GROWTH AND PHYSIOLOGICAL CHARACTERISTICS OF COVER CROP IN SOD-BASED PEANUT-COTTON CROPPING SYSTEMS

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ABSTRACT

It has been confirmed that sod-based peanut-cotton rotation systems can greatly improve soil health and increase crop yield and profitability in the southeastern USA. In the sod-based rotation systems the winter cover crop is an important component in conservation tillage. The objective of this study was to determine effects of summer crops, cotton and peanut on the growth, dry matter accumulation and physiology of an oat cover crop in both a conventional and sod-based peanut-cotton rotation system. Two cropping systems of Peanut-Cotton-Cotton (P-C1-C2, Conventional) and Bahia-Bahia-Peanut-Cotton (B1-B2-P-C, Sod) were established in an experimental field at the North Florida Research and Education Center, Quincy, FL in 2000. Oats were planted 8 December 2006 at a seeding rate of 64 lbs/A and 7 inches of row spacing after mowing down cotton stalks. Plant height, leaf chlorophyll, leaf sap NO_3-N concentration, and above-ground biomass were determined biweekly starting 49 days after planting. Both cropping system and previous crop impacted cover crop growth and physiological parameters measured. Oats grown in plots of the Sod system had higher leaf chlorophyll and NO_3-N concentrations and greater biomass compared with oat plants in the Conventional system. The peanut plots increased the cover crop plant N status and above-ground biomass, as compared to the cotton plots. Increases in cover crop plant growth and N status for the Sod cropping system may be associated with greater soil fertility and soil quality parameters. Information from this study provides growers options in N fertilizer management of cotton and peanuts in two different production systems. The data also serves those using cover crops for grazing livestock.

INTRODUCTION

Conserving cropland soil is a principal goal of sustainable agriculture, as is preservation of surface water and groundwater quality. Numerous studies have confirmed that a winter cover crop helps to conserve both soil and water quality while allowing row crops to be grown profitably. Adding a cover crop component to cropping systems can improve productivity and reduce environmental threats from erosion (Langdale et al., 1991) and nutrient runoff and leaching losses (Meisinger et al., 1991; Sharpley and Smith, 1991).The additional biomass enhances soil organic matter, improves soil-water dynamics, and soil quality (Horton et al., 1994). Unused soil nitrates at the end of the growing season tend to leach from the southeast sandy soils and may cause groundwater contamination. Certain cover crops tend to be very efficient at recycling or scavenging excess nutrients, especially soil nitrogen (N). Additionally, when the cover crop dies or is removed as forage, some of the N will be released and reused by future crops or utilized as protein in the animal feed (Horton et al., 1994).

Cover crops can either increase yield potential or reduce the amount of additional N fertilizer required by a succeeding crop, depending on the type of cover crop and rotation system (Reeves et al., 1995). Studies have also suggested that the sod-based peanut-cotton rotation systems in the southeast USA improve soil health and increase crop yield and profitability (Marois et al., 2002; Wright et al., 2004; Katsvairo et al., 2006; Katsvairo et al., 2007). Including a winter cover crop to a sod-based rotation of peanut and cotton improves the benefits of conservation tillage. To protect highly erodible soils, like those in the southeastern USA, emphasis has been placed on leaving as much residue as possible on the fields during the winter. Reduced tillage and conservation cropping systems have increased markedly in the region. As a result, most of Florida cropland, primarily peanuts, cotton, corn, and soybeans, has about 60% of its surface covered with residue. However, peanuts and soybeans produce a relatively low amount of residue that decomposes rapidly. Also, soil aggregates are less stable under these crops. Therefore, farmers in the region still face a high risk of soil erosion and soil nutrient leaching losses.

Climatic conditions (precipitation and warm weather) in the southeastern USA are favorable for winter cover crops. Horton et al. (1994) reported that an oat (*Avena sativa* L.) cover crop had a dramatic effect on soil erosion and runoff in the simulated rainfall tests with an 84% reduction in sediment loss, compared to non-oat cover crop plots. Cover crops are also attractive as a way of scavenging the soil profile for nitrate, thus lessening winter and spring leaching of nitrate and improving the N and organic matter status of the soil (Horton et al., 1994; Franzluebbers, 2007).

Several sod-based crop rotation systems with oat as a winter cover crop have been established at the University of Florida, North Florida Research and Education Center, Quincy, FL for many years for investigating long-term soil and crop responses to cropping systems and the resulting economic return. The primary goal of this study was to determine effects of summer crops on oat cover crop growth and several physiological parameters using two cropping systems, 1) Peanut-Cotton-Cotton (P-C1-C2 or Conventional System) and 2) Bahiagrass-Bahiagrass-Peanut-Cotton (B1-B2-P-C or Sod System). The specific objectives of this study were to: (1) determine plant growth and above-ground biomass of an oat cover crop and (2) determine oat shoot N concentration and N accumulation as affected by the summer crop and cropping system.

MATERIALS AND METHODS

Experimental location and treatments

The experiment was conducted at the North Florida Research and Education Center, University of Florida, Quincy, FL (84°33' W, 30°36' N). The soil type used in this study was a Dothan sandy loam (fine-loamy, kaolinitic, thermic Plinthic Kandiudult). Two cropping systems, 1) Peanut-Cotton-Cotton (P-C1-C2, Conventional system) and 2) Bahia-Bahia-Peanut-Cotton (B1-B2-P-C, Sod system) with an oat (*Avena sativa* L., Fla 501) as the winter cover crop were used. Treatments included two N fertilizer rates of 0 and 60 lbs N/acre in the preceding cotton crop. The experiment was a split-plot design with three replications. Cropping system was the main plot and N rate was the subplot. The subplot size was 68 ft by 30 ft and rows aligned east to west.

Measurements

Oat was seeded at a seeding rate of 64 lbs/acre and 7 inches of row spacing in all plots on 8 December 2006, after mowing down cotton stalks. Based on the regional cover crop management recommendation, 40 lbs N/acre as ammonium nitrate was broadcasted on 6 February 2007 [60 days after planting (DAP)]. Plant height, above-ground biomass, leaf chlorophyll, leaf sap NO_3-N concentration were determined biweekly starting at 49 DAP until pre-heading (101 DAP). Plant height was determined from ground surface to the last collared extended leaf held upright. Leaf chlorophyll measurements were taken on 10 upper most-fully expanded leaves randomly collected from 10 plants in each plot using a SPAD-502 chlorophyll meter (Minolta Co., LTD., Japan). At the same time, 20 leaves at the same position in each plot were sampled and the leaves were used to collect leaf sap for measuring NO_3-N concentration using a C-141 CARDY meter (Horiba, LTD., Kyoto, Japan). Oat above-ground biomass was estimated by cutting 3-foot row plants from ground surface in each plot at all sampling dates. Plant samples were dried in a forced air oven at 65°C for 48 hours and weighed. In order to estimate oat plant N uptake prior to killing cover crop with ROUNDUP herbicide for the following row crops, the dry oat plant samples collected pre-heading (101 DAP), were ground to determine tissue total N concentration and other mineral nutrient elements using a commercial analytic laboratory (Waters Agricultural Laboratories, Inc., Camilla, GA).

Data analysis

Since no statistical differences were detected in most measured parameters of oat cover crop between the 0 and 60 N treated cotton plots, data collected from the 0 N and 60 N treated cotton plots were averaged. The mean values are presented in this report. Analysis of variance was carried out using SAS PROC MIXED model to determine the cropping system and previous crop effects on winter cover crop oats. The least significant difference (LSD) tests were used to distinguish the treatment differences at $P = 0.05$ level.

RESULTS AND DISCUSSION

Plant height and above-ground biomass

Changes in oat plant height and above-ground biomass during growth were similar and followed a growth pattern typical of winter cover crops. In first 70 days, plant height and shoot biomass increased slowly. Thereafter, the two growth parameters increased more rapidly (Fig. 1). Both cropping system and summer crop significantly oat plant height ($P < 0.001$) and above-ground biomass ($P < 0.0001$). Plant height and biomass of oat in peanut plots were significantly greater than oat in cotton plots at all measurement dates (Fig. 1A). There were no differences in either plant height or above-ground biomass of oats gown in peanut plots of either of the two cropping systems. However, oats grew better (i.e. taller with more above-ground biomass) in the Sod system cotton plots (Fig. 1). At 101 DAP, oats in cotton plots of the Sod system had over 22% greater biomass ($P < 0.05$) as compared to oats in the cotton plots of the Conventional system (Fig. 1B). Improved growth in the Sod cropping system may be an indicator of improved soil properties, particularly soil available N, provided by bahiagrass (Reeves, 1997; Wright et al., 2004; Katsvairo et al., 2006 and 2007). In the southeastern USA, a cover crop can be used as pasture or hay or the crop can be returned to the soil to increase soil organic matter and fertility.

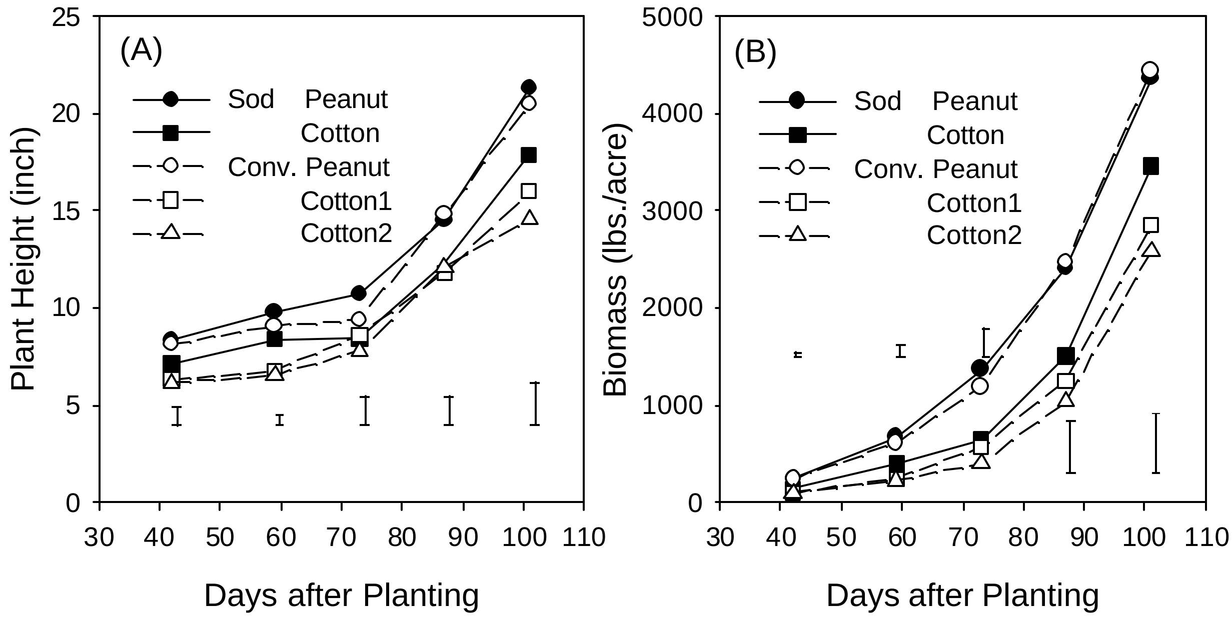

Fig. 1. (A) plant height and (B) above-ground biomass of winter cover crop oats and their responses to the Sod and Conventional cropping systems as well as previous crops of peanuts and cotton. Vertical bars present values of $LSD_{0.05}$.

Leaf chlorophyll and NO_3-N concentrations

Leaf chlorophyll increased between 42 and 73 DAP and then reached a plateau as plants aged (Fig. 2A). The summer crop significantly influenced oat leaf chlorophyll content ($P < 0.0001$). Oats grown in peanut plots had greater chlorophyll values as compared with oats grown in cotton plots over the first three sampling dates (Fig. 2A). Leaf chlorophyll values were not statistically different among treatments at 87 DAP. Cropping systems had no effect on leaf chlorophyll. Averaged across sampling dates, leaf chlorophyll values of oats grown in peanut and cotton plots of the Sod system were 41.6 and 37.6, respectively; while oats grown in peanut and cotton plots of the Conventional system were 42.6 and 36.5, respectively.

Leaf sap NO_3-N concentrations (Fig. 2B) response to cropping system and summer crop were similar to that of leaf chlorophyll (Fig. 2A). However, the variation of NO_3-N in leaves with sampling dates and among treatments was much greater than that of leaf chlorophyll. About 2 weeks after N fertilizer application (60 DAP), both leaf chlorophyll and NO_3-N peaked. Greater leaf chlorophyll and leaf sap NO_3-N concentrations from peanut plots was likely attributed to greater soil N content associated with the leguminous peanut crop, but soil mineral composition was not measured to verify this.

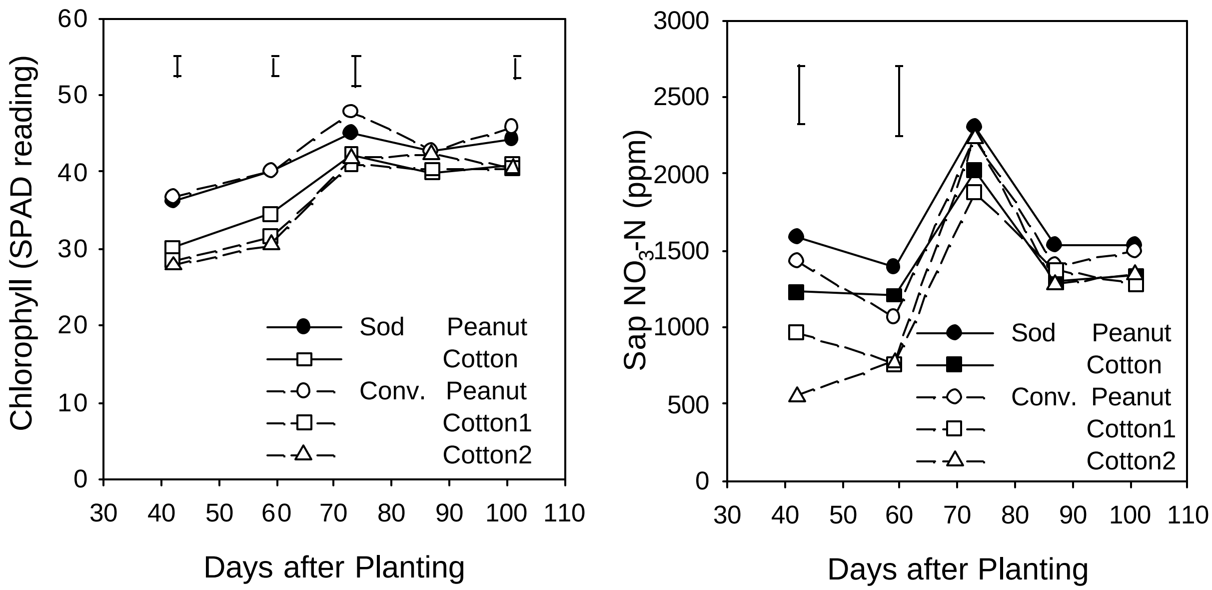

Fig. 2. Changes in (A) leaf chlorophyll and (B) leaf sap NO_3-N concentration of oats during growth and their responses to cropping systems (Sod and Convention) and previous crops (peanut and cotton). Vertical bars present values of $LSD_{0.05}$.

N concentration and N uptake of oat shoots

At 101 DAP, oats grown in peanut plots of the Sod system had greater tissue N concentrations, than oats grown in cotton plots of the Conventional system (Fig. 3A). It is hypothesized that higher soil fertility and better soil quality in peanut plots of the Sod system improved cover crop plant N status, stimulated plant growth, and increased above-ground biomass. The summer crop and cropping system significantly affected cover crop N recovery (Fig. 3B). At pre-heading (101 DAP), approximately 80 lbs N/acre was recovered in above-ground biomass of oats grown in peanut plots, 60 lbs N/acre was recovered from the cotton plots of the Sod system, and only 40 lbs N/acre was recovered from the cotton plots of the Conventional system (Fig. 3B). Therefore, N management will depend upon both, the cropping system and the previous summer crop.

CONCLUSIONS

Results from this study indicated that both, cropping system and the summer crop influenced oat cover crop above-ground biomass, plant N status and therefore, N recovery. Oats grown in plots of the Sod system had greater biomass, leaf chlorophyll and leaf sap NO_3-N concentrations as compared to oat grown in the Conventional system. Oat grown in peanut plots had much greater shoot biomass production and greater tissue N concentration than oats grown in cotton plots. The increases in cover crop plant growth and N status found in the Sod cropping system may be associated with improved soil physical property, soil fertility, and other soil quality parameters contributed by the bahiagrass sod. The data gathered from this study can help growers with their N fertilizer management of cotton and peanuts in either sod-based or conventional rotational cropping systems in the southeastern USA. Our data also may be useful for those producers who manage cover crops for livestock as pasture or hay.

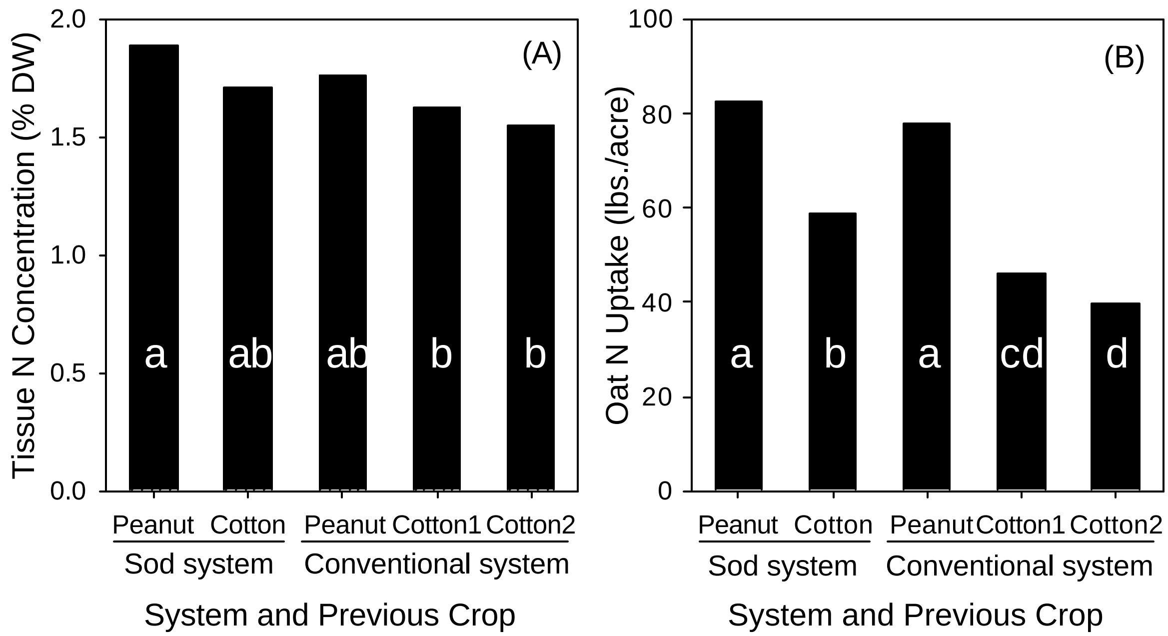

Fig. 3. (A) N concentration (% of dry matter) of oat shoots and (B) shoot N uptake at pre-heading (101 DAP), as affected by previous summer crop and cropping system. Bars with the same letter are not significant at P = 0.05 level.

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