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# INVESTIGATION OF THE EFFECT OF DOUBLE RINGS INFILTROMETER DIMENSION ON INFILTRATION RATE

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## Abstract

Overestimation of vertical infiltration rate as a result of diverges laterally flow is a major problem in the use of infiltrometers. Although, the double-ring infiltrometer minimizes the error associated with lateral divergence, no specific dimension has been given for its usage. This report gives an investigation of the effect of dimension of double rings infiltrometer on the infiltration rate at the University of Agriculture Abeokuta. This study was conducted during the dry season and wet season on a vegetated land in the year 2011. Three pairs of double rings infiltrometer were used comprising of 30:60, 15:30 and 7.5:15 cm diameter rings. The 15:30 dimension offered the best accuracy with significant ($p = 0.01$) coefficient of determination of infiltration, followed by the 7.5:15 cm rings and lastly the 30:60 cm ring. The relative reliability of each dimension in terms of accuracy of measured infiltration data utilized was assessed by the mean of result of infiltration rate from the three pairs of double rings infiltrometer.

**Keywords:** Infiltrometer, Soil, Season, Double- Ring, Diameter

## INTRODUCTION

Despite the importance of infiltration in the quantification of hydrologic water balance for water and soil conservation and water resources study in particular, accurate measurement of infiltration rate has been difficult (Reynolds, 2002). In particular is the ring infiltrometer which is the most widely use in under developed countries (Ayoade, 2003) due to cost implication of most of the other measurement methods and reliability of some infiltration models. Several methods are currently used to estimate infiltration, with varying degrees of complexity and labour intensity (Maheshwari, 1996; Reynolds et al., 2002). The ring infiltrometer has been shown to overestimate vertical infiltration rate as a result of diverges laterally flow rather than the expected purely vertical flow of water beneath the cylinder during measurement (Gregory *et al.,* 2005). This lateral divergence is said to be as a result of the capillary forces within the soil and layers of reduced hydraulic conductivity below the cylinder. However, the double-ring infiltrometer minimizes the error associated with the single-ring method because the water level in the outer ring forces vertical infiltration of water in the inner ring though no specific dimension has been given for its usage. For instance, Bouwer, 1986 gave the inner and outer cylinder diameters as 20 and 30 cm respectively, Arriaga, *et al.*, 2010 gave the cylinders diameter as 14.6 and 33.0 cm, Ayoade (2003) gave 23cm and 36cm, and Elizabeth Shaw(1988) gave 25cm and 52cm among other, Hence, the need to determine the reliable diameter for double ring infiltrometer cannot be ignored. It is therefore imperative to assess the effect of rings diameter on measurement of infiltration rate of soil in the forest zone of Nigeria.

## MATERIALS AND METHODS

### *Description of Study Area*

The research was conducted at the Teaching and Research farm of University of Agriculture along Alabata road, Abeokuta ($7^{o}$ 15’N, $3^{o}$25’E) in Odeda Local Government Area of Ogun State, South Western Nigeria (Fig. 1) during the dry and wet season of the year 2011. The study area is characterized by a tropical climate with distinct wet and dry seasons with bimodal rainfall pattern and mean annual air temperature of about $30^{o}$C. The actual rainfall totals during the experimental year was 1201.6mm. The soil at the experimental site was categorized as a well-drained tropical ferruginous soil. The A horizon of the soil is an Oxic Paleudulf of the Iwo series with 83% sand, 5% silt and 12 % clay with a pH of 6 (Olasantan, 2007).

Infiltration rate data covering a period of 10 sampling weeks each within the dry and wet months of 2011 were collected from different sampling points at the experimental site in the study area (Fig. 1). The measurement of infiltration rates were determined from 3 sets of double rings infiltrometer, vis-a-vis 30:60, 15:30 and 7.5:15 diameters dimension. The reliability of the double ring infiltometer dimension considered in this study was assessed by comparing the pattern of distribution of infiltration and the magnitude of measurement derived by each set of infiltometer and the mean of the 3 sets. Data collected were subjected to Simple correlation. Results were compared to check if there were difference at a 0.05 level of significance difference using least significance difference (LSD) $P \leq 0.01$.

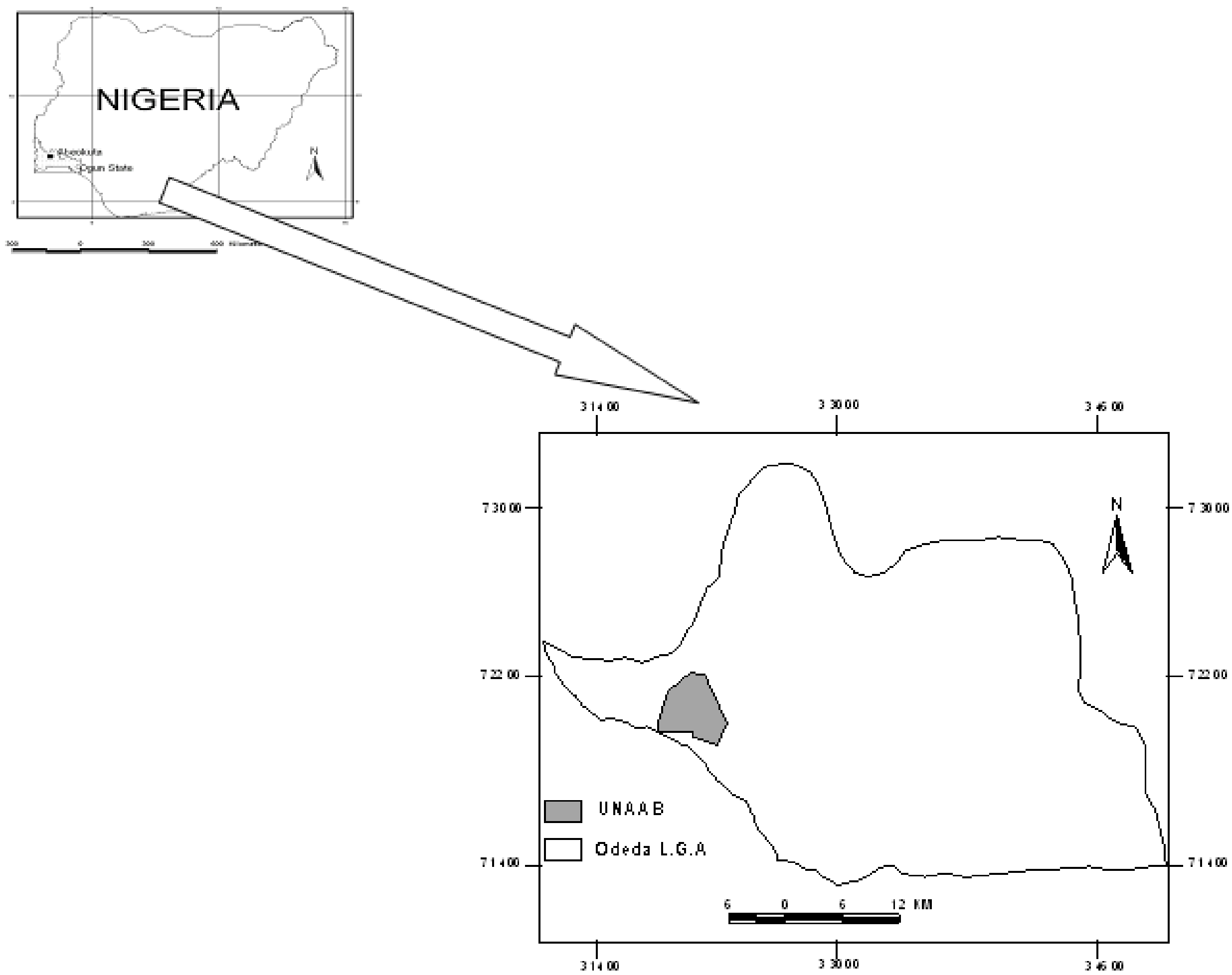
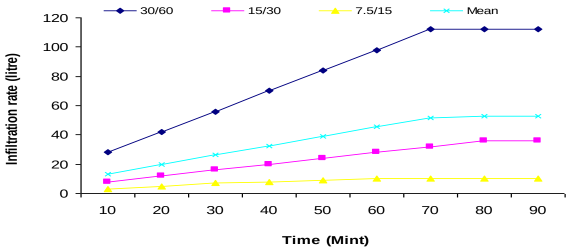
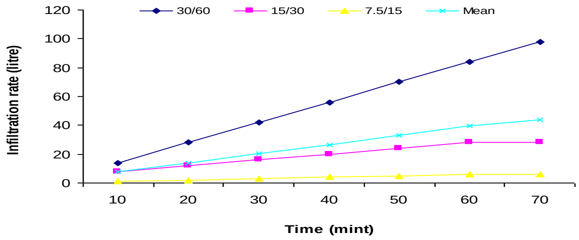



***Fig. 1.*** *Location of University of Agriculture, Abeokuta within Odeda Local Government Area in Ogun State, Southwestern Nigeria.*

## RESULTS AND DISCUSSION

Table 1 and 2 shows the relationship between infiltration rate with dimension during the dry and wet season respectively. It was observed that there is no significant difference ($p < 0.01$) in the infiltration rate as determined using the selected dimension. The chart of infiltration against elapse time is presented for 10 trials during the dry season on the vegetated land as shown in fig.2 and 3 for dry and wet season respectively. It was observed that though the pattern of distribution of infiltration were similar, the higher the diameter of infiltometer, the higher the infiltration rate. This may be as a result of area extent of the varying dimension. When the infiltration rate of the mean values of the 3selected dimensions was compared with each of the selected dimension, the 30/60 and 7.5/15 deviated from the mean than the 15/30cm dimension. The study shows that 15:30 dimension is highly correlated with the mean which implies that it gave the most accurate value of infiltration rate. Observation from literature shows that most dimensions used in the design of infiltrometer were closer to 15:30 centimeter dimension. For instance, Arriaga, et.al., 2010 gave the inner and outer cylinder diameters as 14.6 and 33.0 cm and Ayoade (2003) gave 23cm and 36cm. Furthermore, the study shows that values of infiltration were higher than the mean during dry season and lower during wet season. This can be attributed to the prevailing moisture condition in the soil. it can be concluded from the results that the 15:30 should be taking as most appropriate double ring infiltrometer dimension but when not available, any of the infiltration models can be used to arrive at the desirable estimate of the infiltration.

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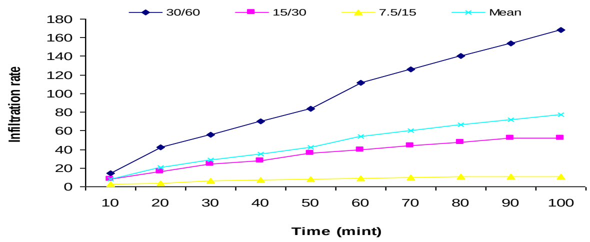


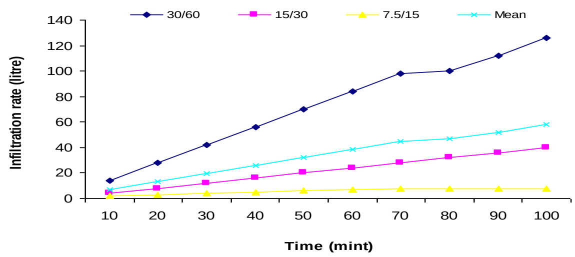


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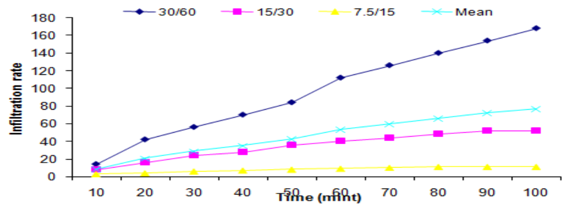


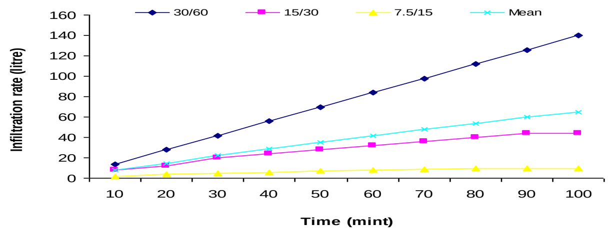


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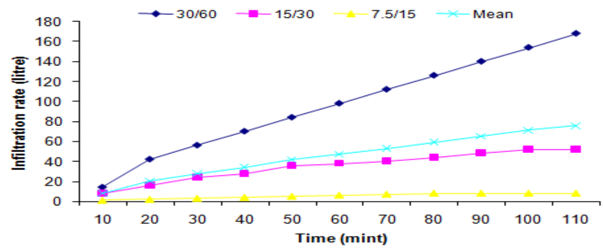


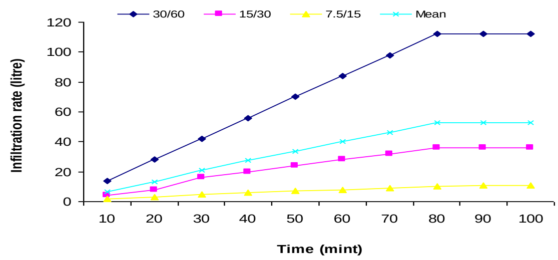


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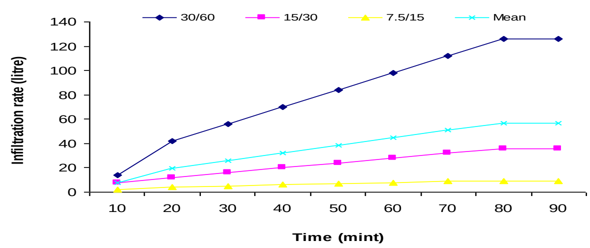
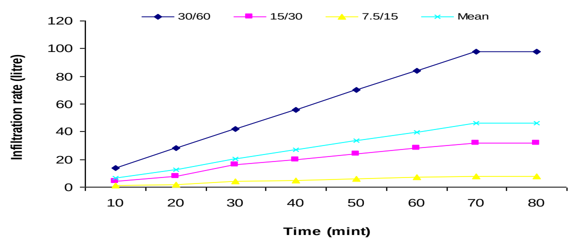
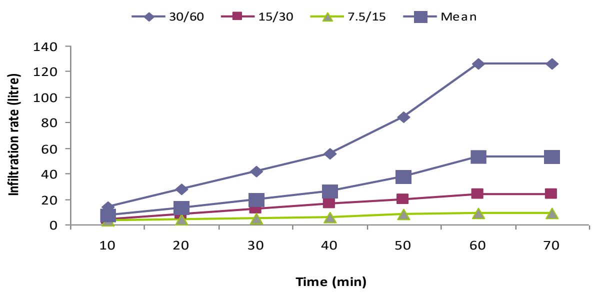
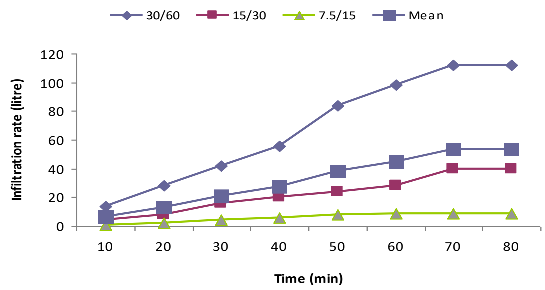



Week 9 Week 10

***Fig. 2.*** *Graph showing the infiltration rate with time for varying dimensions (30:60, 15:30, 7.5:15 and mean) during dry season.*

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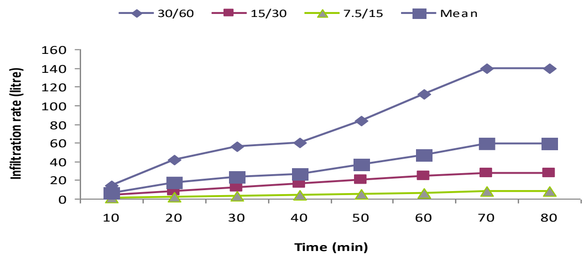


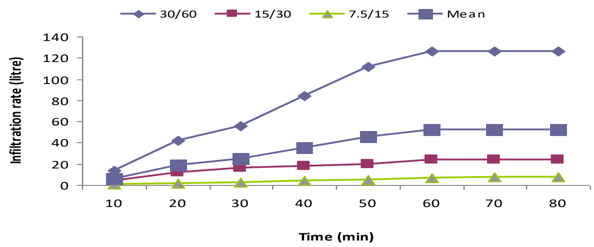


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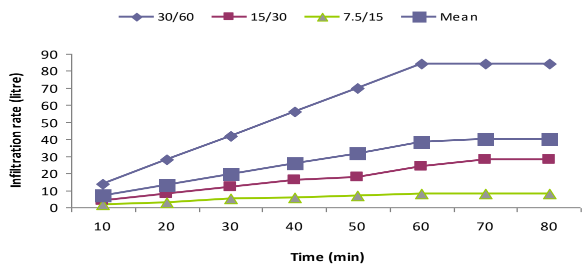


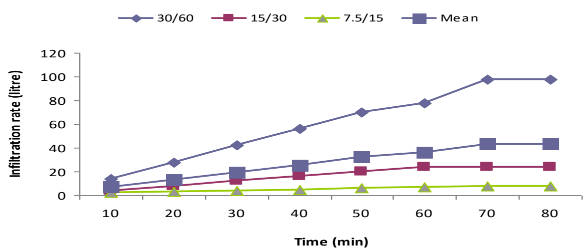


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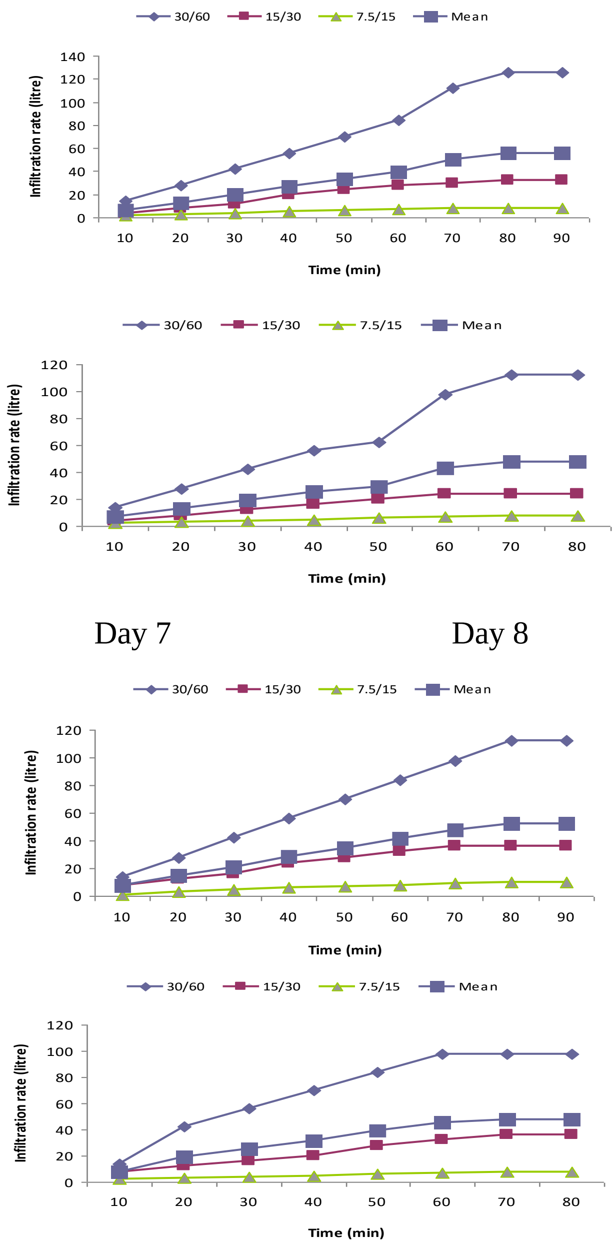


Day 7 Day 8

Day 9 Day 10

***Fig. 3.*** *Graph showing the infiltration rate with time for varying dimensions (30:60, 15:30, 7.5:15 and mean) during wet season.*

**CONCLUSION**

It has been shown that infiltration rate can be determined using all the selected rings dimension whereas high rings diemension (30/60cm) and low rings diemension (7.5/15cm) deviated greatly rom the mean the moderate dimention ring (15/30cm) was closely related to the mean. Thus, in the study area which is characterized by an irregular sequence of wet and dry spell and having seasonal and variable distribution of rainfall coupled with high temperature that does not vary much during humid period, the 15/30cm diameter rings gave comparatively more desirable results than the other 2 dimensions in the measurement of infiltration.

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**Table 1:** Correlation between infiltration rate with time for the different dimensions during dry season

| | | D30/60 | D15/30 | D7.5/15 | Mean |
|---|---|---|---|---|---|
| D30/60 | Pearson correlation | 1 | *.999*** | *.986*** | *1.000*** |
| | Sig. (2-tailed) | . | .000 | .000 | .000 |
| | | 11 | 11 | 11 | 11 |
| D15/30 | Pearson correlation | .999** | 1 | *.991*** | .999** |
| | Sig. (2-tailed) | .000 | . | .000 | .000 |
| | | 11 | 11 | 11 | 11 |
| D7.5/15 | Pearson correlation | .986** | .991** | 1 | .986** |
| | Sig. (2-tailed) | .000 | .000 | . | .000 |
| | | 11 | 11 | 11 | 11 |
| Mean | Pearson correlation | 1.000** | .999** | .986** | 1 |
| | Sig. (2-tailed) | .000 | .000 | .000 | . |
| | | 11 | 11 | 11 | 11 |

**Table 2.** Correlation between infiltration rate with time for the different dimensions during wet season

| | | W30/60 | W15/30 | WC7 5/15 | Mean |
|---|---|---|---|---|---|
| W30/60 | Pearson correlation | 1 | .863** | .821** | .991** |
| | Sig. (2-tailed) | . | .003 | .007 | .000 |
| | | 9 | 9 | 9 | 9 |
| W15/30 | Pearson correlation | .863** | 1 | .977** | .923** |
| | Sig. (2-tailed) | .003 | . | 0 | 0 |
| | | 9 | 9 | 9 | 9 |
| WC7.5/15 | Pearson correlation | .821** | .977** | 1 | .888** |
| | Sig. (2-tailed) | .007 | 0 | . | .001 |
| | | 9 | 9 | 9 | 9 |
| Mean | Pearson correlation | .991** | .923** | .888** | 1 |
| | Sig. (2-tailed) | .000 | 0 | .001 | . |
| | | 9 | 9 | 9 | 9 |