ASSESSING PHOTOSYNTHETIC LEAF AREA OF CORN UNDER DIFFERENT TILLAGE SYSTEMS AND SOIL ZONES

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ABSTRACT

The photosynthetic leaf area may be influenced by soil texture. The objective of this experiment was to evaluate photosynthetic leaf area under different soil textures, based on soil electric conductivity (EC) measurements, tillage systems, and N rates in dryland corn (*Zea mays* L.) from 2007 to 2009. A commercially available soil electric conductivity (EC) measurement system (Veris Technologies 3100) was used to identify soil texture variations prior to planting wheat (*Triticum aestivum* L.) cover crop and create soil zone maps. Corn was planted across four different soil zones (based on soil EC measurements and ranging from 1 - sandy soils to 4 – clay soils) under three tillage systems (no-till, conventional, and strip-till) and two N applications at planting (40 and 80 lb N/acre). The leaf area index (LAI) meter was used to measure photosynthetic leaf area during corn vegetation at 2 months after planting. The results showed that plant LAI was generally higher with higher soil EC for no-till and conventional tillage systems. However, plant LAI was not influenced by soil EC under strip-till at either 40 or 80 lb N/acre. These results indicate that soil EC and plant LAI measurements may be utilized to help improve soil and crop management recommendations.

INTRODUCTION

Due to high variability in soil texture in the Southeastern United States, plant growth varies across the fields due to mostly nitrogen (N) utilization. Previous research has shown that N utilization depends on seasonal changes in soil temperature, water content, soil structure, and organic matter distribution (Radke et al., 1985; Johnson and Lowery, 1985; Wagger, 1989; and Ranells and Wagger, 1992) and therefore affects crop growth.

Soil management like tillage is a major factor affecting soil profiles (Miyamoto et al., 2003). Tillage operations change the soil characteristics and hydrodynamic processes in soils (Miyamoto et al., 2001). Grant et al. (2001) noted that tillage system may influence grain yield more in clay loam than sandy loam. A significant relationship was observed between the permittivity of a material and its water content (Robinson, et al., 2003). In dry farming areas, the water content in soil also varies during the growth cycle due to tillage operations, which drastically alter both the total pore space and the relationship between macro- and micro-pores (Josa and Hereter, 2005). Water is the main limiting factor to rainfed corn yield and efficient retention of precipitation is essential to maximize crop growth (Roygard et al., 2002).

Light interception and crop growth is affected by leaf area index (LAI) (Pearce et al., 1965). Wilhelm et al. (2000) indicated that measurement of leaf area index (LAI) is critical to understanding many aspects of crop development, growth, and management. Therefore, plant LAI is a key variable in agricultural modeling for quantitative measurements (Baez-Gonzalez et al., 2005), and analysis of water use, foliage density, and crop growth (Tewolde et al., 2005). A significant correlation was found for corn LAI at V7 to 9 stage and grain yield (r=0.87) (Bavec and Bavec, 2002). Other research reported that LAI of at least 3.5 is needed by early reproductive stage of soybean in order to have optimum light interception (Board and Harville, 1993; Board and Tan, 1995). Board and Harville (1996) noted that plant LAI was positively correlated with soybean grain yield.

A commercially available soil electrical conductivity (EC) measurement system (Veris Technologies 3100) helps to identify variations in soil texture across the field and create soil zone maps using global positioning system (GPS) and geographic information systems (GIS). For the Southeastern U.S., there is limited information on assessing of photosynthetic leaf area of corn under different and soil zones, which are derived based on the EC measurements. Therefore, the objective of this study was to evaluate corn LAI under different soil zones, tillage systems, and N application rates.

METHODS AND MATERIALS

This experiment, part of a larger study, was conducted on Dothan loamy sand (fine loamy, kaolinitic, thermic Plinthic Kandiudult) at Clemson University, Edisto Research and Education Center near Blackville, SC from 2007 to 2009. Prior to planting wheat cover crop in 2006, soil electrical conductivity (EC) measurement system (Veris Technologies 3100) was used to identify variations in soil texture across the field and create soil zone maps using global positioning system (GPS) and geographic information systems (GIS). Feed wheat planted in early December of 2006 and Pioneer 26R12 wheat planted on 21 November 2007 and 4 December 2008 was killed on 26 February 2007 and 6 March in 2008 and 2009, respectively. Field was divided into 4 different soil zone areas based on the soil EC readings. Great Plains Turbo Till was used in the no-till (NT) sections and worksaver following disk was used in the conventional (CV) sections of the study prior to planting corn.

Pioneer 31G65 corn was planted at aproximately 28,000 seeds/acre in CV and NT sections using a John Deere 7300 MaxEmerge II Vaccum planter on 13 March 2007 and strip-till (ST) sections were planted using a Univerferth Ripper-Stripper (Unverferth Mtg. Co., Inc., Falida, OH) and John Deere 1700 MaxEmerge XP Vaccum planters on 14 March 2007. In 2008 and 2009, the Univerferth Ripper-stripper implement was used in ST and Pioneer 31G65 corn was planted in all plots, at the same rate as 2007, using a John Deere 7300 MaxEmerge II Vaccum planter on 18 and 23 March, respectively. Plots size was 20 ft by 12.7 ft (4 rows) and the row with was 38 inches. Liquid fertilizer (25N-0-0-25S) was applied at 40 and 80 lb N/acre on both sides of rows to selected plots using a fertilizer applicator (Reddick Equipment Co., Inc., Williamson, NC) following corn planting. Weed control was based on the South Carolina Extension recommendations.

The leaf area index (LAI) was recorded from the two adjacent middle rows of each plot. The LAI was measured within a 3 m long rows of the center rows at 2 months after planting (MAP) corn using LAI-2000 (Li-Cor, Lincoln, NE). The experimental design was a split split-plot with four replications. The PROC Mixed (SAS, 1999) was used to compare treatments. The difference between treatments was considered significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

The influence of soil zone on leaf area index (LAI) at 2 months after planting corn (V8) in conventional tillage at 40 and 80 lb N/acre applied at planting is shown in Fig. 1 and 2. Significantly lower plant LAI was observed from soil zone 1 than soil zone 2; however, there was no significant difference between soil zones 1, 3, and 4 at 40 lb N/acre. With increased N rate of 80 lb N/acre, plant LAI was lower from soil zone 1 than zone 4, while no significant difference was observed between zones 1, 2, and 3.

Plant LAI was also influenced by soil zone under no-till at 40 and 80 lb N/acre (Fig. 3 and 4). It was lower for soil zone 1 than 3 and 4 at 40 lb N/acre, and lower for zone 1 compared to other zones at 80 lb N/acre. As for strip-till, there was no significant difference between soil zones at 40 and 80 lb N/acre (Fig. 5 and 6).

These results indicate that plant LAI was mostly influenced by soil zone, except under strip-till. Greater plant LAI in high soil EC zones under conventional and no-till could be due to higher biomass carbon and soil mineral nitrogen production in clay loam than sandy loam as indicated by Banerjee et al. (1999). However, plant LAI did not increase under strip-till in heavier soils (higher EC) compared to sandy soils (low EC) due to most likely insufficient rainfall.

When compared main effects, there was no significant difference between tillage systems and N rates (data not shown). Other research also reported that with limited rainfall, the difference of water distributions between the minimum tillage and conventional tillage sites was small (Miyamoto et al., 2001). Williams et al. (2000) noted similar soil water content in the surface when comparing tillage systems. Strachan et al. (2002) reported that corn growth is a function of the availability of N and water, and mid-season water deficits would override the effect of N, despite duration, if there were no other limiting factors present. However, according to Josa and Hereter (2005), soils under minimum tillage system store more soil water than under conventional tillage. They also indicated that applying no-tillage and not incorporating crop residue to soils increases the amount of water. This could be due to the fact that the no-till system had as great or greater hydraulic conductivity as conventional systems owing to either a greater continuity of pores or to water flow through a few very large pores (Benjamin, 1993).

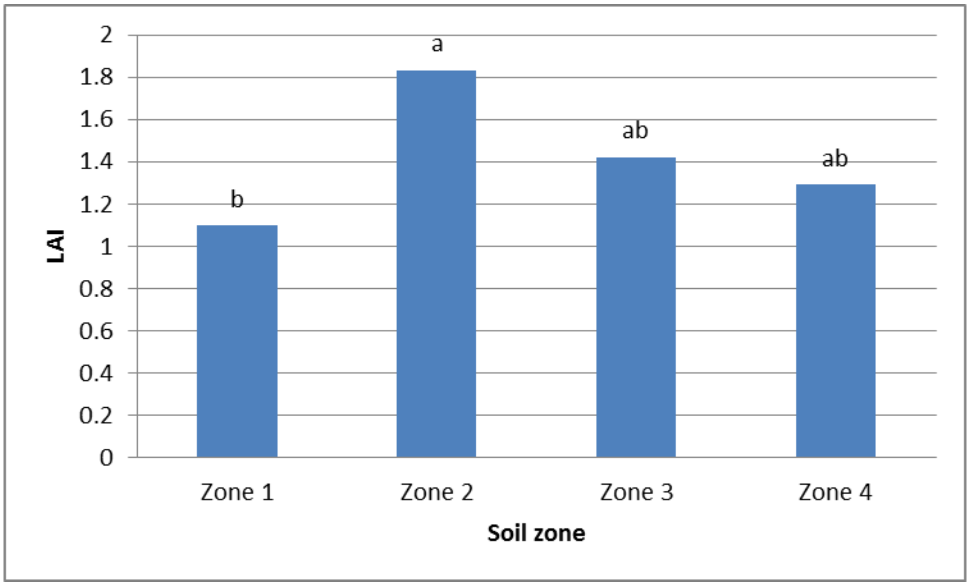

Fig. 1. Influence of soil zone on leaf area index (LAI) at 2 months after planting corn (V8) in conventional tillage and 40 lb N/acre applied at planting. Letter separation indicates significant difference at $P \leq 0.05$.

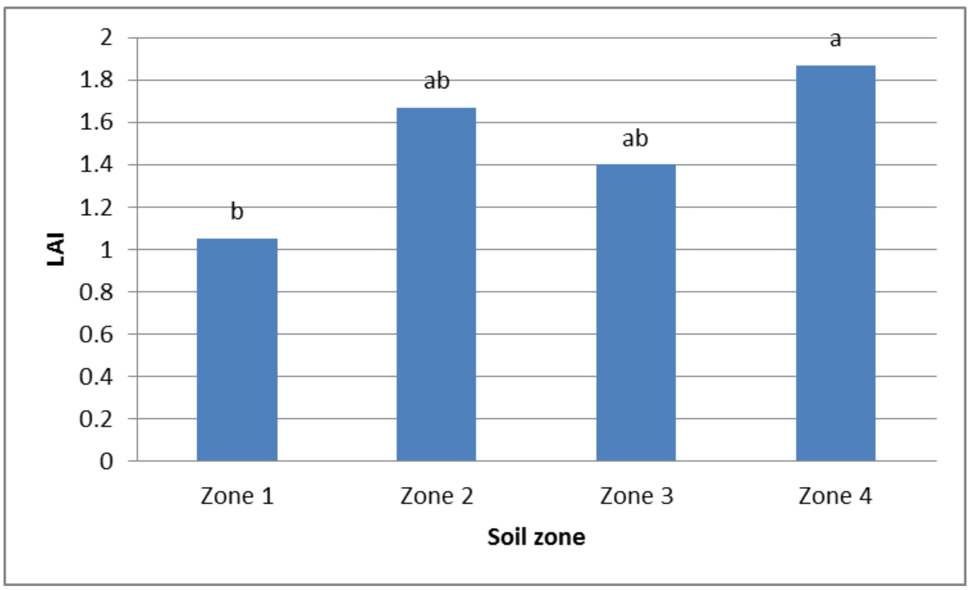

Fig. 2. Influence of soil zone on leaf area index (LAI) at 2 months after planting corn (V8) in conventional tillage and 80 lb N/acre applied at planting. Letter separation indicates significant difference at $P \leq 0.05$.

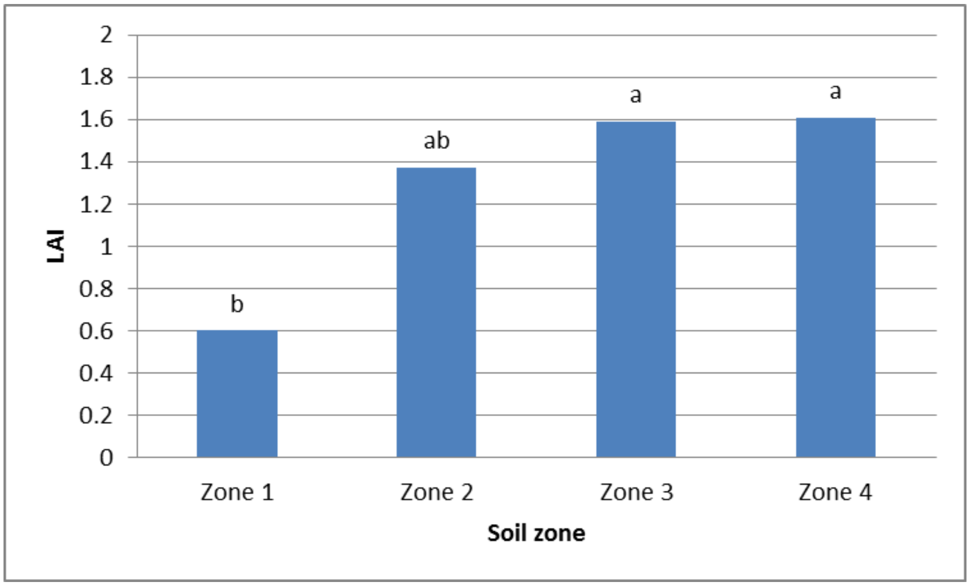

Fig. 3. Influence of soil zone on leaf area index (LAI) at 2 months after planting corn (V8) in no-till and 40 lb N/acre applied at planting. Letter separation indicates significant difference at *P*≤0.05.

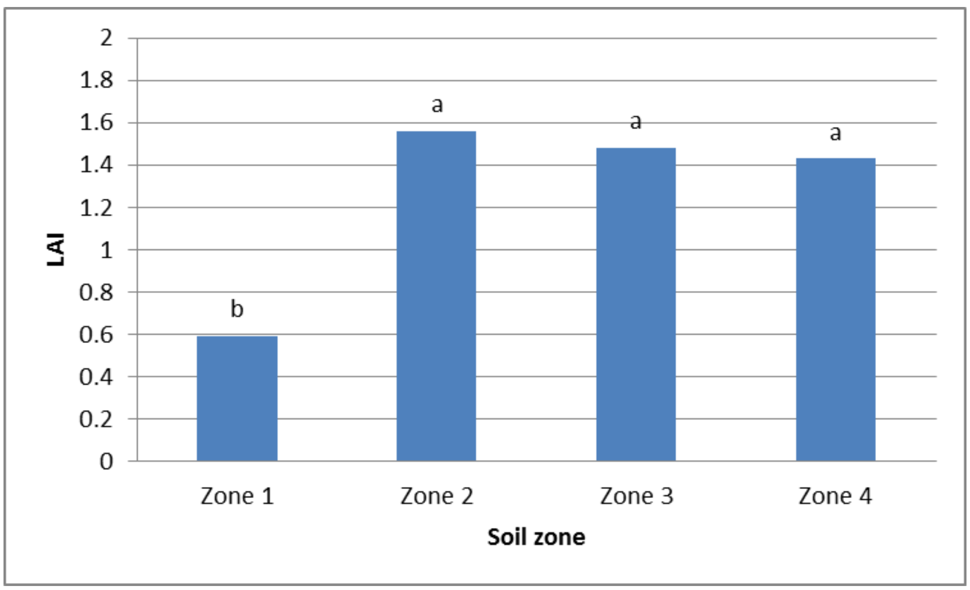

Fig. 4. Influence of soil zone on leaf area index (LAI) at 2 months after planting corn (V8) in no-till and 80 lb N/acre applied at planting. Letter separation indicates significant difference at *P*≤0.05.

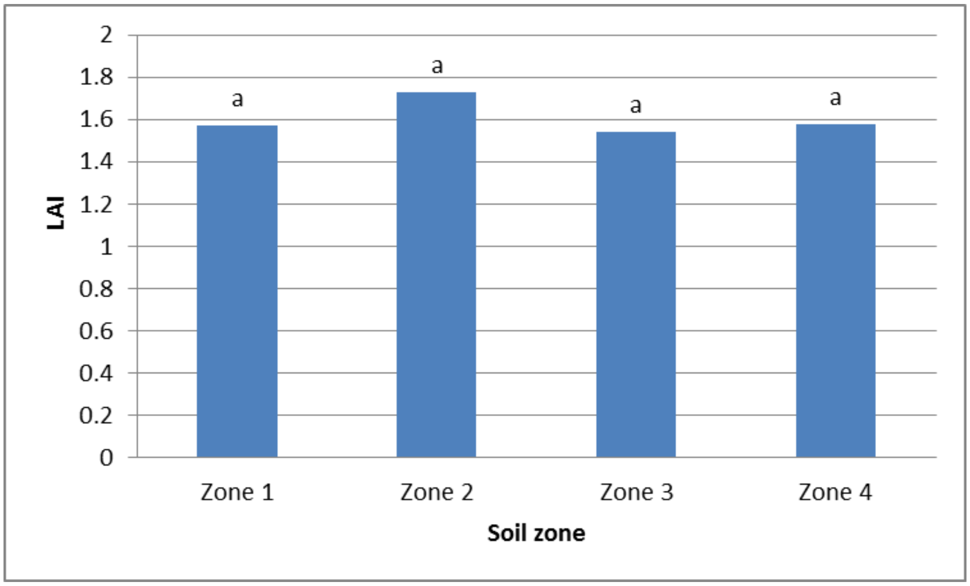

Fig. 5. Influence of soil zone on leaf area index (LAI) at 2 months after planting corn (V8) in strip-till and 40 lb N/acre applied at planting. Letter separation indicates significant difference at *P*≤0.05.

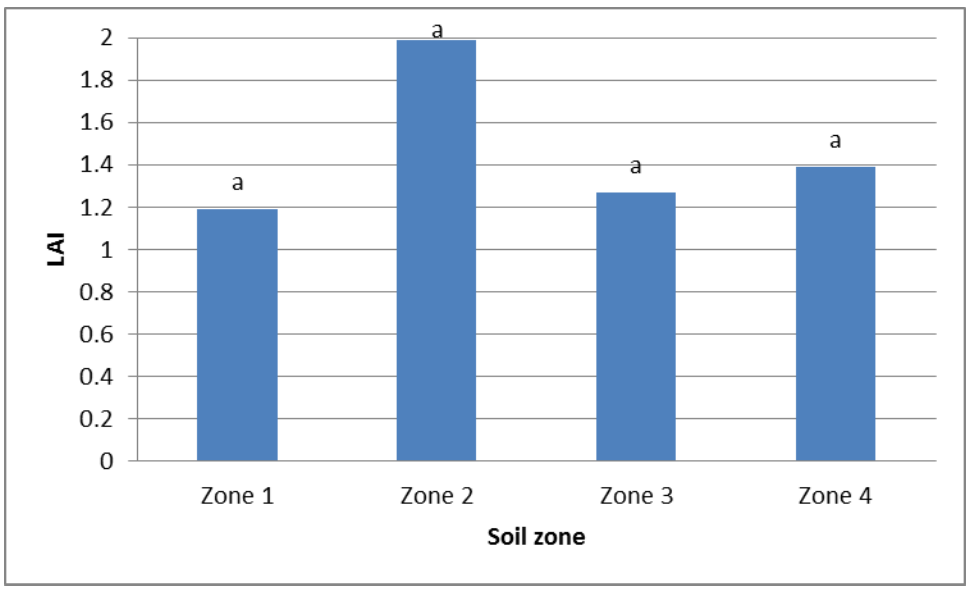

Fig. 6. Influence of soil zone on leaf area index (LAI) at 2 months after planting corn (V8) in strip-till and 80 lb N/acre applied at planting. Letter separation indicates significant difference at *P*≤0.05.

CONCLUSION

Soil zones mostly affected plant LAI under no-till and conventional tillage systems, but there was no difference between soil zones under strip-till. The plant LAI values varied, but generally showed greater plant LAI from higher soil EC zones and soils with lowest soil EC values had the least plant LAI. These results indicate that soil EC and plant LAI may be used as tools in improving soil and plant management.

Acknowledgements

This material is based upon work supported by NIFA/USDA, under project number SC-1700328.

Disclaimer

Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the USDA.

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