The use of different methods to evaluate soil volumetric water content

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Overview and Objectives:

Measurement of soil water content is essential for the characterization of soil hydrology, crop water use for mulch and dry land cropping systems, and soil water dynamics of the biologically active soil layer. However, for most irrigation, crop water use, and irrigation and water use efficiency work, what is required is the volume of water in a certain volume of soil or the equivalent depth of water in a certain depth of soil. Both of these require knowledge of the volumetric water content. Direct and indirect methods can be used to determine the volumetric water content of soils. The direct methods consist essentially of drying and weighing a known volume of a soil sample, whereas indirect methods are based on the correlation of certain physical and physiochemical properties of the soil with its water content. Many studies suggest that ovendry (direct method) is not precise enough and could create uncertainties and inaccuracies in the measured result of soil water content because of texture, bulk density and other soil properties and vegetation (Gardner, 1986). Similarly, indirect estimation of water content in soil were found by using sophisticated and expensive technology like neutron moisture meters, capacitance sensors that work from within a plastic access tube, time domain reflectometry systems that employ waveform capture and analysis, tensiometers etc. So, there is critical need of indirect measurement method which is easy and helps to determine the other soil properties which influences soil water content with capability to provide continuous measurements of water content and also the factors (texture and vegetations) that influence in direct measurements. The use of heat pulse probe (HPP) to determine soil volumetric water content in indirect way might be very essential for accurate insitu soil physical measurements along with soil thermal properties.

The long term goal of this study is to advance scientific understanding of the factors influencing soil moisture and use them to practice for analysis with different soil physical properties. *The objective* of the proposal is to measure the soil water content by using direct (ovendry) and indirect (HPP) methods and factor influence in direct measurement. The agronomy research station plot, Stillwater and Perkins will be taken as study site. *The rationale* for these studies is that accurate estimation of soil moisture by using different methods which is necessarily important for understanding other soil properties. Likewise, using HPP methods will facilitate to know the status of soil thermal properties and ultimately use to determine soil water content. The influence factors like vegetation and texture may influence on soil water content which effects in inaccuracy measurements in direct method. *It is hypothesized* that the indirect estimation using HPP method will have high soil water content measurement than direct method and also soil type (texture) will have higher influence on direct estimation method. The proposal team is well prepared to succeed with this project due to knowledge and experience to carry out soil sampling and analyses, experiences using technology like HPP. *The specific aims* for this proposal are to:

1) *Determine the volumetric water content of soil by using direct (ovendry) and indirect (HPP) method.*

   Oven dry method and heat pulse probe will be used to determine volumetric water content in different type of soil texture (Clay and Sand), and different vegetation plots.

The soil core from the agronomy research plot, (Stillwater and Perkins) (0-10cm) is obtain to determine volumetric water content.

2) *Determine the factors influencing the volumetric water content in soil.*

Soil cores (0-10cm), from different vegetative (Forage Sorghum and Switchgrass) plots, will be collected to measured volumetric water content by using both direct and indirect method.

3) Test statistically if measured volumetric water content will be varied with methods and influencing factor (soil type and vegetation).

ANOVA test will be used if methods and vegetative and soil type difference will have significant effect on volumetric water content.

Significance:

The soil water content is highly categorized properties which is crucial for the agriculture production. So, to estimate the water content is other challenging fact which is possible due to various measurement techniques. *Ren et al. (2000)* reported on the possibility of using a three needle HPP for the indirectly estimation of water content from temperature responses. Sequential measurements of the heat input and resulting temperature rise further allow estimation of the change in soil water content without knowledge of soil specific properties (Bristow et al., 1993). Similarly, different types of soil and vegetation may influence in the soil water content because of the different textural properties of soil like clay, sand etc and the plant roots distribution. Therefore, effect of different factors will be determined using direct and indirect method so that more robust method could be built to estimate water content.
Therefore, this proposed project is significant because HPP technique could be novel to determine water content along with soil thermal properties and also will insight on the major influencing soil factor on volumetric water content.

Methodology:

1) Determine the volumetric water content of soil by using direct (ovendry) and indirect (HPP) method.

Oven dry method and heat pulse probe will be used to determine volumetric water content in different type of soil texture (Clay and Sand) and in different types of vegetative soil (Switchgrass and Sorghum plots). The soil core from the agronomy research plots, (Stillwater and Perkins) (0-10cm) in different time periods (3 times in 3 week) is obtain to determine volumetric water content.

<u>Indirect method:</u>
The dual-probe heat-pulse technique consists of two parallel needle probes separated by a distance (r). One probe contains a heater and the other a temperature sensor. The

dual probe device is inserted into the soil and a heat pulse is applied and the temperature sensor records the response as a function of time. That is, a heat pulse is sent from the probe across the soil (r) to the sensor. The great benefit of this device is that it measures both thermal diffusivity and volumetric heat capacity.

$$C_{bulk}=C_s(1-Ø)+C_wΘ. \text{ (Campbell, 1985)}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where Ø is the porosity (m^3m^{-3}), Θ= volumetric water content (m^3m^{-3}), and s and w indicates soil solid and water phase respectively. The volumetric water content can be computed directly if C_{bulk} (soil volumetric heat capacity) is measured using the HPP and volumetric heat capacity values of the solid values of the solid phase and water will be known.

Direct method:

The volumetric water content, in the soil (also called the volume wetness or volume fraction of soil water) represents the fraction of the total volume of soil that is occupied by the water contained in the soil. Assuming that V_l is the volume of the liquid phase (water) in the soil sample and that V_t is the total volume of the sample, the volumetric water content, can then be defined as follows:

$$\theta = \frac{V_l}{V_t} = \frac{V_l}{V_s + V_p} \quad ,$$

Where V_s and V_p represent, respectively, the volumes of the solid phase and the pore space.

2) *Determine the factors influencing the volumetric water content in soil.*

Both the methods will be used to determine soil water content. The factors like soil type, bulk density, and vegetation may influence in soil water content. So individual soil cores (0-10cm) from each plot varied with soil type and vegetation will be taken and used both methods to estimate water content in soil. However, indirect method will be in-situ process to obtain soil volumetric heat capacity, which is directly correlated with volumetric water content as shown in eqn. 1. All the data will be collected and will observed the differences to evaluate the influencing factors.

3) Test statistically if measured volumetric water content will be varied with methods and influencing factor (soil type and vegetation).

ANOVA test will be used if methods, vegetative and soil type difference will have significant effect on volumetric water content. SAS or R tool will be used for different statistical test.

Budget:

Transportation
Mileage $0.45 per mile (3 times*40 miles) …….. $54.00
Soil physical analyses

- Soil texture
- Soil porosity
- Bulk density
- Volumetric water content

Heat pulse probe (Available in soil physics lab)…….. $780.00
Soil core (10cm diameter, 15cm depth cylinders)

Timeline:

	Date	Time
Soil Sample (From Stillwater and Perkins) and Pulse probe reading in field	September 25th, Tuesday	10 am-3pm
	October 2nd, Tuesday	10 am-3pm
	October 9th, Tuesday	10 am-3pm
Measurements and analysis	September 26th - Oct.1st	2:30 pm-7pm
	October 3rd-Oct.8th	2:30 pm-7pm
	October 10th-	2:30 pm-7pm

References:

Bristow,K.L., Measurement of thermal properties and water content of unsaturated sandy soil using dual-probe heat pulse probes, Agric. *For.Meteorol*., 89, 75-84, 1998.

Campbell, G.S., Soil Physics with BASIC- Transport models for soil-plant systems, 150 pp., *Elsevier Sci*., New York, 1985.

Gardner, W. H., Water content, Methods of soil analysis. Part1. Physical and mineralogical methods, pp. 493-544, 1986

Ren, T., G. J. Kluitenberg and R. Horton, Determining soil water flux and pore velocity by heat pulse technique, *Soil Sci. Soc. Am. J*., 2001.

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Education

- Oklahoma State University, PhD in Agronomy and Soil Science, June, 2012- Present
- Oklahoma State University, Master of Science in Agronomy and Soil Science, Janaury, 2010- May2012
- Institute of Agriculture and Animal Sciences, Nepal, Bachelor Degree in Agriculture, 2004-2008

Experience

Jan, 2010- Present: **Graduate Research Assistant** under Dr. Gopal Kakani, Department of Plant and Soil Science, Oklahoma State University, Stillwater, OK, USA.

2008- 2009: Worked as a Field officer in **Jhimruk Industrial Development Center (P.) Ltd**. (JIDCO), Pyuthan district, Nepal.

2007- 2008: Worked as an assistant researcher in the project titled " **Carbon sequestration under Zero Tillage Rice –Wheat- Legume Cropping System**" under Asst. Professor Rajan Ghimire and other project titled "**Assessment and Impact of climate change in Agriculture Sector and livelihood of marginalized community in chitwan**" under Bibek Poudel.

Feb, 2008 : Worked as a trainer "**Soil Testing and fertilizers Recommendation**" supported by Fulbari VDC, chitwan, Nepal.

Publications,Presentations and Seminars:

Pandey, A., Warren, J. and V. G. Kakani. 2011. Evaluation of Root Characteristics of Different Switchgrass Cultivars. ASA, CSSA, SSSA International Annual Meetings, San Antonio, TX, October 16-19.

Pandey, A., Warren, J. and V. G. Kakani.2011. Impacts of Row Spacing on Root Characteristics of Switchgrass. Oklahoma EPSCoR Annual State Conference, University of Oklahoma, Norman, OK, April 21.

Attended annual meetings and research presentation on Oklahoma Research Day on Nov 12, 2010, Lawton, Ok, USA.

Attended seminar/ workshop on Training of Trainers (TOT) on *Jatropha* c. Plantation on Apr 16-18, 2009 conducted by Alternative Energy Promotional Centre (AEPC).