5	9.2	0.46	10.0	8.2	0.37	5.6	8.8	0.39	6.8
Oct. 91	19.8	0.35	14.6	22.0	1.42	15.7	18.3	1.22	15.0	18.7	1.22	14.8	15.3	1.17	9.8	16.2	1.19	2.6
Nov. 91	9.4	0.54	11.0	10.6	0.59	10.6	8.9	0.54	10.0	9.0	0.58	10.2	7.8	0.50	9.6	8.3	0.52	9.6
Dec. 91	2.1	0.21	1.5	3.0	0.25	1.9	1.7	0.22	1.3	2.0	0.23	1.4	1.4	1.19	1.0	1.4	0.20	1.1
Jan. 92	0.9	0.10	1.9	1.2	0.11	2.1	0.8	0.08	1.8	0.7	0.09	1.8	0.7	0.06	1.5	0.8	0.07	1.7
Feb. 92	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mar. 92	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apl. 92	5.1	0.33	3.4	6.2	3.35	3.6	4.7	0.30	3.0	4.8	0.31	3.1	3.8	0.28	4.0	4.2	0.29	3.2
May 92	10.3	0.90	7.0	11.4	0.96	8.0	9.6	0.86	7.7	9.9	0.88	7.8	8.1	0.86	7.1	8.9	0.85	8.0
Total	73.0	4.48	61.3	86.1	4.74	64.5	67.8	4.14		69.4	4.29	60.5	57.2	3.84	47.1	61.6	3.95	52.1
Mean	6.1	0.37	5.1	7.2	0.40	5.4	5.6	0.35	4.9	5.8	0.35	5.0	4.8	0.32	3.9	5.1	0.33	4.3
S.D.	5.8	0.60	4.8	6.6	0.42	4.2	5.7	0.37	4.8	5.5	0.37	4.6	0.4	0.35	4.9	4.8	0.37	4.1

cover under cultivated annuals as well as under the tree species, a lower level of soil erosion (60 kg/ha/month) than that of the cleared natural cover (70 kg/ha/month) was noticed. These results were in agreement with findings of Unger *et al.* (1977). As to constructed conservation measures bench terracing (45 kg/ha/month) was found to be superior to contour stone wall (63 kg/ha/month). Plots without any conservation measure recorded the highest sedimentation (86 kg/ha/month). This proved the effectiveness of bench terracing and contour walls as soil conservation measures as confirmed by Mc Cool *et al* (1977). The cumulative soil loss recorded for one year under different vegetational ecosystem revealed that 1120 kg of soil/ha had been lost under the 'control' system namely eucalyptus plots on cleared ground. This clearly indicated that the tree ecosystem without any conservation measure was prone to leaching and soil erosion to a very great extent. The contour stone wall reduced the soil loss to some extent (760 kg/ha) though it was not as effective as bench terracing (Table 2).

The cumulative loss of run off water (Table 2) varied between 4.56 to 9.08 lakh l per ha and it was found to be the lowest under apple planted bench terraces and the highest in eucalyptus plantation on cleared ground coupled with no soil conservation measure. Among the conservation measures, bench terracing recorded the lowest quantity of run off water (5.14 lakh l/ha), compared to contour stone wall (6.74 lakh l/ha) and in plots without any conservation measures (8.31 lakh l/ha). The magnitude of water lost through run off corresponded to the sediment loss for the same amount of rainfall. Here again, the superiority of bench terracing was well established. This was in line with the observations made by Mc Cool *et al.* (1977) and Kannan (1990). As in the case of soil loss, the effectiveness of natural cover in reducing run off water loss was evident under different conservation measures. The run off water loss recorded under natural soil cover was always low. The perusal of the monthly and cumulative run off water recorded under different vegetational covers revealed that the tree species without any soil conservation had caused higher magnitude of water loss than the annual crops like vegetables and also the apple which was raised on bench terraces. These in spite of intensive cultivation checked to some extent the run off water from the system.

Among the major nutrients lost through run off water, high loss was noticed in the instance of N followed by K. Relatively low quantities of P were

Table 4. Soil loss, run off water and dissolved nutrient losses in different vegetation and conservation measure for the year 1991-1992

Soil ecosystem	Soil loss (kg/ha)	Run off water (l/ha)	Dissolved nutrient loss (kg in total run off water)		
			N	P_2O_5	K_2O
No conservation					
Uncleared Eucalyptus	963.32	7,53,865	73.01	4.476	62.27
Cleared Eucalyptus	1115.35	9,08,673	86.11	4.732	64.45
Contour stone wall					
Uncleared Acacia	696.51	6,46,060	67.77	4.138	58.66
Cleared Geranium	820.55	7,02,861	69.39	4.291	60.48
Bench terraces					
Uncleared Apple	499.06	4,55,793	57.24	3.835	47.10
Cleared vegetable	586.02	5,73,900	61.61	3.953	52.11
Mean	780.14	6,73,025	69.18	4.139	57.28
SD	232.90	1,54,462	10.03	0.336	6.46

observed to be lost through run off water (Table 3). This fact was ascribed to the low solubility of P by way of precipitation as insoluble P by the presence of Al and Fe oxides in the soils at the experimental site. The escalation of N and K loss could be attributed to the excessive rainfall, the nature of their solubility (Subramanian, 1988) and the initial soil nutrient status (Table 1). The quantity of N leached out varied between 62 to 86 kg and k between 52 to 64 kg/ha/year. The bench terracing method of soil conservation proved to be effective in checking the nutrient loss as compared to the contour stone wall. The magnitude of losses of the major nutrient elements was higher in eucalyptus on cleared ground followed by eucalyptus with natural cover underneeth, both of which enjoying no constructed conservation measure. The variation in P loss (O to 1 kg P_2O_5/ha/year) under different situations was low as compared to N and K. This again was attributed to its degree of solubility in the run off water. The natural soil cover had a decisive role in checking the nutrient loss. For instance, as much 5 kg of N and K were saved by the presence of natural cover under apple plantation as compared to the vegetable plot, both of which remained under bench terraces. This was in line with the results of Unger *et al.* (1977). The quantum of major nutrients lost during October was high followed by November which corresponded to the loss of water by surface run off. The study emphasized that the bench terracing method of soil conservation was effective in arresting soil erosion and run off (Table 4). The natural grass soil cover had a major role to play in conserving the soil and water. The apple plantation on bench terracing with grass as a soil cover had low magnitude of soil, water and nutrient loss when compared to other situations of vegetation and conservation measures studied under Kodaikanal hills.

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