EFFECTS OF SPECIES COMPOSITION ON THE INFILTRATION CAPACITY OF SOIL

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ABSTRACT

This study was carried out to determine the effects of different species composition on infiltration capacity of soil. The study area was divided into three zones, namely, Zone-I: Pure Chir (*Pinus roxburghii*) Zone, Zone-II: Chir and Robinia (*Robinia pseuodocacia*) Mix Zone, and Zone-III: Pure Robinia Zone. Twenty (20) sample plots were established randomly in each zone for determination of infiltration capacity. Double Ring Infiltrometer was used to collect the required information on each sample plot.

The infiltration rate for Zone-I, Zone-II and Zone-III was in the range of 5.72 to 23.84 cm/hr; 5.54 to 40.18 cm/hr; and 6.20 to 45.98 cm/hr. Maximum infiltration rate; 45.98, 40.18 and 23.84 cm/hr for Zone-III, Zone-II and Zone-I, was observed at the 2nd minute. The lowest reading for infiltration rate was at the 80th minutes of reading corresponding to 5.72, 5.54 and 6.20 cm/hr for Zone-I, Zone-II and Zone-III respectively.

The soil of the study area varies from loam to sandy loam. The soil analysis, carried out at the soil laboratory of PFI, reveals that the organic matter in the soil is in the range of 6.16 to 12.56 %. The soil is acidic with ph value of 5.02 to 6.2. The bulk density of soil is in the range of 0.87 to 1.26 gm/cm³. The total pore spaces vary from 33 % to 48%.

The F-value (5.30) of ANNOVA indicates significant difference among the mean infiltration values ($P< 0.05$) of Zone-I, Zone-II and Zone-III. Hence it can be inferred that the mean infiltration rate of Zone-III was higher than Zone-II and Zone-I.

Key Words: Chir, Robinia, infiltration rate, bulk density

INTRODUCTION

Mountain areas are of immense importance from watershed management point of view as these are the prime sources of water for water reservoirs, canal irrigation system and a source of drinking water to the downstream communities. These watersheds are important for the livelihood of upland community as well.

In Pakistan soil erosion is a serious problem. Artificial reservoirs such as

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Tarbela, Mangla, Warsak and many other small dams have been constructed for the supply of irrigation water. These reservoirs are being silted up at a very high rate; Tarbela at 109,000 acre feet per year while Mangla at 49,000 acre feet per year (Sheikh & Hafiz, 2000).

These reservoirs play a pivotal role in the country's economy as these are the main sources of the world's largest canal irrigation system. One of their many functions is the production of hydroelectricity for the country. Agriculture production of Pakistan depends largely on this canal irrigation. The industries like textile, tobacco, sugar, paper and food industries are agriculture-based. Majeed *et al* (2008) stated that the cumulative incremental irrigation water benefits alone for the period of 1967-2006 were 2.6 billion US $ due to regulation of these multipurpose dams.

The movement of water into the soil surface is termed as infiltration. Water contents and the number of pores are the most important factors that determine the part of the precipitation that infiltrates and the amount of runoff produced. High infiltration rates, therefore, not only increase the amount of water stored in the soil for plant use but also reduce flood threats and erosion resulting from surface runoff (Lull & Reinhart, 1972).

Vegetation enhances infiltration in a number of ways. Presence of litters and humus layer lowers surface runoff. Interception of rainfall increases the duration of effective precipitation. Crumb or aggregated structure, which is essential for high infiltration, is maintained by vegetation (Roitzsch, 1968).

The study investigated the impacts of zones under different species composition on the infiltration capacity of soil, and based on the findings of the study, appropriate watershed management practices were suggested to improve the soil infiltration capacity.

MATERIAL AND METHODS

The Study Area

Located at distance of about 22 Km from Mansehra, the study area lies between latitude 34°28'0N and Longitude 73°16'60E at an altitude of 3346 feet (1019 meters). The climate of the area is known as sub tropical continental highland type with warm summers and cold winters. There are two distinct seasons; one summer from April to august and the other is winter from October to February. In winters especially during the month of January and February the temperature goes below freezing point. The summers remain short, slight warm and the temperature during the month of June-July is about 30 C° to 35C°. Mean annual rainfall in the area is about 61.66 inches and distributed in the area

irregular over whole of the year. Maximum rainfall is received during July and August. January and February are the coldest months with maximum and minimum temperature of about 14C° and 2C° respectively (Ahmad, 1990).

The tract is hilly and rugged. The gradient ranges from moderately steep to precipitous. The upper slopes are rocky and precipitous. The lower slopes are steep to moderately steep. The narrow valleys formed between hill ranges slope gently towards ventral nullahs. The soil of the study area varies from loam to sandy loam. The soil analysis, carried out at the soil laboratory of PFI, reveals that the organic matter in the soil is in the range of 6.16 to 12.56 %. The soil is acidic with ph value of 5.02 to 6.2. The bulk density of soil is in the range of 0.87 to 1.26 gm/cm^3. The total pore spaces vary from 33 % to 48%.

Methodology

The study area was divided into three zones or strata based on the species composition. These include, Zone- I (Pure Chir Zone); Zone-II (Robinia & Chir Mix Zone); and Zone-II (Pure Robinia Zone). This division facilitated the field crew to collect infiltration data separately for each zone. In each zone, twenty (20) sampling units (SUs) were established randomly for data collection. Thus, the total number of SUs was 60, although, in the approved study plan 10 SUs were proposed for each zone, but for more accuracy, the number of SUs was increased from 10 to 20 for each zone.

Data collection

After correct layout of the sampling unit in field, the infiltration rate was determined using double ring Infiltrometer. The inner diameter of the ring Infiltrometer was 21.5 cm whereas the outer diameter was 26 cm. The total height of the double ring Infiltrometer was 27 cm.

The ground was cleaned for twigs, litter etc and inner ring was driven into the soil with the help of hammer and crowbar upto 15 cm into the soil. Then the outer ring was driven into the soil upto the same depth. A known quantity of water was added into the inner ring with the help of graduated cylinder. First, a plastic sheet was wrapped around the ring Infiltrometer so as to avoid soil disturbance with the impact of water. The water was then poured into the plastic sheet and then gradually into the ring Infiltrometer. Readings of the volume of water added was noted at 2, 4, 7, 10, 15, 20, 30, 40, 60 and 80th minute. After each reading, water was added upto the fixed level i.e 4 cm. For noting time, stop watch was used (Brouwer, 2000).

The quantity or volume of water added upto 4 cm depth was calculated as:

$$V = \pi D^2/4 \times L$$

Where;

V = Volume of water added =
D = Diameter of Inner Ring = 21.5 cm
L = Depth of water = 4 cm

The infiltration rate was determined using the following formula:

$$i = 4V/3.14 D_r^2 \Delta t$$

Where

i = Infiltration Rate
V = Volume of water added in time, Δt
D_r = Diameter of Inner Ring
t = Time

Statistical Analysis

The data was analysed used student's t test, ANNOVA and Correlation Co-efficient (r) to test the significance at α=0.05.

RESULTS AND DISCUSSIONS

Infiltration Rate

The infiltration rate for Zone-I, Zone-II and Zone-III was in the range of 5.72 to 23.84 cm/hr; 5.54 to 40.18 cm/hr; and 6.20 to 45.98 cm/hr. Maximum infiltration rate; 45.98, 40.18 and 23.84 cm/hr for Zone-III, Zone-II and Zone-I, was observed at the 2nd minute. The lowest reading for infiltration rate was at the 80th minutes of reading corresponding to 5.72, 5.54 and 6.20 cm/hr for Zone-I, Zone-II and Zone-III respectively.

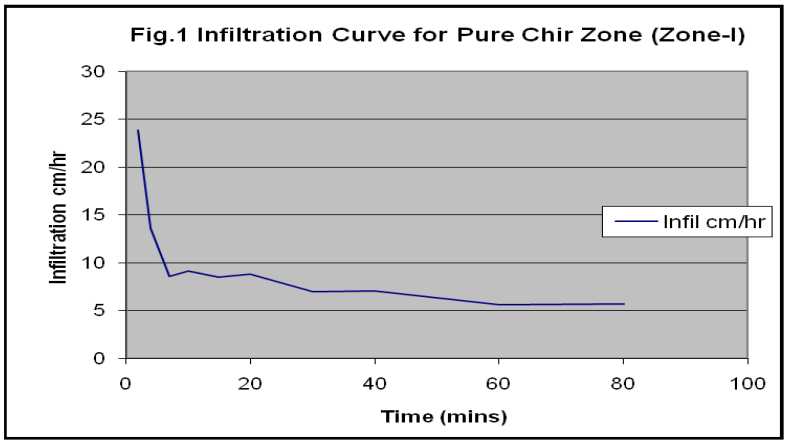
Table 1. Infiltration Rate (cm/hr) at different time interval

Time (mins)	Zone-I (cm/hr)	Zone-II (cm/hr)	Zone-III (cm/hr)
2	23.84	40.18	45.98
4	13.62	20.09	25.03
7	8.59	14.59	18.82
10	9.09	11.99	16.39
15	8.45	10.61	13.25
20	8.8	10.31	12.96
30	6.95	8	9.33
40	7.01	7.82	9.08
60	5.6	6.42	7.08
80	5.72	5.54	6.20
Mean	9.76	13.55	16.49

Infiltration Curves

The infiltration curve indicates that the infiltration rate was higher at the first reading point (2nd min) and it went on decreasing with the increase in the time interval, and was lowest at 80th min (Fig 1,2,& 3). The infiltration curve of Zone-III stayed above the infiltration curve of Zone-II and Zone-I throughout, which indicated that the infiltration rate in Zone-III was higher as compare to Zone-II and Zone-I (Fig.4).

The mean maximum infiltration rate (16.49 cm/hr) was highest in Zone-III, followed by Zone-II (13.55 cm/hr) and Zone-I (9.76 cm/hr) respectively.



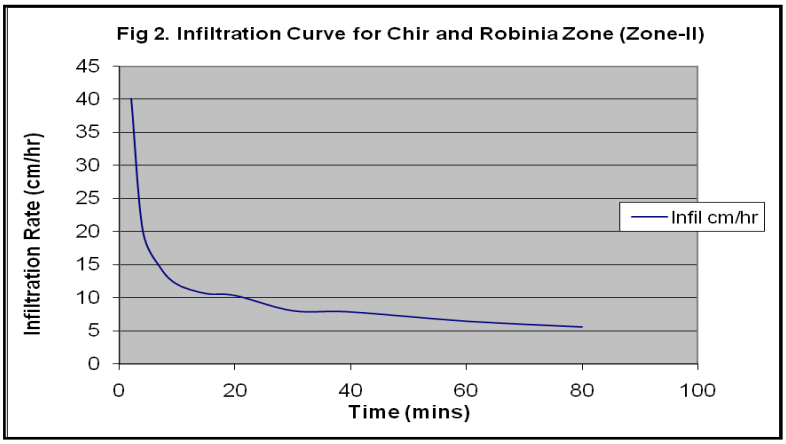


Fig 2. Infiltration Curve for Chir and Robinia Zone (Zone-II)
Infiltration Rate (cm/hr)
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Time (mins)
Infil cm/hr

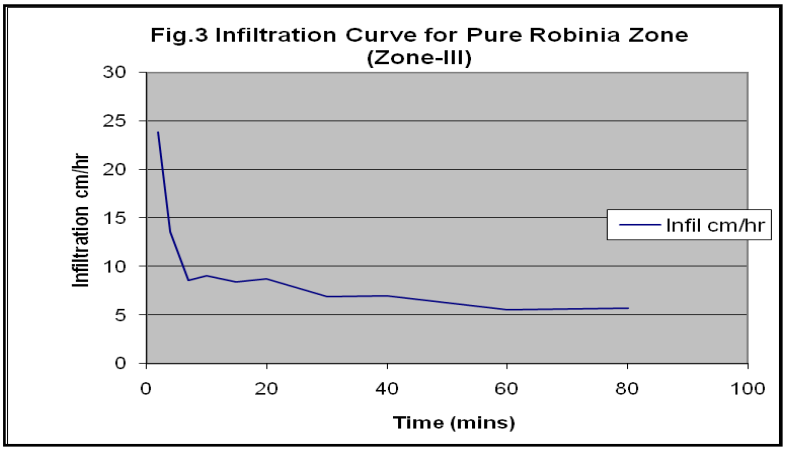


Fig.3 Infiltration Curve for Pure Robinia Zone (Zone-III)
Infiltration cm/hr
30
25
20
15
10
5
0
0
20
40
60
80
100
Time (mins)
Infil cm/hr

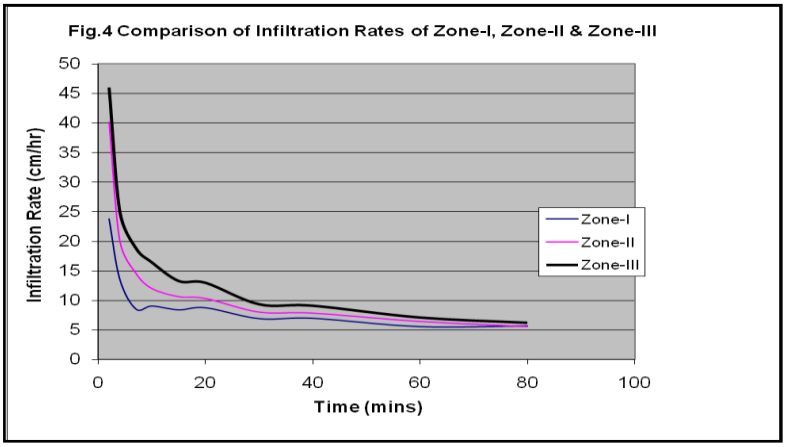


Fig.4 Comparison of Infiltration Rates of Zone-I, Zone-II & Zone-III
Infiltration Rate (cm/hr)
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
Time (mins)
Zone-I
Zone-II
Zone-III

Soil Properties and infiltration rate

The soil of the study area varied from loam to sandy loam. The soil analysis, carried out at the soil laboratory of PFI, revealed that the organic matter in the soil was in the range of 6.16 to 12.56 %. The soil was acidic with ph value of 5.02 to 6.2. The bulk density of soil was in the range of 0.87 to 1.26 gm/cm^3. The total pore spaces varied from 33 % to 48%. The properties of soil in terms of bulk density, soil ph and total pore spaces (%) was given in the Table 2.

Table 2. Mean values of soil pH, bulk density and total pore spaces

Zone	Soil Properties		
	Ph	Bulk density (gm/100 cc)	Total pore spaces (%)
Zone-I	5.51	99.99	38.46
Zone-II	5.66	101.57	39.06
Zone-III	5.90	109.61	42.16
F-value	2.40^{NS}	1.78^{NS}	1.78^{NS}

NS = Non-significant at 95% Confidence level

F value calculated indicates that the means of soil ph, bulk density and total pore spaces ($P > 0.05$) do not differ significantly as there is non-significant difference among the means of the above parameters. In other words, the soils of the three zones viz Zone-I, II and III are uniform in properties, and therefore, the change in the infiltration rates of the zones is not due to the properties of soil but due to the species composition.

Test of significance for infiltration rates

The F-value (5.30) of ANNOVA indicates significant difference among the mean infiltration values ($P < 0.05$) of Zone-I, Zone-II and Zone-III. Hence it can be inferred that the mean infiltration rate of Zone-III was higher than Zone-II and Zone-I. Least Significant Difference (LSD) indicates that the mean infiltration rate of Zone-III differs significantly from that of Zone-I but does not differs significantly from Zone-II.

Table 3. ANNOVA Table

Source	DF	SS	MS	F	P
Between	2	454.63	227.315	5.30	0.007
Within	57	2442.46	42.850		
Total	59	2897.09			

CONCLUSION

The infiltration rate of Zone-III (Pure Robinia) was found highest as compare to Zone-II (Chir and Robinia Mix) and Zone-I (Pure Chir). The soils of the zones under study were found uniform in physco-chemical properties due to which it can be inferred that the soil infiltration capacity is influenced by the type of vegetation. Hence it can be concluded that promotion of Robinia can be beneficial for enhanced infiltration and soil conservation.

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