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PERFORMANCE EVALUATION OF LOCALLY MADE GYPSUM BLOCKS FOR IRRIGATION SCHEDULING IN FEDERAL COLLEGE OF FORESTRY JOS, NORTHERN NIGERIA.

[1]POPOOLA, A. S., [2]ADEDIRE, O., [3]MBAH, J. J., [4]OLADEJO, A. O., [5]YAKUBU, C. K., AND [6] E. OLORI-OKE.

[1]Department of Forestry Technology, Federal College of Forestry, P.M.B 2019, Jos, Plateau State, Nigeria.[2&3]Statistics department, Federal College of Forestry, P.M.B 2019, Jos, Plateau State, Nigeria. [4&6]Pest Management Technology department, Federal College of Forestry, P.M.B 2019, Jos, Plateau State, Nigeria. [5]Horticulture and Landscape department, Federal College of Forestry, P.M.B 2019, Jos, Plateau State, Nigeria.

Abstract

Majority of farmers in Nigeria are practicing irrigating farming during dry season without using any irrigation scheduling criteria. Consequently, the application of excess irrigation water causes water logging, wastage of precious water resources, plant diseases, soil salinity as well as the lack of water results into crop water stress.The study evaluate the performance of a locally made Gypsum Blocks for irrigation scheduling in Federal College of Forestry Jos, Northern Nigeria. Gypsum blocks were fabricated and tested, using the gravimetric method as a reference. Prior to the installation, soil samples were take at three different depth (0-15cm, 15-30cm & 30-45cm respectively) from three plots, making a total of Nine soil samples on the field. Nine gypsum blocks were intalled (. Performance of the blocks were based on mean difference and relationship between the blocks and the gravimetric method. The result of the experiment showed that gypsum block worked best in sandy-loam soil and best tool for automated irrigation scheduling. The fabricated gypsum block performed within depth 0-15cm, followed by 15-30cm. The reliability of the installed *gypsum blocks decreases as the depth increases down the soil profile, as observed in the study site. Therefore, this work recommend 0-15cm depth for gypsum block intasllation for the study site. The major root distribution patterns were concentrated in this root zone depth for most crops and the same could be used for designing irrigation systems and planning crop irrigation scheduling.*

Keywords: *Irrigation scheduling, Gypsum block, Gravimectric method, soil moisture, wilting point.*

INTRODUCTION

Good agricultural practice include both the knowledge of water used by crop and techniques that permit an efficient irrigation management Khan *et al.,* 2013 [1]. The judicious application of irrigation water is majorly to reduce water consumption and improve water use efficiency, for improved soil water management. There is a need for better methods and technique to collect accurate and real time soil water measurements at specific depths while minimizing disturbance of the soil Veeranna *et al.,* 2013 [2]. A variety of traditional and newly emerged technologies have been reported for monitoring the soil water content. The gravimetric soil sampling method is a traditional way to estimate the water content in soil by measuring the weight difference between the original wet soil and the soil dried by an oven, the water content can be directly calculated NIC, 2001 [3]. The electrical permittivity of the soil can be used as an index to estimate the soil moisture content, by using two or three stainless needle as poles, the local calibration of various types of soil specimen soil moisture content can be calculated Qingzhao *et al.,* 2017 [4]. Most common soil water monitoring methods present one or more limitations, however capacitance probes can achieve accurate soil a water measurements with small intervals and very little disturbance if installed correctly Paltineanu *et al.,* 1997 [5]. Soil electrical conductivity has a direct positive correlation with the clay content of a soil and a direct negative correlation with sand contents, soil moisture content is an important characteristics used to evaluated irrigation need run-off susceptibility and plant available water

Christopher, 2009 [6]. To relate soil water measurements with gypsum block readings a calibration must be performed between the resistance meter and actual soil moisture readings taken from the soil. Calibration implies the establishment of a precise relationship between a new system of measurement and one which is long established and accepted as a standard method for measuring the same variable Bell *et al.,* 1987 [7]. Non – destructive soil water content determination is a fundamental component of agricultural applications such as precision agriculture and irrigation scheduling Svatoplik *et al.,* 2016 [8]. Irrigation scheduling is a technique that involved determining how much water is needed and when to apply it to the field to meet crop demands. The main purpose of scheduling irrigation is to increase the profitability of the crop by increasing the efficiency of using water and energy. The can be done by reducing the amount of run-off and deep percolation water loss around the plant. Therefore, by managing the soil water status and the current crop water use, water can be applied at specific times to meet the crop demands, and minimize water loss run-off and deep percolation Niyaza, 2006 [9]. The study was carried out wth the following set of objections; to describe the soil properties in the study site, determine the calibration curves of gypsum blocks used to determine the suction pressure in soil and determine the device sensitivity to different depth in the soil.

MATERIALS AND METHODS

Study Area

The field experiment was conducted in Federal college of Forestry Jos, Plateau State of Nigeria located in the North West of plot. It's in a region of the middle belt of Nigeria and falls between latitude 7 and 11 North longitude 7 and 25 East with an altitude of 1,200mm above sea level. The topography of the area lies south of guinea savannah of Nigeria, with mean annual rainfall of 1460mm and temperature between 10C and 32 C. Jos has an area of about 219km and a population of about 492,300 Geography and land survey Unijos, 2013 [10].

Soil Sampling and Analysis

Soil samples from 0 -60cm depth was collected, air dried ground and passed through 2mm sieve and analyze for soil texture, field capacity, permanent wilting point, bulk density, electrical conductivity, P.H. Na, Ca, and Mg Concentrations. The effect of temperature was minimized by performing the experiment under controlled laboratory conditions at a room temperature.

Fabrications and Specification of Gypsum Block Soil Moisture Sensors.

For fabrication of gypsum block sensors a mold containing 15 cubicles of size (5 x 4 x 2.5) cm in a wooden boxes type frame was fabricated using ply board of 10mm thickness. Stainless screen electrodes of 10 x 5 x 2mm size were connected to 0.1cm diameter thick single care with P.V.C coated wire. The electrodes were taken out with help of single ply aluminum wires. The electrodes were spaced 1cm apart and embedded in the block. The ten parts of plaster of Paris and eight parts of stilled water were mixed to prepare the slurry for fabricating the gypsum block sensor.

Sensors Installation and Accuracy

Performance of gypsum were evaluated under field conditions. Soil samples from three depth at 0 – 15, 15 – 30, and 30 - 45cm, were collected close to sensors at different times during the study period to determine water contents and evaluate sensor performance in the field. The gravimetric method was used as a reference method for the calibration of water testing devices. Volume of water was applied at different times and the corresponding moisture content were evaluated.

Calibration of Gypsum Blocks

The measurement of soil moisture was based on the electrical resistivity of the block which decreases as the water content increases and vice versa. The amount of electricity that was passing through the porous block depended partly on the material and partly on the water content as described by Nagy *et al.,* 2013 [11].

Statistical Analysis

Performance of the blocks were determined based on mean difference Addiscott *et al.,* 1987 [12], relationship between the blocks and that derived from the laboratory was obtained using scattered plot graphs.

RESULT AND DISCUSSION

Results

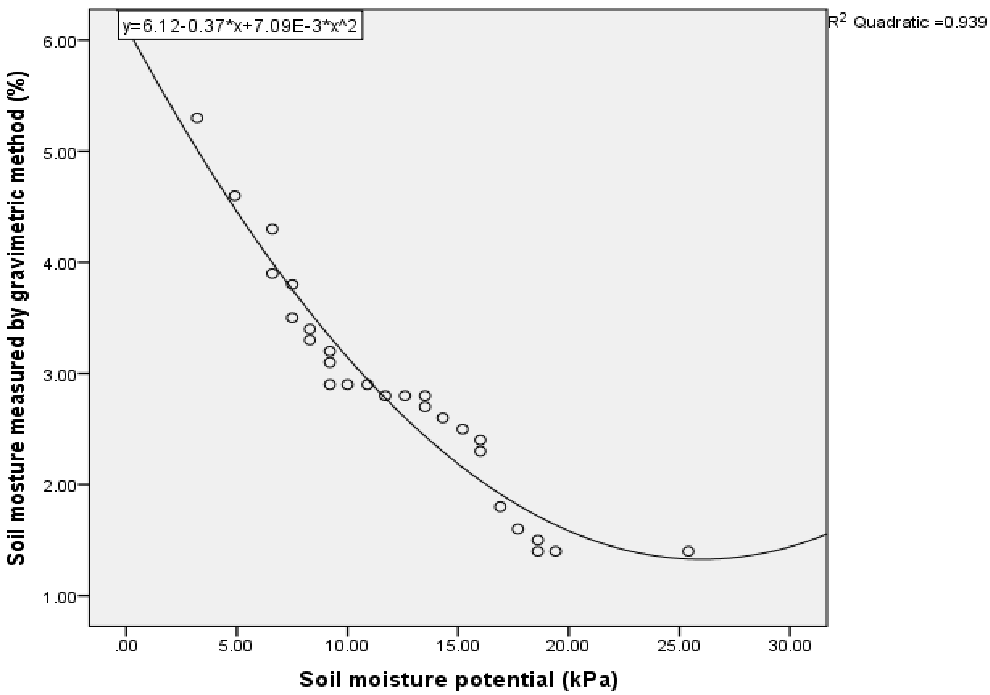
Particle size obtained from the depth of 15cm from the soil at the Meteorological station (MS) site was 66% sandy, 19% silt and 15% clay soils. At 30cm depth, the sizes were 64% sandy, 20% silt and 16% clay respectively. At 45cm, **70**% sandy, 19% silt and, clay 11% respectively. Is was observed that the soil particles varies in sizes across the depth, as shown in table 1. The textural class of soil that was obtained from the depth of 15cm, 30cm and 45 at the MS site was sandy loam. Bulk density of the soil at a depth of 15cm is 1.17, 30cm is 1.15 and at 45 was 1.01g/cm^3 respectively. Particle size obtained from the depth of 15cm from the soil at the CPT site was 74% sandy, the silt was 20% and 6% clay. At 30cm depth, the size were 86% sandy, 12% silt and 2% clay respectively. At 45cm, **64**% sandy, 24% silt and, clay 12% respectively (table 1). The textural class of soil that was obtained from the depth of 15cm, 30cm and 45 at the CPT site was sandy loam. Bulk density of the soil at a depth of 15cm is 0.89, 30cm is 0.81 and at 45 was 0.78g/cm^3 respectively. Particle size for the sand (%) which was obtained from the depth of 15cm from the soil at the nursery site was 92% sandy, the silt was 4% and clay was 4%. At 30cm depth, the size were 94% sandy, 4% silt and 2% clay respectively. At 45cm, 94% sandy, 4% silt and, clay 2% respectively. Is was observed that the soil particles were of similar sizes, as shown in table 1. The textural class of soil that was obtained from the depth of 15cm, 30cm and 45 at a nursery site location was sand. Bulk density of the soil at a depth of 15cm is 1.08, 30cm is 1.29 and at 45 was 0.9g/cm^3 respectively. Figure 1 present the relationship between soil moisture measured by gravimetric method and soil moisture potential. The soil moisture potential measurements by gypsum block developed ranged from 3 to 25kpa for the study site soil. The device demonstrate the measurement of soil moisture based on the electrical resistivity of the block which decreases as the water content increases and vice versa. Figure 2, 3 and 4 gives the relationship between moisture content (MC) measured by gypsum block with gravimetric method at different depths considered. The developed gypsum block performed well in the range 2.4-5.3%, 1.4-3.2% and 2.8-4.3% of MC by gravimetric method at 15cm, 30cm and 45cm depths respectively, as shown in Figure 2, 3, and 4. The maximum measurement were 25.4, 18.6 and 12.6kPa at 2.4, 1.4 and 2.8% VMC. The blocks were reliable in the range of 9.2-25.4, 6.6-18.6 and 3.2-12.6kPa for 15, 30 and 45cm depths respectively. The reliability of the installed gypsum blocks decreases as the depths increases down the soil profile, as observed in the study site.

Table 1: Physical properties of the soil in the study site.

Depths	Sample No	Particle size distribution			Textural class	Bulk Density (g/cm^3)	Field Capacity (FC) (%)	Permanent wilting point (PWP) (%)
		Sand %	Silt %	Clay %				
15cm	MS	66	19	15	Sandy loam	1.17	26.8	8.3
30cm	MS	64	20	16	Sandy loam	1.15	25.7	8.7
45cm	MS	70	19	11	Sandy loam	1.01	24.2	10.4
15cm	CPT	74	20	6	Sandy loam	0.89	21.4	7.3
30cm	CPT	86	12	2	Loam sand	0.81	21.6	7.6
45cm	CPT	64	24	12	Sandy loam	0.78	21.2	7.7
15cm	NS	92	4	4	Sand	1.08	22.1	8.5
30cm	NS	94	4	2	Sand	1.29	22.9	8.9
45cm	NS	94	4	2	Sand	0.96	22.2	9.4

(Source: Field survey, 2019)

(Key: MS = Metereological atation soil; CPT = Crop production technology department soil; NS = Nursery soil)



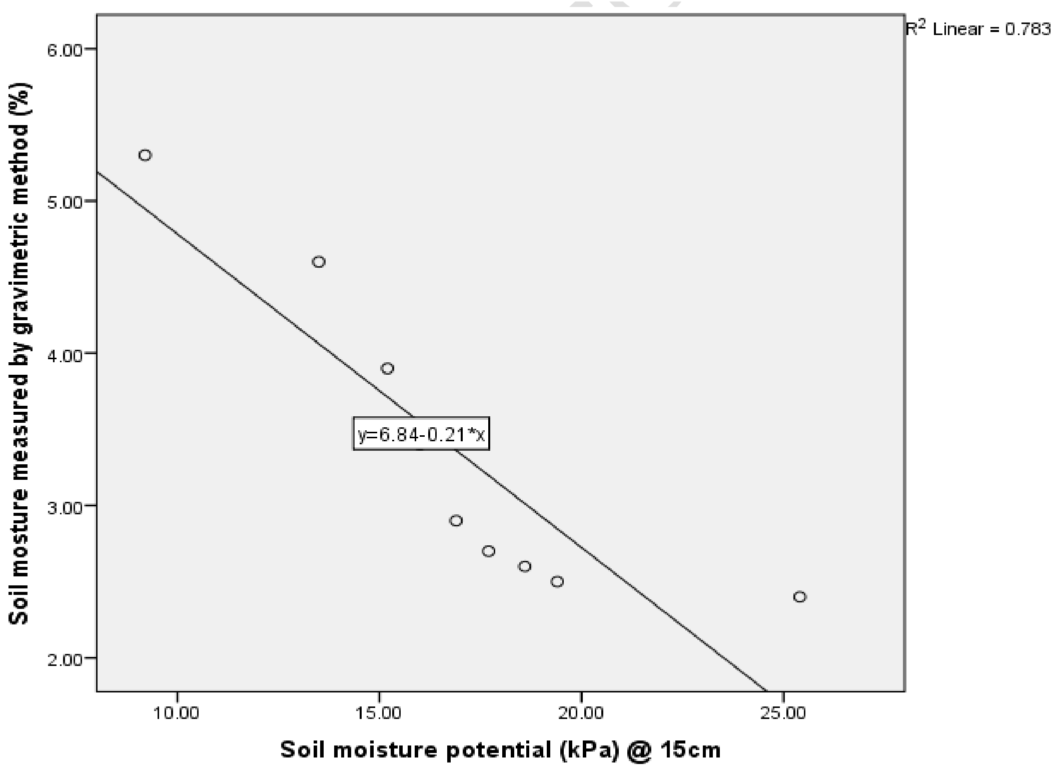
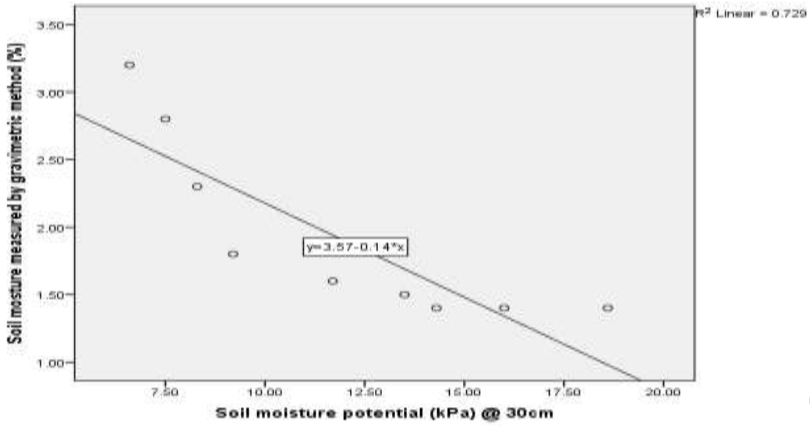


Figure 2: Sensitivity of Gypsum block to 15cm depth in the Soil.
Figure 1: Calibration curve of gypsum blocks



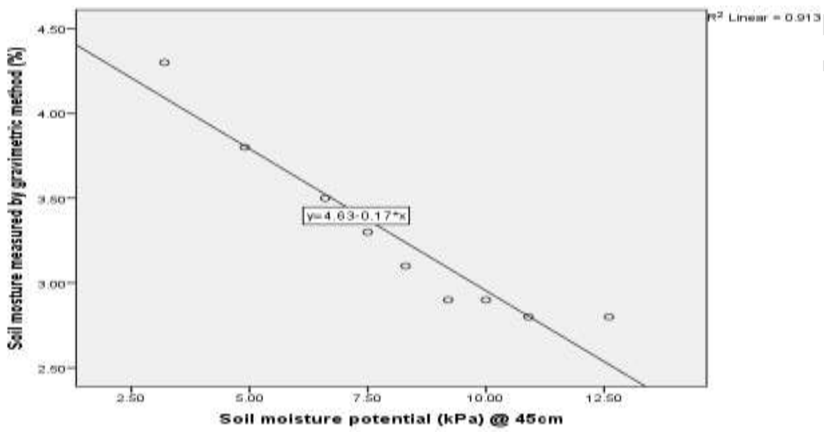


Figure 3: Sensitivity of Gypsum block to 30cm depth in the Soil. Figure 4: Sensitivity of Gypsum block to 45cm depth in the Soil.

Discussion

The soil moisture potential curve from gypsum block device showed that the maximum water productivity maintained by providing soil moisture up to field capacity level and applicable for high tension range. Therefore, the gypsum block can be operated in a drier range domain on the field. These results obtained same with Intrigliolo & Castel, 2004 [13]; Irmak & Haman, 2001 [14]. As a result it was concluded that the gypsum block work best in sandy loam and best tool for automate irrigation scheduling. The developed gypsum blocks performed better within depth 0-15cm, followed by depth 15-30cm and 30-45depth (Fig. 2, 3, & 4). The reliability of the installed gypsum blocks decreases as the depths increases down the soil profile, as observed in the study site.

CONCLUSION

The gypsum block device was developed and tested for irrigation scheduling. The developed gypsum block performed well in the range of 2.4-5.3% volumetric moisture content. These blocks were reliable in the range of 9.2-25.4, 6.6-18.6 and 3.2-12.6kPa for 15, 30 and 45cm depth respectively. Therefore this work concluded that most of the developed gypsum block performed good between depths 0-15 cm. The major root distribution patterns were concentrated in this root zone depth for most crops and the same could be used for designing irrigation systems and planning crop irrigation scheduling. The developed blocks would be successful in maintaining the moisture in the crop root zone at field capacity throughout the growing season. The present research work opens up new vistas and revolution in on-farming and off-farming agriculture.

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