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TOWARDS THE MILLENNIUM DEVELOPMENT GOALS

An evaluation of soil water status for irrigation and drainage control

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THE ESTABLISHMENT OF irrigation schemes on a farmland require the understanding of the water retention and infiltration characteristics of the soil in the area for the purpose of irrigation scheduling, crop-water modeling, water balance studies etc. This study was aimed at establishing the water retention and infiltration characteristics of a southwestern soil in Akure, Nigeria. Pertinent soil physical properties (Soil texture, bulk density, particle density, porosity) which influences water retention and movement were determined using standard methods. Soil moisture content, matric suction and infiltration rate were also determined in-situ. The soil textural classification showed that the soil is sandy, mean bulk density, particle density and porosity were 1.32 g/cm^3, 2.25 g/cm^3 and 42% at 0-30cm soil depth; 1.67 g/cm^3, 2.55 g/cm^3, and 35% at 30cm-60cm soil depth; 1.16 g/cm^3, 1.72 g/cm^3, and 33% at 60cm-90cm soil depth respectively. This shows that the soil is highly porous and thus limited in it ability to retain water. The shape of the water retention curve also corroborates this, furthermore infiltration characteristics established in-situ proved that the soil is predominantly sandy because infiltration rate was initially high at 156 cm/hr at an antecedent soil moisture content of 6.2 %, this later reduced drastically to 4.8 cm/hr after two hours. The presence of ironstone at a soil depth of 90cm suggests that flow will be lateral at that depth. The above result reveals that the soil on the farmland is quick draining, having good infiltration characteristics but poor in retaining water for plant use. The recommended water application method is the sprinkler irrigation system. It is also strongly advised that crop residues should be ploughed into the soil in order to improve the water retention characteristics of the soil, another method is by carrying out green manuring, these measures will permit the formation of loamy condition in the soil thereby improving the water retention characteristics of the soil on the farmland.

Introduction

The planning of an irrigation scheme for a farmland requires the understanding of the soil water status of the land especially the water retention and infiltration characteristics. Several workers have developed mathematical theories to describe soil water retention and transport under different sets of initial and boundary conditions especially the relationship between matric suction and soil moisture content and on infiltration characteristics (Hillel (1980); Su and Brooks, (1980); Gee et. al. (1992); Vervoort et. al. (2000); WRCSA (2001) and USGS (2002)) However, no satisfactory theory exists for the prediction of the matric suction versus moisture content relationship from basic principles. This is largely due to the fact that the adsorption and pre geometry effects are often too complex to be described by a simple model. Hence, the empirical approach is normally used.

An increase in soil water suction is associated with a decreasing thickness of hydration envelopes covering the soil particle surfaces. Increasing suction is thus associated with decreasing soil wetness; it is represented graphically by a curve known as the " soil moisture retention curve". Infiltration studies are important for irrigation, soil and water conservation etc. Such studies makes it possible to estimate the amount of water that will enter into the soil and the amount of runoff that is likely to accumulate in a watershed. Cumulative infiltration indicates the time that is required to give a certain depth of irrigation water.

Infiltration is influenced by soil properties, fine textured soils has low infiltration than coarse textured soil. Soils exhibit great spatial variability even within relatively small areas such as a field. The purpose of this work was to determine the water retention and infiltration characteristics of a southwestern soil on a farmland and to suggest the best method of water application and necessary soil improvement measures for the farmland.

Materials and methods

The study was conducted on a farmland located in Akure in the south- western part of Nigeria which lies on latitude 07^{0}17"N and longitude 05^{0}18"E, the mean annual rainfall is 1450mm.

Soil samples were taken randomly from a 10x10 meters plot, from a depth range of 0-30 cm, 30 cm - 60 cm, and 60 cm – 90 cm using soil core samplers, pertinent soil physical properties were determined using standard methods, these include soil texture, bulk density, particle density, and porosity. Soil moisture suction was measured at 30 cm and 40 cm depth by using carefully prepared Irrometer tensiometers. Readings of pressure suctions and soil moisture content were taken at twenty-four hours interval for twenty-five days in the month of December. In-situ soil moisture content was measured using the speedy moisture tester with calcium carbide as the absorbent. Infiltration rate was also measured using a double ring infiltrometer. The data obtained were then subjected to regression and correlation analysis for possible relationship between them.

Result and discussion

The sieve analysis shows that the soil on the farmland is sandy in texture. The sand content at 0-30cm, 30cm – 60cm and 60cm – 90cm soil depth is 89%, 85% and 76% respectively. This shows that the sand content decreases down the soil profile. On the other hand, the gravel content was found to increase with soil depth with ironstone encountered at 90cm depth. Mean bulk density, particle density and porosity was found to be 1.32g/cm^3 2.25g/cm^3 and 42% at 0 –30cm depth; 1.67g/cm^3, 2.55g/cm^3 and 35% at 30cm - 60cm depth; 1.16g/cm^3, 1.72g/cm^3 and 33% at 60cm 90cm soil depth respectively. The water retention curves obtained is very similar to the ones advanced by Hillel (1980) for a sandy soil, a comparison of the curves at the different depths shows that the soil at 40cm depth has greater ability to retain water; this was found to be due to a higher clay content (See figure 1 and 2).

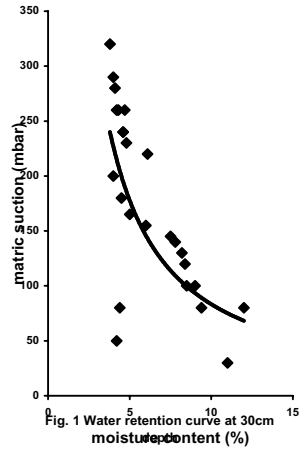

Figure 1. Water retention curve at 30 cm moisture content (%)

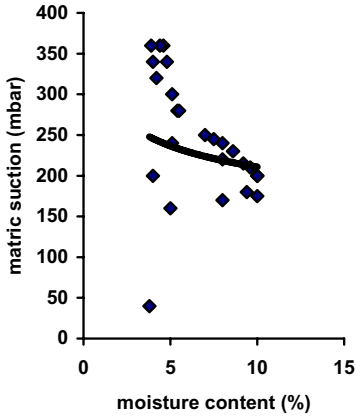

Figure 2. Water retention curve at 40 cm moisture depth

The use of non-linear regression technique produced an empirical relation,

$$H = a\, q^{-b}$$

for the soil where H is matric suction in mbar, q is soil moisture content in % and, a and b are constants. The constants range between 300 – 1000 and 0.5 – 1 respectively at a depth of 30cm – 40cm respectively. It is very obvious from the above that the soil has a very poor water retention capacity. The infiltration measurements carried out in-situ corroborates the water retention characteristics of the soil. With antecedent moisture content of 6.2%, infiltration of water was very high initially with a value of 156cm/m; this value decreased exponentially after one hour and later follows a gradually decreasing pattern (See figure 3).

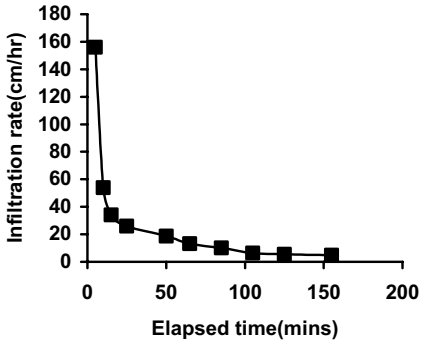

Figure 1. Infiltration vs time

The cumulative infiltration values show the time it will take to give certain depths of irrigation water.

Conclusion

The present study has established the soil water status of the farmland, the soil on the land is quick draining, hence will require frequent irrigation, the most suitable water application method is the sprinkler irrigation system. The water retention characteristics of the soil can be improved by ploughing crop residue into the soil or by carrying out green manuring, these measures will permit the formation of loamy conditions in the soil.

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