Measurement of Water Infiltration Rates for Soil

Rationale

Some of the rain water (or irrigation water) runs off the ground and the rest soaks into the ground though its pores. Plants survive and grow on this infiltrated water. The infiltration rate is influenzed by the structure, compaction and organic matter of the soil. If the infiltration rate is low, more of the rain water will run off and be wasted. *Infiltration refers to the rate at which water enters the soil. Soil permeability refers to the rate at which water moves through the soil.* (Extract from Farmer Field Schools Facilitators' manual). At a more basic level, infiltration and permeability can be related to the hydraulic conductivity K (m/d metre/day) of the soil.

While both infiltration and permeability are important for soil moisture, it is easier to measure infiltration, especially relative infiltration rates between soil of different structure, land use and vegetation. It is much more difficult to measure the rate at which water moves through the soil. In laboratory methods of measurement, core samples of the soil with fixed boundaries are subject to hydraulic measurements to arrive at conductivity values. As opposed to this hydraulic small scale in-situ methods carry out simple tests like measuring the infiltration rate from a pipe driven into a hole in the ground. In these methods, the outer boundary of the soil investigated is not known. But these methods give fast results in the field using very simple apparatus. The method used here is classified as a small scale, above water table, infiltrometer or inversed auger hole method [ILRI162 Chap 12).

[ILRI162] Drainage principles and applications, ILRI publication 16 Second edition, H.P Ritzema (Editor-in-Chief], The Netherlands 1994 (http://www2.alterra.wur.nl/Internet/webdocs/ilri-publicaties/publicaties/Pub162/download-162.html)

Hypothesis or Theory

The infiltration rate over a small soil surface is a constant (m/day). The actual infiltration will be proportional to the head of water above the ground. If the head is kept constant, then the rate of infiltration has to be measured. It is easier to have a let the head fall with the infiltration and measure the time for the head to cross between high and low points.

If a pipe is partially driven into the ground and water is continuosly poured into it, then over a period the soil below would be saturated with water to a considerable depth. Assume that the level of water above the soil surface is at h in the pipe. Consider the deep boundary layer at z metres below the ground. The average hydraulic gradient in between the soil surface and the deep surface at z is approximately (z+h)/z. As z tends to numbers greater than 10 times h, the hydraulic gradient approaches value of 1. In this case, according to Darcy's laws, the mean flow velocity at z, approaches K, the hydraulic conductivity. It is shown (ILRI162 equation 12.14) that

$K = 1.15r(\log(h_0+0.5r)-\log(h_t + 0.5r))/(t)$

t= time since start of measurement (s)

h_t = height of water in pipe at time t

h_0 = height of water in pipe at time 0.

In this experiment we have to pour the continuosly till the infiltration rate is almost constant. But it is easier to take pour a reasonable amount of water, say 5 litres, into a a pipe and assume that it has

penetrated to sufficient depth. The time taken for the water level to cross two marked points can be measured.

Methodology

The method is directly taken from:

Farmer Field Schools Facilitators' manual
Vol 1, Integrated soil, water and nutrient management in semi arid Zimbabwe
O. Hughes and J.H.Venema (eds), 131 pages,
Dept of Agricultural Research and Extension, and FAO of the UN
Harare, Zimbabwe, Feb 2005
ftp://ftp.fao.org/agl/agll/docs/ffsfm_zim.pdf

Field Study 2.3. Comparing Water Infiltration Rates for Different Soils

The surfaces of some soils are more dense and compacted than others. Some soils have a surface crust. What causes soil to compact and crusts to be formed? Are they trampled by feet, machinery, raindrops or cattle? What in nature keeps soils from becoming compacted: earthworms, insects, roots, organic matter, wetting and drying? Is compacted or non-compacted soil more porous? This exercise should help answer some of these questions.

Objectives

- Understand how water moves into soil
- Understand relationship between particle size of the surface horizon and rate of water flow into the soil
- Test the infiltration rate of soils having different colours
- Demonstrate differences in the infiltration rate of soils having different cropping histories and soil cover.

Time required: 2-3 hours

Materials

- 30-35 cm length of 20 cm diameter PVC drainage pipes
- watch
- water source
- one 5-liter bucket to carry water
- permanent marking pen
- paper and pens for report

Procedure

1. Explain the objectives of the study.
2. Visit three sites in a field where soil samples were taken for the previous exercise.
3. At the first location, carefully push the pipe into the ground (using a screwing motion) a few centimetres. Try not to disturb the soil inside the pipe.

4. Make a prediction about the rate of water absorbed by each soil type and discuss reasons why differences might occur.
5. Fill the PVC cylinder with water to a few centimetres below the top. Record the time taken for 5 litres of the water to enter the soil. Note any changes in the soil's behaviour and record these observations.
6. Repeat steps 2-4 at the second and third locations.
7. Each group should present their results and findings at their location. Thus, all the three sites will be studied, and the results discussed.

Conclusions

1. Which soil sample had the highest infiltration rate?
2. Discuss the reasons for differences observed in time taken for water to infiltrate into the three types of soil. Relate these differences to the texture, porosity, colour and surface cover (if any) of soil in each case.
3. How does the texture and porosity of each soil compare to its infiltration rate? Does soil cover make any difference to infiltration rate? How important is it for us to know this?
4. Discuss the impact that these differences will have on soil erosion and loss of rainwater, nutrients and fertilisers by runoff and by drainage.
5. Which soil type is suited for which crops? How does this correlate with the cropping history observed in the field?
6. Are livestock kept in the area? If so, what kind of livestock?
7. How could farmers use this knowledge? For example, will the results of this experiment change the criteria used by farmers in future to better match crop needs with the different soil types on their fields? Why or why not?

Data table: Record data using the following table.

Soil type	Soil texture and colour	Cropping history	Time for water to enter soil (minutes)