A Note on Comparing Rate of Soil Moisture Loss for Conventional and Conservation Tillage Production methods for Peanut (*Arachis hypogaea*)

G.L. Hawkins, J. Kelton, N. Smith, K. Balkcom*[1]

ABSTRACT

Soil moisture retention is important for peanut production as well as water conservation in irrigated and non-irrigated fields. One way to increase soil moisture retention of the soil is by increasing soil organic matter. Research was conducted to determine if there is a difference in the rate of soil moisture loss in a field operated under a conservation production system (CPS) method and a conventionally tilled (CT) method, and if there was a time difference between needed wetting events. Experiments were conducted on two different fields with Tifton sandy loam soil. Soil moisture was monitored with Watermark sensors installed at 10, 20 and 30 cm depths. Data was analyzed to determine the rate of soil moisture loss when the soil was wet (below 50 kPa) and dry (above 80 kPa). The rate of soil moisture loss was not significant between CPS and CT when the soil was wet; however, there was a difference in the soil moisture loss rate when soils were dry. When dry, the CT soils lost moisture at a rate 2.5 times that of the CPS soils. This increased rate of loss indicates that water would need to be supplied to the CT soils every 1.5 d whereas the CPS soils would need water every 3.9 d. These results indicate that use of CPS increased the water holding capacity of soil, increased time required between wetting events, and can aid in the conservation of water resources in peanut production.

Key Words: Soil moisture, water loss rate, conservation tillage, water management

According to the USDA National Agricultural Statistics Service (USDA-NASS, 2016), ten states grow 99% of the peanuts in the United States of America with Georgia and Alabama combining to harvest 60% of that production. In the Southeast, soils are highly weathered and are prone to drought conditions (Faircloth *et al*., 2012). With drought prone soil, irrigation is an important part of peanut production from the setting of pods to final yield not just in the US, but across the globe (Faircloth *et al*., 2012; Tojo Soler *et al*., 2013; El-Habbasha *et al*., 2015; Rowland *et al*., 2007; Suleimam *et al*., 2013; Stansell and Pallas, 1985; Pahalwan and Tripathi, 1984). Irrigation in Georgia has been the focus of agricultural water use in the southern regions of the state and is presented in the form of management practices listed in the Regional Water Plans approved in 2011 for the Lower Flint-Ochlockonee Region, Upper Flint Region, Altamaha Region, and Suwannee-Satilla Region (Anonymous, 2011). Some of the management practices referenced in the Regional Water Plans deals with increased efficiencies of irrigation systems as well as the use of conservation tillage to name a few.

In the southeast, the cropping rotation will include peanuts and cotton. Within the rotation, there are two methods of managing soil, conventional and conservation tillage. Conventional tillage (CT) methods may use a cover crop but prior to planting the commercial crop, the cover crop will be tilled into the soil. Conservation production systems (CPS), also known as conservation tillage, will plant the commercial crop into the residue remaining on the soil surface, with at least 30% soil coverage. Both methods are used by farmers with CPS use in Georgia at approximately 30% (Tubbs and Gallaher, 2005; Rowland *et al*., 2007). However, Reeves *et al*. (2005) states the Conservation Technology Information Center estimated that less than 11% of the peanut acres in Georgia were planted in a CPS. There have been numerous studies conducted comparing CT systems to CPS. Faircloth *et al*. (2012) states that five studies give CPS a clear advantage as it relates to yield, improved quality or net economic returns, seven studies favored CT systems and seven studies showed no difference in the two systems. Faircloth *et al*. (2012) further states that some authors of research on CPS supports the practice for peanuts, others give it no clear advantage over CT, and some oppose the practice for peanuts. Based on the weather conditions during the growing season, peanut yields can even be comparable for the two

[1]First author: Assistant Professor, Crop and Soil Science Department, University of Georgia; Watkinsville, GA 30677; Second author: Regional Extension Agent, Auburn University Wiregrass Research and Education Center, Headland, Alabama 36345; Third author: Professor, Agricultural and Environmental Science Department, Clemson University, Columbia, SC, 29224; Fourth author, Research Associate, Auburn University Wiregrass Research and Education Center, Headland, AL 36345

*Corresponding author's E-mail: ghawkins@uga.edu

methods of CPS and CT (Tubbs and Gallaher, 2005; Bosch *et al*., 2005; Faircloth *et al*., 2012).

The use of a CPS can have environmental benefits, including reduced water runoff, increased water infiltration, and building of soil organic matter when including a winter cover crop such as rye (*Secale cereale* L.) (Jemia *et al*., 2013; Bosch *et al*., 2005; Balkcom *et al*., 2003; Arriaga and Balkcom, 2005). Studies have been conducted where peanuts are grown under reduced irrigation amounts in both CT and CPS (Stansell and Pallas, 1985; Pahalwan and Tripathi, 1984; Faircloth *et al*., 2012; Bosch *et al*., 2005; El-Habbasha *et al*., 2015; Bosch *et al*., 2012; Rowland *et al*., 2007). The results from this research indicates as water availability decreases that yield also decreases. However, some of these studies and others (Ohu *et al*., 2009; Reeves *et al*., 2005) also indicate that by increasing the organic matter in the soil, water is made more available to the plants in that specific study.

With increased focus on water resources and water management in Georgia as well as the Southeast, it is important to understand how soil moisture and moisture loss occurs in both tillage practices. Previous studies have reduced water applications but the final measured parameter was peanut yield. This leads to a knowledge gap on how quickly applied water dissipates through the soil profile. Retention of soil moisture and the rate of water movement in the soil is governed by the pressure head of the water, hydraulic conductivity, soil particle size and other physical factors of the soil (Lal and Shukla, 2004; Miyazaki, 2006). From a soil physical property aspect, water potential is the main driver of water movement in a soil profile as explained by basic physical soil properties and laws. Soil water movement at a theoretical level will follow the water retention curve for a given soil type. These curves can be produced in the laboratory under controlled environmental and physical conditions. Groenevelt and Grant (2004), van Genuchten (1980), Grant and Groenevelt (2015) and others have conducted research to demonstrate how soil water moves within a column. In production fields, soil moisture retention can be related to the amount of soil organic matter. As soil organic matter increases, the potential to hold or retain water in the soil increases (Sullivan *et al*., 2007; Ohu *et al*., 2009; Bosch *et al*., 2012; Jemai *et al*. 2013; Kahlon *et al*., 2013; Strickland *et al*., 2015; Balkcom *et al*., 2003). This increased water holding capacity of the soil, or increased water retention, can have major benefits to producers in times of drought, or short duration rainfall events (Sullivan *et al*., 2007). With increased water holding capacity of the soil based on soil management, this study was designed to measure the water loss rate in a soil profile where CPS and CT were used in peanut production.

Materials and Methods

Site Description

Two experimental sites were established for the 2014 growing season. Both sites were established on a Tifton loamy sand with one located in Bulloch County on a TqA and TqB soil just south of Register, Georgia (32.276855, -81.86574), and the other in Worth County on a TfB soil just north of Sylvester, Georgia (31.565934, -83.811264). The Worth County site was used as the CT site. The CT site had a typical rotation of cotton and peanuts with no rye cover added in the non-cropping season. The Bulloch County site used CPS with a winter cover crop utilized in conjunction with reduced-tillage practices and had been in such a system for over 10 years. Peanuts were rotated with cotton once every seven yr. The CPS site had been planted in cotton the two yr prior to the peanut rotation used for this project and a rye cover crop planted in the non-cropping season. The rye (Wrens Abruzzi) cover crop was planted at a rate of 56 kg/ha after cotton harvest on 22 Nov. 2013. Cover crop termination was completed on 5 April 2014 with peanuts planted on 4 May 2014. Following rye termination at the CPS site, Georgia 06G (Branch, 2007) were planted in single 97 cm rows at a rate of 123 kg seed/ha into standing rye using a John Deere 1700 Max emerge planter with an attached roller/coulter and offsetting 20 cm from the previous cotton row. The CT field was left fallow during the winter following cotton crop harvest the previous year, and planted in single 91 cm row 06G peanuts after a disc tillage prior to planting on 6 May 2014.

Data Collection

Soil moisture was monitored at each location through the use of resistance based Watermark sensors (Irrometer®, 1425 Palmyrita Ave., Riverside, CA 92507), which produce an electrical resistance based on soil moisture. Four sensor sets were installed in the row after peanut shoot appearance on 17 June 2014. Each set consisted of three sensors placed at depths of 10, 20 and 30 cm. Data was collected and stored on a datalogger (WATERMARK Monitor 900M, Irrometer®, 1425 Palmyrita Ave., Riverside, CA 92507) every hr until it could be downloaded bi-weekly. Soil moisture readings recorded during maximum water use for peanut as shown on the water use curve

(Harrison, 2012), at 90 to 110 d after planting, were used for this analysis. Rate of soil moisture loss was calculated from the time of a saturating wetting event. A saturating wetting event refers to an occurrence when the senor readings dropped to 0 kPa indicating a saturated soil profile. Data was analyzed which corresponded to a wet soil condition and a dry soil condition; wet conditions were defined by a tension reading between 0 and 50 kPa while a dry condition was defined as anything above 80 kPa (Irrometer, 2013). The 50 kPa is slightly less than the usual range for irrigation in most soils and the 80 is slightly less than the range where soils are becoming dangerously dry for maximum production and the grower should proceed with caution (Irrometer, 2013) and corresponds to an irrigation frequency where pod weight is reduced by 25% (Gomes de Sousa, *et al.*, 2014). The experiment was a randomized complete block with two blocks and four replications. Data analysis was performed using SAS JMP with means separated by LSD at a P=0.05 level.

Results and Discussion

Water retention in the soil profile is important in many different aspects from meeting plant needs to scheduling irrigation, if available. The data collected from the experiment sites was used to determine a rate of soil moisture loss in the CPS and CT systems. The rate of water loss was calculated and is presented in terms of kPa loss per hr (kPa/hr).

There were differences in soil moisture loss rate at different depths under different moisture conditions (Table 1). The highest moisture loss was the dry soil at 10 cm in the CT system, and the slowest moisture loss was the CT system at 30 cm. There was no significant difference in the moisture loss rate between the CPS dry and the CT wet soils. The

Table 1. Rate of soil moisture loss at different monitoring depths, locations and soil moisture conditions.

Location	Soil moisture	Rate of soil moisture loss (c) 10 cm	20 cm	30 cm
		kPa/hr		
Bulloch County (CPSa)	Wet	0.18 deb	0.18 de	0.15 e
	Dry	0.32 cd	0.35 c	0.30 cd
Worth County (CTb)	Wet	0.17 de	0.11 e	0.05 e
	Dry	0.77 b	0.98 a	0.81 ab

[a]Conservation production system.

[b]Conventional tillage system.

[c]Means followed by the same letter are not significantly different from each other according to LSD at 0.05 level

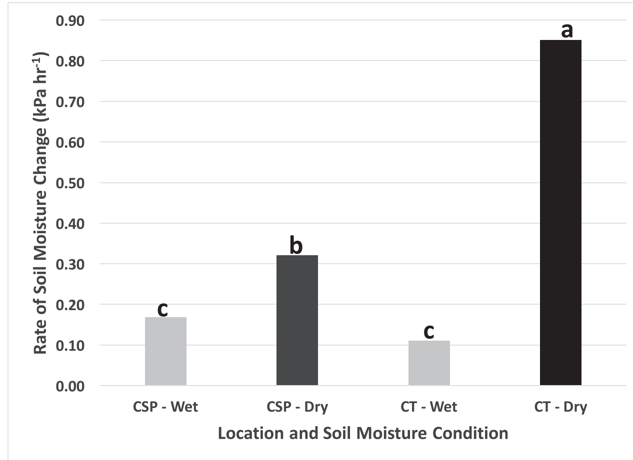

Fig. 1. Average rate of soil moisture loss in conservation production system and conventional tilled peanuts. Letters shown on the bars indicates significance with like letters having no difference at the P=0.05 level. CSP is the conservation production system field in Bulloch County and CT is the conventional tillage field in Worth County. Wet is the condition of the soil moisture potential below 50 kPa and dry is soil moisture potential condition above 80 kPa.

rate of soil moisture loss for each location and soil moisture condition averaged over depth is presented in Figure 1. Further, the rate of soil moisture loss is greatest in the CT field when the soil moisture condition was dry. Interestingly, the lowest soil moisture loss occurred in the CT field when the soil was saturated. Overall the CT field loses water the least when the profile is wet, but loses moisture the greatest when the soil profile is drying out. The CPS field, when wet, has a higher soil moisture loss rate when compared to the CT wet soils, but not significant. There is however, a significant difference in the loss rates in the CT soils under different soil moisture levels. As described, one of the benefits of CPS is the increased infiltration rates associated with soil organic matter and greater open pore spaces. Therefore, when the soil profile is wet, as would be the case directly after a saturating wetting event, the water infiltrates rapidly and leads to a higher soil moisture loss rate in the wet CPS soils as compared to the wet CT soils. When the fields are dry, the rate of soil moisture loss in the CPS field is doubled as compared to a wet CPS soil. When compared to that of the CT field, the rate of loss in the CPS field is two and a half times less under dry conditions. Based on known benefits of increased soil organic matter and as referenced by different authors (Jemai *et al.*, 2013; Kahlon *et al.*, 2013; Strickland *et al.*, 2015), it is expected that in this experiment, water infiltrates faster in the CPS field when wet and has more available water as the soil dries. With more available water, the CPS soil holds water longer than that of the CT soils. The increased

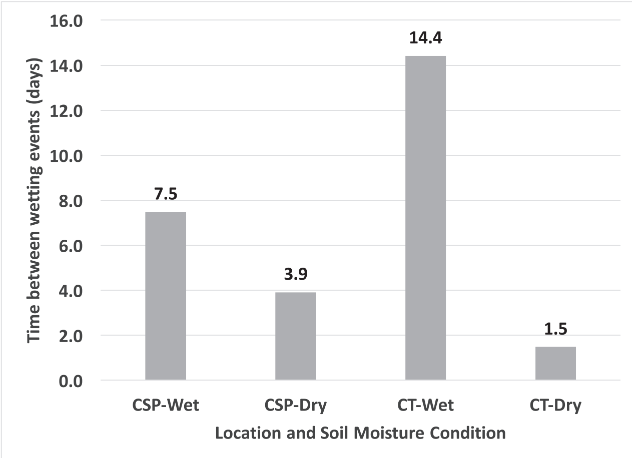

Fig. 2. Time needed between wetting events under different soil moisture conditions on conservation production system and conventional tillage fields growing peanuts. The numbers shown over the bars indicates the d needed between wetting events to maintain soil moisture in the 50 to 80 kPa range. CSP is the conservation production systems field in Bulloch County and CT is the conventional tillage field in Worth County. Wet is the condition of the soil moisture potential is below 50 kPa and dry is soil moisture potential condition above 80 kPa.

water holding capacity increases the time between needed water application from either rainfall or irrigation (Figure 2). When the soil profile is wet, the need for a wetting event is approximately 8 or 14 d for a CPS or CT field, respectively. When the soil is dry, the d between water application for the CT and CSP fields are 1.5 and 3.9 d respectively.

Summary and Conclusions

Soil moisture data was collected from two fields operated under either a CPS with residue management or a CT practice. The overall objective was to determine if there was a difference in the soil moisture loss rate down to 30 cm. The data indicated that when the soil was wet, as measured below 50 kPa, the CPS soil loss soil moisture at a faster numerical rate than that of the CT soils, but there was no significant difference. However, as the soils dried, measured above 80 kPa, the CT soil had significantly faster soil moisture loss rates than the CPS soils. The CT soils loss soil moisture approximately 2.5 times faster than that of the CPS soils. These loss rates indicates that the soil needs to receive some form of precipitation every 1.5 d for the CT soils and 3.9 d for the CPS soils to maintain soil moisture conditions for peanut growth. The study, provides further information that agrees with others that increasing soil organic matter through the use of CPS increases infiltration and holds water longer in the soil profile. This retention of soil moisture allows the farmer to extend the time between irrigation applications of water or provides some storage of water within the soil profile, thereby reducing the risk if farming without irrigation.

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Disclaimer

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