Various Soil Moisture Sensors Used in Agriculture: An Overview

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***Abstract*- Water is a very precious resource and a driving force in irrigation. Optimal use of water is a need of the hour. Efficient irrigation watering helps in saving water, getting better plant yields, reduce dependency on fertilizers and improve crop quality. Various methods, both laboratory and field including remote sensing are available to measure soil moisture content, but the quickest and better one is with the use of soil moisture sensor electronic devices. For successful irrigation, it is necessary to monitor soil moisture content continuously in the irrigation fields. The selection of soil moisture probes is an important criterion in measuring soil moisture as different soil moisture sensors have their own advantages and disadvantages. The soil moisture sensors are used intensively at present because it gives real time readings. An attempt is made in this article to review some of the sensors available, their specifications, properties, applicability, advantages and disadvantages so that an informed decision on selection of appropriate sensor can be made for a particular application.**

Key words: Crop, irrigation, moisture sensors, soil moisture

I. INTRODUCTION

The world, at present is facing shortage of water which is hampering the development of agriculture and hence the food production. Judicious use of water is therefore necessary (Munoth et al., 2016) and in agriculture particularly, optimum use of water is necessary as there is shortage of water in most parts of India. Soil moisture is primary information in achieving optimum water requirements for the crops (Schroder, 2006). The various levels of soil moisture content are shown below in figure 1. As the water infiltrates into the soil, the pore spaces are filled with water and water starts percolating downwards. As this process continues, the soil attains field capacity but the percolation of water continues due to capillary action and gravity. When soil water exceeds the field capacity, the excess water drains out (saturation point). Permanent wilting in this figure indicates the point at which plants have absorbed all of the available water and they wilt such that they cannot recover. There are generally two methods of measuring soil moisture, which are Direct inspection (Feel and appearance method, Hand-push probe, and Gravimetric method), and Meters and Sensors (Soil moisture blocks, TDRs, FDRs, etc.(Evans et al., 1996) The soil moisture sensors are very productive instruments in measuring soil moisture to assess crop growth.(Scherer *et al.*, 2013).

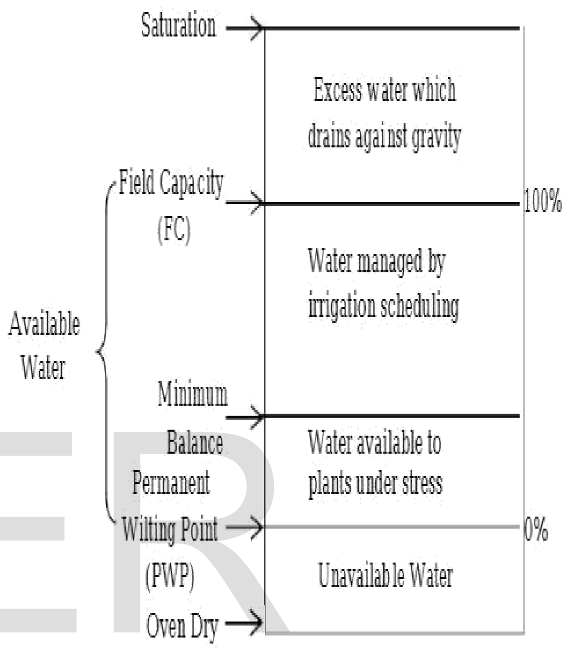

Figure 1. Various water levels in soil water content
(Source: Yonts *et al.*, undated)

However, one must take care in selecting the appropriate type of sensor by taking into account the sensor characteristics, applicability, advantages and disadvantages and most importantly cost. Effort have been made in this article to discuss some common sensors used in the field with their advantages and disadvantages so that one is able to easily identify the type of sensor required for his particular application.

II. DIFFERENT TYPES OF SENSORS

There are numerous types of sensors available today, each having variable performances (Francesca et al., 2010). Some measure soil moisture content while other measure soil water potential and dielectric constant (volumetric content). Although there are numerous techniques available for soil moisture sensing, but in this review the soil water tension based sensors (tensiometers and granular matrix sensors) and soil water content based sensors (TDR, FDR and VH400) are discussed. The nuclear scattering and gamma ray attenuation techniques have not been discussed here as they use radioactive material which may prove to be hazardous (McKim et al., 1980).

A. TENSIOMETERS

Tensiometers are simple soil moisture tension measuring devices used frequently in irrigation scheduling. The figure 2 shows a typical tensiometer which consists of a porous ceramic tip connected to vacuum gauge through a PVC tube.

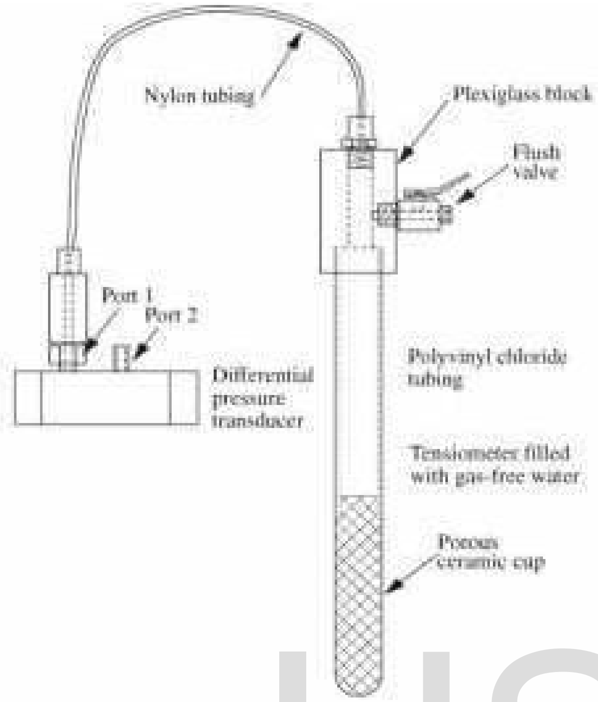

Figure 2. Soil water tensiometer (Source:Freeman *et al.*, 2004)

Hanson *et al.*,(2002) has given values of soil moisture tension measured by tensiometer for different types of soil as shown in table 1.

Table 1. Variation in soil water tension for different types of soil

Soil Type	Soil Moisture Tension
	(centibars)
Sand or loamy soil	40-50
Sandy loam	50-70
Loam	60-90
Clay loam or clay	90-120

(Source: Hanson *et al.*, 2002)

Advantages

a) Tensiometers are simple, rapid, inexpensive and easy to use (Enciso-Medina et al., 2007).

b) Different types of liquid like ethylene glycol solution can be used to obtain data during freezing and thawing conditions (Schmugge et al., 1979).

Disadvantages

a) Periodic maintenance is required as air bubbles accumulate under normal use (Hensley et al., 1999).

b) It is prone to damage due to freezing temperatures (Alam et al., 1997).

c) Several tensiometers are required for measurement because they measure soil water potential only in the vicinity of the tensiometer (Goodwin, 2009).

d) The usable range is only between 0-85 centibars of tension above which the gauge will malfunction (Werner, 2002).

Applicability

The tensiometers can be used in any horticulture crop under irrigation (Goodwin, 2009).

B. GRANULAR MATRIX SENSOR (GMS)

The granular matrix sensor is made of a porous ceramic external shell through an internal matrix structure containing two electrodes as shown in figure 3. The electrodes inside the GMS are imbedded in the granular fill material above the gypsum wafer. The water conditions in the granular matrix change with variation in corresponding water conditions in the soil and these changes are continuously indicated by difference in electrical resistance between two electrodes in the sensor (Berrada et al., 2014). This resistance between the electrodes is inversely related to soil water (Irmak et al., 2006).

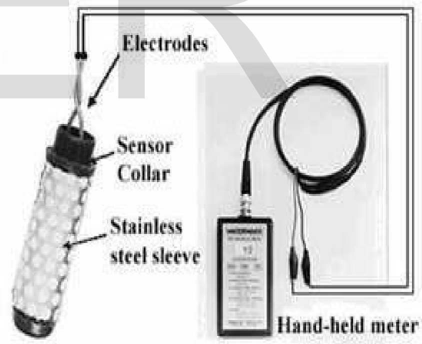

Figure 3. Granular matrix sensor (Model 200SS)

(Source: Irmak et al., 2006)

Advantages

a) GMS is cheaper and requires less maintenance compared to tensiometer (Shock et al., 1998).

b) Automation of irrigation in fields can be achieved (Muñoz-Carpena et al., 2005).

Disadvantages

a) It shows different response to different soil types (Enciso-Medina et al., 2007).

b) Sometimes, poor contact between the soil and the sensor occurs which could cause high readings which are most likely to occur in heavy soils (Berrada et al., 2014).

Applicability

The GMS is used for assessing soil moisture in crops like cotton, onion, potato, urbanized landscapes (Muñoz-Carpena et al., 2005), corn (Irmak et al., 2006), drip irrigated vegetable crop (Thompson et al., 2005). The GMS has good accuracy in medium to fine soils because the soil particle size will be similar to that of the transmission material which has a consistency close to that of fine sand that is wrapped in porous membrane of the GMS.

C. TIME DOMAIN REFLECTROMETRY (TDR)

In time domain reflectrometry, a pulse of radio frequency energy is injected into a transmission line and its velocity is measured by detecting the reflected pulse from the end of the line. This velocity depends upon the dielectric constant. It measures the moisture content by measuring how long it takes for the reflected pulse to come back (Cepuder etal., 2008 and Haman et al., undated). The response of a TDR is very quick (≈ 28 sec) (Zazueta et al.,1994).

Advantages

a) TDR respond quickly to varying soil moistures (Marenghi, 2013).

b) It measures moisture quite accurately (± 2%) in any type of soil (Cepuder et al., 2008).

Disadvantages

a) They need to be carefully calibrated to precisely measure the amount of time it takes for the pulse to come back (Paige et al., 2008).

b) This instrument is costlier than other measuring methods (Zazueta et al., 1994 and Heiniger, 2013).

III. CONCLUSION

Water is a limited resource in the world and agriculture is a primary market. Therefore, a sustainable and economic approach is to be adopted for efficient agricultural practice and irrigation scheduling (Levido et al., 2014). The use of soil moisture sensors helps growers with irrigation scheduling by providing information about when to water the crops. Selection of sensor for a particular application or on the basis of type of soil can become a tiresome exercise as there are wide level of soil moisture sensors available in the market. The advantages and disadvantages of sensors must be considered as criteria for selection because the working principle behind each type of sensor varies with its application and type of soil. The development of wireless sensor applications in agriculture makes it possible to increase efficiency, productivity and profitability of farming operations as well as the maximum crop yield with minimum use of irrigation water.

References

[1] Abouatallaha A, Salghia R, Hammoutib B, Fadlc A El., et al., (2011) Soil moisture monitoring and plant stress measurement of young citrus orchard. Der Pharma Chemica, 3 (6): 341-359.

[2] Hensley D, Deputy J (1999) Using tensiometers for measuring soil water and scheduling irrigation. Coopertive Extensive Service.Department of horticulture, College of tropical agriculture & human resources, University of Hawaii at Manoa. Landscape L-10

[3] Munoth P, Goyal R, Tiwari K (2016) Sensor based irrigation system: A review. International Journal of Engineering Research & Technology (IJERT), NCACE-2016 Conference Proceedings, 4 (23):86-90. http://www.ijert.org

[4] Schroder HJ (2006) Soil moisture-based irrigation for efficient use of water and nutrients and sustainability of vegetables cropped on coarse soils. A thesis presented to the Graduate School of the University of Florida.

[5] Evans R, Cassel KD, Sneed ER (1996) Measuring soil water for irrigation scheduling: monitoring methods and devices. Publication no.AG 452-2.North Carolina Cooperative Extension Service.https://www.bae.ncsu.edu/programs/extension/evans/ag 452-2.html

[6] Scherer FT, Franzen D, Cihacek L (2013) Soil, water and plant characteristicsimportant to irrigation. Extension Service, North Carolina State University, AE 1675 (Revised). https://www.ag.ndsu.edu/pubs/ageng/irrigate/ae1675.pdf

[7] Francesca V, Osvaldo F, Stefano P, Paolo PR (2010) Soil moisture measurements: Comparison of instrument performances. Journal of Irrigation and Drainage Engineering, 136, (2).DOI: 10.1061/(ASCE)0733-9437(2010)136:2(81).

[8] Maughan T, Allen NL, Drost D (2015) Soil Moisture Measurement and Sensors for Irrigation Management. AG/Irrigation/2015-01pr, Agriculture Extension, Utah State University McKim H, Walsh JE, Arion, DN(1980) Review of techniques for measuring soil moisture in situ.Special Report 80-31 of United States Army Corps of Engineers, Cold Regions Research and Engineering Laboratory

[9] Freeman AL, Carpenter CM, Rosenberry OD, Rousseau PJ, Unger R, McLean SJ (2004) Use of submersible pressure transducers in water-resources investigations. 40-43

[10] Zazueta SF, Xin J (1994) Soil moisture sensors. Bulletin 292, Florida Cooperative ExtensionService, Institute of Food and Agricultural Sciences, University ofFloridawww.experimentalhydrology.net/wiki/index.php?title= Soil_moisture_- FDR_(profile_probe)

[11] Hanson B, Orloff S (2002) Monitoring soil moisture for maximum profit irrigation of alfaalfa. Proceedings, Dec 11-

ISSN 2229-5518
13, 2002, Western Alfalfa and Forage Conference. Heiniger R (2013) Sensors and monitors for measuring soil moisture. Corn Kernels, No.1 North Carolina State University.

[12] Enciso MJ, Porter D, Périès X (2007) Irrigation monitoring with soil water sensors. Cooperative Extension, B-6194, The Texas A&M University System.

[13] Schmugge TJ, Jackson TJ, McKim HL(1979)Survey of methods for soil moisture determination. NASA Technical memorandum

[14] Shock CC, Barnum MJ, Seddigh M (1998) Calibration of watermark soil moisture sensors. Oregon, State University

[15] Berrada A, Hooten MT, Cardon EG, Broner I (2001) Assessment of irrigation water management and demonstration of irrigation scheduling tools in the full service area of the Dolores project: 1996-2000. Technical Report, TR01-7, Colorado State University:
7-9.