Effect of different soil conservation measures on infiltration capacity of soil at FazaGat Swat

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ABSTRACT---For management of watershed area land use optimization is the best management tool for the managers. Knowledge about the effect of different soil conservation measures on the water budget is very important. In mountainous area loss of water from the watershed is one of the major problems in Pakistan due to low infiltration capacity. Pakistan Forest Institute Peshawar initiated a study to determine the effect of different land uses/bio-technical treatments on runoff and sediment yield in the sub tropical Chir pine zone in the head water catchment. For this purpose five contiguous sub-watersheds (having almost similar slopes and soil characteristics) were selected which have been instrumented in to measure stream flow, sediment yield, precipitation and other atmospheric and soil parameter at FazaGat, near Saidu Sharif, Swat, KPK. Different treatments namely; mix plantation with engineering techniques, mix plantation, pure chirpine plantation with engineering techniques and pure chirpine plantation with range land improvement practices and closed to grazing were randomly applied to four sub-watershed, while the 5th one was kept untreated and open for grazing. The objective of present study was to assess the effect of different soil conservation measures on infiltration capacity of soil at experimental watershed, FazaGat, Swat District, KPK. Soil infiltration capacity was studied in the field using double ring infiltrometer with a constant head of 2.5 cm. At each point total ten readings were recorded The statistical analysis of the data was carried out, using F-test. A probability level of 5 % was used. The average maximum (9.16 cm/hr) infiltration rate was recorded from sub-watershed (SWl) treated with (mixture of tree species + check dams + on grazing) followed by (6.40 cm/hr) infiltration rate from sub-watershed (SW2) treated with (Chirpine + check dams + on grazing). While the lowest (2.5 cm/hr) infiltration rate was recorded from sub-watershed (SW5) have no treatment. It was observed from the analysis of data that planting mixture of tree species (conifers and broad-leaved) with check dams and control to grazing has been found the best treatment for watershed management and soil conservation purposes as compare to other treatment tested in the area.

KEYWORDS: land use bio technical methods, stream flow, sediment yield, precipitation, atmospheric and soil parameter, infiltration capacity

1. INTRODUCTION

Water is the main source for the survival of life in the ecosystem. Like other resources, nature has created a balance between its various forms for its better utilization and for the continuity of normal hydrological cycle. The number of the pores and water contents are the most important factors determining the part of the precipitation that infiltrate and the amount of runoff produced. So far there is no evidence that the more presence/absence of forest cover affects infiltration to such an extent that either the prevention or causes of major flood can be related directly to it (Lull & Rrinhart 1972).

In a catchment, watershed management has important to all types of land uses non-urban, cultivated, non-cultivated, forest and range for the provision of fresh water, minimizing the loss of soil, flood hazards and siltation of productive lands and dams. Moreover loss of soil in catchment areas paralyzes the ability of land surface to take advantage of huge amount of precipitation. (Anees 1988).

Infiltration is an absorptive process. The moving forces are gravity; surface tension (capillary) and hydrostatic pressure except gravitational pull. The rest of the forces are influenced by the different kind of land uses, in nutshell infiltration is the downward movement of water through the soil surface and infiltration capacity, is the maximum potential for the surface layer to absorb water (Hayat 1990).

2. MATREIALS AND METHODS

The study area is located in the zone of sub-tropical Chirpine forest. The climate varies with place to place. The summer monsoon covers only the Swat proper and the outer fringes of the Swat Kohistan, whereas the rest of the area receives precipitation mainly in the form of snow. Snow starts falling on high elevation by about middle of October and descends to the forest belt in the middle on November.

The area includes a catchment with five contiguous sub-watersheds.

The following soil conservation measures were carried out in each sub-watershed.

- **SW1** Mix plantation of *Pinus roxburghii* and broad-leaved species included *Eucalyptus camaldulensis*, *Robinia pseudoacacia* and *Ailanthus altissima* with engineering techniques (loose stone check dams). Grazing was also excluded.

- **SW2** Without engineering control structures, however its biological treatments and protection from grazing was similar to SW1.

- **SW3** Planted with pure chirpine (*Pinus roxburghii)* plantation with engineering control structures (loose stone check dams) and grazing was excluded.

- **SW4** Treated with pure chirpine *(Pinus roxburghii)* plantation with rangeland improvement practices, consisted of interseeding with grasses/forbs species such as *Medicago sativa, Chrysopogon auchari, Onobrychus sativa* and *Bothriochloa pertusa.* Grazing was excluded.

- **SW5** Open to grazing and no biological or engineering treatments were given to it. It was taken as control.

Procedure

The double ring infiltrometer with a constant head of 2.5 cm maintained in each ring was used for data collection. The inner ring of diameter was 21.5 cm while the outer ring of 26 cm diameter was used. The cross sectional (surface area) of the soil in the inner ring was 363.05 cm^2. The rings were driven in the soil up to 15 cm depth, to prevent the lateral movement of water during the process of infiltration. First of all outer ring was driven into the soil followed by the ring inner using wooden hammer and crowbar (for least soil disturbance). Care was taken to keep the rings vertical and the same space between the two rings. In the inner ring known quantity of water was added up to the level already fixed. Water head was maintained at 4 cm by vertically fixing a nail in the inner ring.

The readings were noted for each minute during the first 5 minutes period. Afterwards readings were recorded at interval of 5, 10, 15, 20 and 30 minutes. Hence at each point ten (10) readings were recorded for total of 85 minutes duration. Time for each reading was recorded with the help of a stop watch. A graduated glass cylinder was used for measuring the volume of water. Infiltration rate was calculated in cm/hour for each treatment.

Statistical Analysis

Basic statistics of site data were calculated. The statistical analysis of the data for infiltration capacity of soil was carried out, using F-test. A probability level of 5 percent was used for rejecting or accepting the hypothesis. Following steps were used to calculate the F-value.

The study area included a catchment with five contiguous sub watersheds. The sub watershed ranges in size from 4 to 20 hectares.

3. RESULTS AND DISCUSSION

The data regarding infiltration capacity of different soil conservation treatments (Biological+Engineering) and its statistical analysis and interpretation are given below.

The infiltration rates at various time intervals under different soil conservation measures.

Time (min)	SW1	SW2	SW3	SW4	SW5
1	150	133.3	127.66	111.3	83
2	48	45	37.2	33.6	22.2
3	44.2	37.6	31	27.3	19.5
4	34.1	30.2	28.8	22	16
5	31.8	30.1	26.7	21.9	14
10	28.7	24.7	25	14	8.9

20	26.7	23.6	24.6	12.3	7.3
35	15.8	11.4	11.3	7.7	6.3
55	11.6	7.6	6.2	5.7	3.5
85	9.4	6.4	5	3.8	2.5

The results are also shown with the help of graph/curve in Fig 1, 2, 3, 4, and 5 respectively. These figures show clearly the decrease in infiltration rate with time.

Fig 1. Infiltration curve of sub-watershed (SW1)

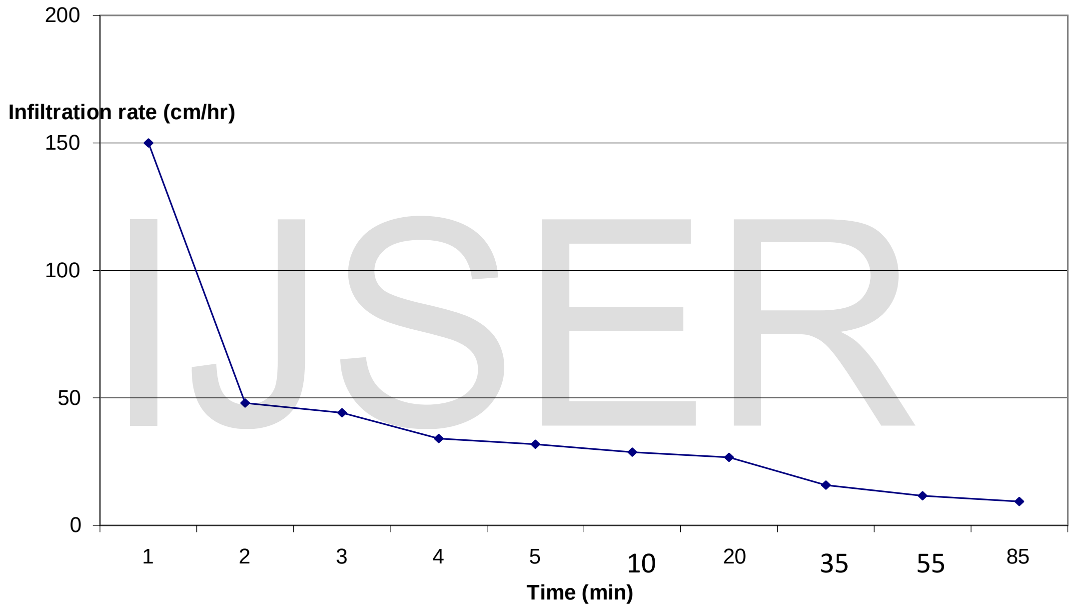

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Fig 2. Infiltration curve of sub-watershed (SW2)

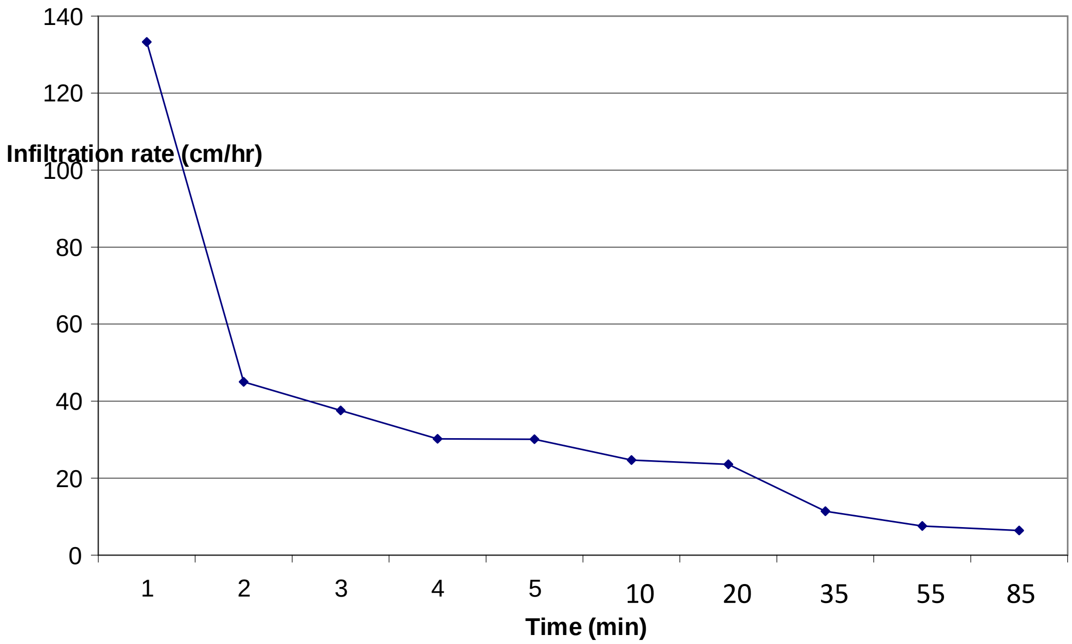


Fig 3. Infiltration curve of sub-watershed (SW3)

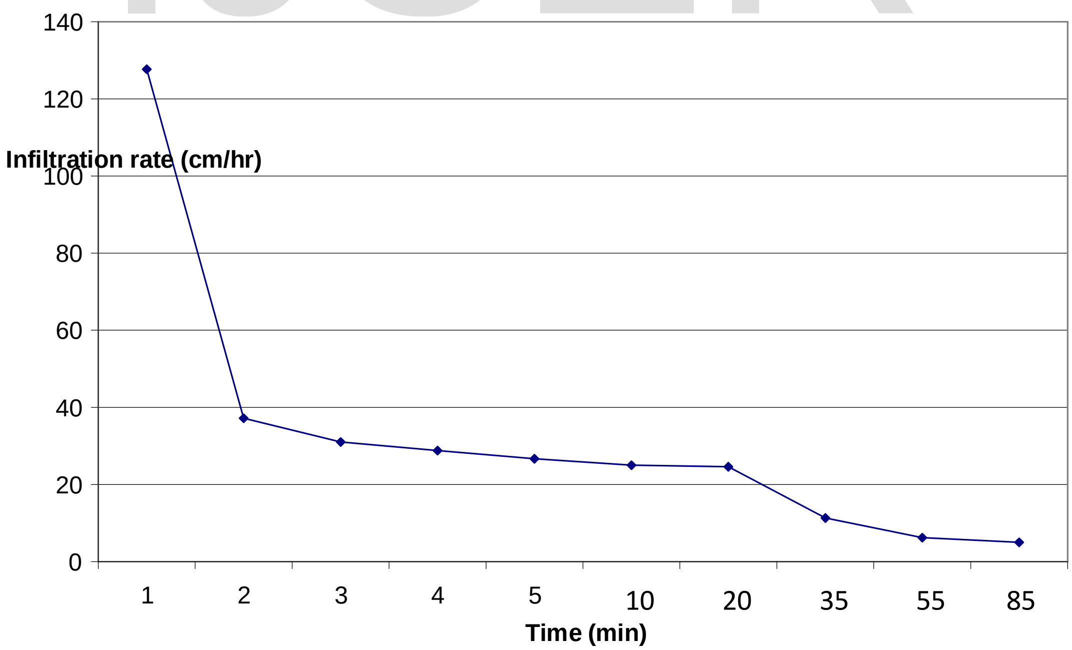


Fig 4. Infiltration curve of sub-watershed (SW4)

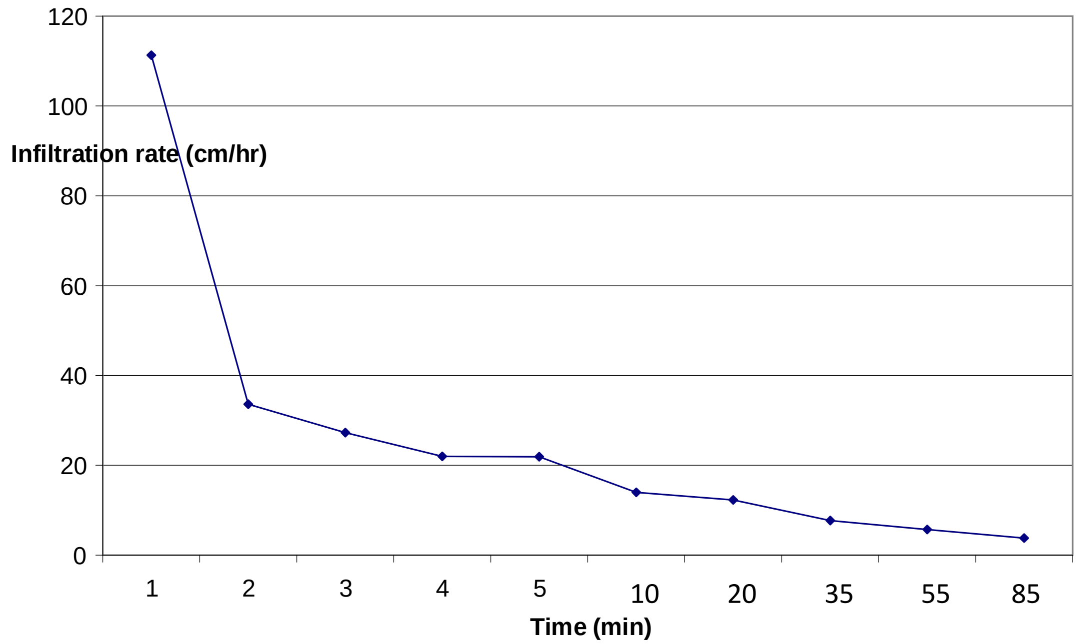
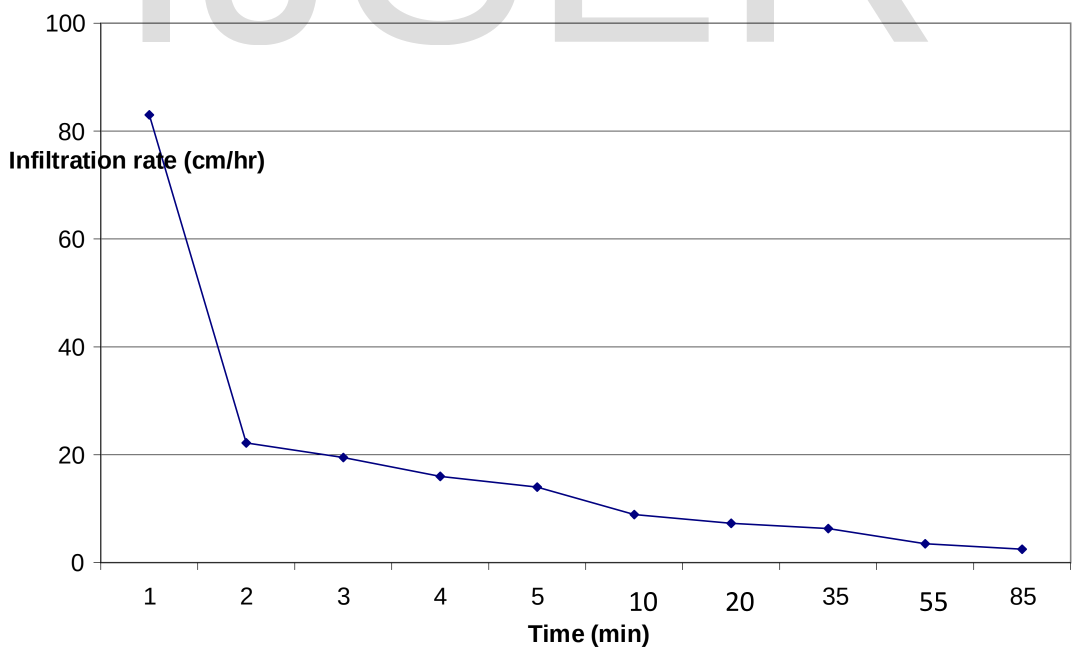


Fig 5. Infiltration curve of sub-watershed (SW5)



Analysis of variance (ANOVA) for Infiltration capacity (cm/hr) of different soil conservation measures.

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Replications	Treatments					Rep. total	Rep. means
	T 1	T2	T3	T4	T5		
R-I	10	6.6	4.5	4	2	27.1	5.42
R-II	8	6.5	5.5	3.8	3	26.8	5.36
R-III	9.5	6.2	5	3.5	2.5	26.7	5.34
Treatment total	27.5	19.3	15	11.3	7.5	80.6	
Treatment means	9.16	6.40	5.0	3.77	2.5		

Computation and Analysis

Correction factor (C.F) $= \dfrac{(\text{Grand total})^2}{\text{No. of observations}} = \dfrac{(80.6)^2}{15} = 433.09$

Total sum of squares $= \Sigma X^2 - \text{C.F}$

ΣX^2 = Sum of square of all observations

Therefore Total sum of squares = 515.94-433.09 = 82.85

Treatment sum of squares $= \dfrac{(27.5)^2 + (19.3)^2 + (15)^2 + (11.3)^2 + (7.5)^2 - C.F}{3}$

$$= \frac{1537.68 - 433.09}{3} = 79.47$$

Replication sum of squares= $\dfrac{(27.1)\text{-}+(26.8)^2 + (26.7)^2 - \text{C.F.}}{5}$

$$= \frac{2165.54 - 433.09}{5} = 0.018$$

Error sum of square = Total sum of squares - (Treatment sum of Square + Replication sum of square)

= 82.85-(79.47+0.081) = 3.362

ANOVA Table

Source of variation	df	S.S	M.S	F ratio
Replication	2	0.081	0.009	$\frac{0.009}{0.4202} = 0.0214$
Treatment	4	79.47	19.867	$\frac{19.867}{0.4202} = 47.28$
Error	8	3.362	0.4202	
Total	14	82.85		

4. CONCLUSIONS

- From the results of infiltration capacity under different soil conservation measures (biological + engineering) it is derived that there is a clear relationship between the infiltration capacity of soil and different soil conservation measures.
- Analyses of the replications mean indicate that there were no differences in the infiltration capacity of soil in various replications.
- These results also indicate that the planting of tree species with engineering structure and control of grazing arc essential for effective watershed management and soil conservation purposes in the up-hill watershed areas.
- The infiltration capacity of the area treated with mix plantation of conifer and broad leaved species was higher than the area planted with pure conifer trees *(Pinus roxburghii).*
- The sub-watersheds (SW2 & SW4) which have been treated biologically only also have positive effect on infiltration capacity of soil.
- Comparing the mean infiltration rate of different sub-watersheds it was observed that biological treatments have more positive effect then engineering treatments.
- The grazing exclusion from treatment areas has marked effect on cover percent and biomass production due to which erosion decreases and infiltration capacity of soil increases which reduce runoff and sedimentation processes.

The analysis of data concluded that the mix plantation of tree species with engineering structure and control of grazing have been found as the best use for water and soil conservation purposes in the uphill watershed areas of Pakistan as compared to other land uses tested under the project area.

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