Overview of the Sod Based Rotation Using Conservation Techniques

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Abstract

Perennial grasses are the backbone of the U.S. livestock industry and are widely recognized as a key in conserving soil. Certain government programs require perennial grasses such as the Conservation Reserve Program (CRP) as a way to enhance and protect soil quality while setting aside land from production. Perennial grasses are used along roadsides all across the country to provide stable slopes for water runoff and to keep erosion to a minimum while providing a firm foundation for auto traffic with their immense root systems. Most perennial grasses have a wide tolerance to soil fertility, moisture, pH and other environmental conditions making them a good choice for various uses. Research has shown the benefits of perennial grasses to following crops; however, it is seldom reintroduced into the rotation once fields are taken out for row crop production. Our research has focused on a short term system that keeps perennial grasses in the rotation with row crops and has been found to be economically and environmentally advantageous. Several of our publications highlight the increasing organic matter content and water infiltration along with improved plant growth and yields of following crops that economically take 2-3 years in the conventional rotation to make the profit that is made the first year after perennial grasses. In both conventional and the perennial grass rotations, conservation tillage techniques have been adhered to in order to provide information for growers on implementing then in a farming system. As a general rule perennial grasses have been turned under when going to a row crop or have had intense tillage prior to planting a row crop. The sod based rotation has been shown to conserve natural resources, increase crop yields, and improve long-term agricultural sustainability and profitability.

Introduction

In the southeast USA, peanut, cotton and corn are major summer agronomic crops requiring a long growing season. However, regional farmers face great challenges in maintaining production sustainability and profitability using the traditional crop rotation system of peanut-cotton-cotton. For instance, Florida ranks 15th in cotton yield and total production among 17 states where cotton is planted (USDA, 2005). In 10 U.S. peanut production states, mean peanut yield of Florida ranks 8th in 2007. The major challenges include multiple pests, infertile soils, low soil organic matter (OM), and low soil water holding capacity. Integration of perennial grasses, such as bahiagrass, into the current rotation system of peanut and cotton has been proposed and proved by several studies (Katsvairo et al., 2007; Wright et al., 2007). For example, including bahiagrass in the rotation adds significantly to the soil organic and nitrogen pools as well as helps diminish nematodes and other pests normally found with annual row crops (Boman et al., 1996; Elkins et al., 1977; Marois, 2002; Marois and Wright, 2002).

Our current sod based rotation research is a multi-states project (Florida, Alabama and Georgia). In Florida (Marianna) and Alabama (Headland) sites, cattle are used to graze the grass produced as cow-calf operation. At another Florida site and a Georgia site, the grass is harvested as hay. Winter annual forages planted after cotton and peanut are also used for grazing or harvested as hay. In this paper, we summarized our sod based rotation studies at University of Florida's North Florida Research and Education Center (NFREC).

Sod Based Rotation Studies in Florida

Four major field trials of the sod based rotation research at the University of Florida's NFREC include:

(1) "Comparison of the sod based peanut-cotton rotation system (Bahiagrass-Bahiagrass-Peanut-Cotton) and a conventional peanut-cotton rotation system (Peanut-Cotton-Cotton)". This study consists of the two cropping systems, two levels (low N and high N) of N applications and two irrigation regimes (irrigated and non-irrigated) with three replications to determine long-term sustainability, profitability, and N and water use efficiencies of the sod based rotation. Bahiagrass in this study is used for hay;

(2) "Bahiagrass kill date and tillage method effects on peanut growth, yield and grades in the sod based rotation". This study was conducted at two locations (Marianna and Quincy of the NFREC) and has two bahiagrass kill dates (fall vs. spring) and six tillage methods (strip-till, disk+turned, disk+chisel, paratill+strip-till, disk+strip-till, and strip-till+45 kg N ha^{-1}) with four replications;

(3) "Corn growth and yield responses to crop sequences in sod based peanut-cotton-corn rotations". The study includes three crop sequences, (i) bahiagrass-bahiagrass-corn-corn, (ii) bahiagrass-bahiagrass-cotton-corn, and (iii) bahiagrass-bahiagrass-peanut-corn with four replications;

(4) "Integration of cattle into the sod based peanut-cotton rotation system". In the system, bahiagrass and winter cover crops are grazed by cattle. This is a center pivot irrigation system at Marianna with a total of 160 acres. Four quadrants are four phases of the system (bahia-bahia-peanut-cotton). To investigate short-term and long-term impacts of cattle on soil properties, crop growth and yield as well as economic returns, three 50 x 50 ft exclusion cages have been established in each quadrant.

In these studies, we investigated soil physical, chemical and biological properties, including soil bulk density, soil penetration resistance, soil water infiltration, soil water content and water holding capacity, soil conductivity, soil organic matter and mineral nutrient concentration and availability, soil earthworm population and soil respiration; plant disease, insects and weeds pressure; crop growth, physiology, yields and quality; system inputs and net returns.

Highlights

When rotating summer crops with bahiagrass, both nutrients and water in the deep soil profile are utilized, due to improved rooting depth of the crops following bahiagrass. Rooting depth can be improved as much as 10 times, as compared to conventional cropping systems (Katsvairo et al., 2005; Katsvairo et al., 2006). Improved water capture reduces irrigation needs from a normal application of approximately 30 cm of irrigation per year to as little as 5 cm, with similar or greater yields (Wright et al., 2004; 2005; 2006; 2007). This results in as little as 17% of the current water use for irrigation.

Most important findings of the sod-based rotation effects on soil properties and on crop growth and yields from our studies at Quincy in last several years have been published on Agronomy Journal (Katsvairo et al., 2006; Katsvairo et al., 2007a; Katsvairo et al., 2007b; Katsvairo et al., 2008a), Journal of Food Science and Agriculture (Katsvairo et al., 2008b), Proceedings of Southern Conservation Agricultural Systems Conferences (Marois et. Al., 2007; Wright et al., 2007; Zhao et al., 2007a; Zhao et al., 2007b), and Proceedings of Beltwide Cotton Production and Research Conferences (Katsvairo et al., 2007; Wright et., 2007; Wright et al., 2008; Zhao et al., 2008). To better understand crop growth and physiological responses to sod

based rotation, we are currently investigating crop insects and diseases as affected by crop rotations in addition to crop yields. Preliminary results from the Quincy research site indicate that sod-based rotations can considerably reduce insect, disease, and weed pressure, improve crop water status, increase crop yields and water use efficiency.

Peanut

Results of our sod based peanut-cotton rotation with two bahiagrass kill dates (fall vs. spring) and different tillage studies at two locations (Marianna and Quincy, FL) have indicated that bahia kill date did not affect peanut yield and strip-till can reach high or equivalent yield compared to the intensive tillage method. Therefore, farmers have a wide window to kill bahiagrass for their peanut crop in sod based rotation using conservation tillage. Sod based peanut yields in 2006-2007 ranged from 4,000 to 4,500 lbs acre^{-1}, when using strip tillage, which is 60 to 80% higher than state average yield (about 2500 lbs acre^{-1}) of peanut in the Southeast USA (Zhao et al., 2007a). In our replicated plot studies, the sod based peanut yield was significantly higher than conventional peanut (Fig. 1). We also found that increase in peanut yield in sod based rotation is mainly associated with reduction in insect and disease pressure in normal and wet years (Fig. 2) and with mitigation of water deficit stress in dry years (Data not shown).

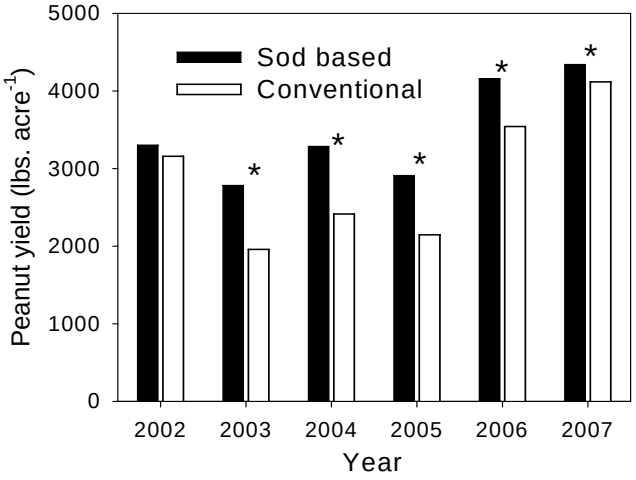

Fig. 1. Sod-based and conventional peanut yields in 2002-2007 at NFREC, Quincy, FL. The * indicates that the difference is significant.

Aflatoxin concentration in peanut kernels is the major concern for food safety and product quality. It is known that water deficit stress during pod development and maturity is a major factor increasing kernel aflatoxin level. Our preliminary results showed that sod based rotation greatly reduced peanut kernel aflatoxin concentration in a drought year especially for non-irrigated peanut (Fig. 3). Therefore, sod based rotation can reduce drought effect on non-irrigated peanut in the Southeast.

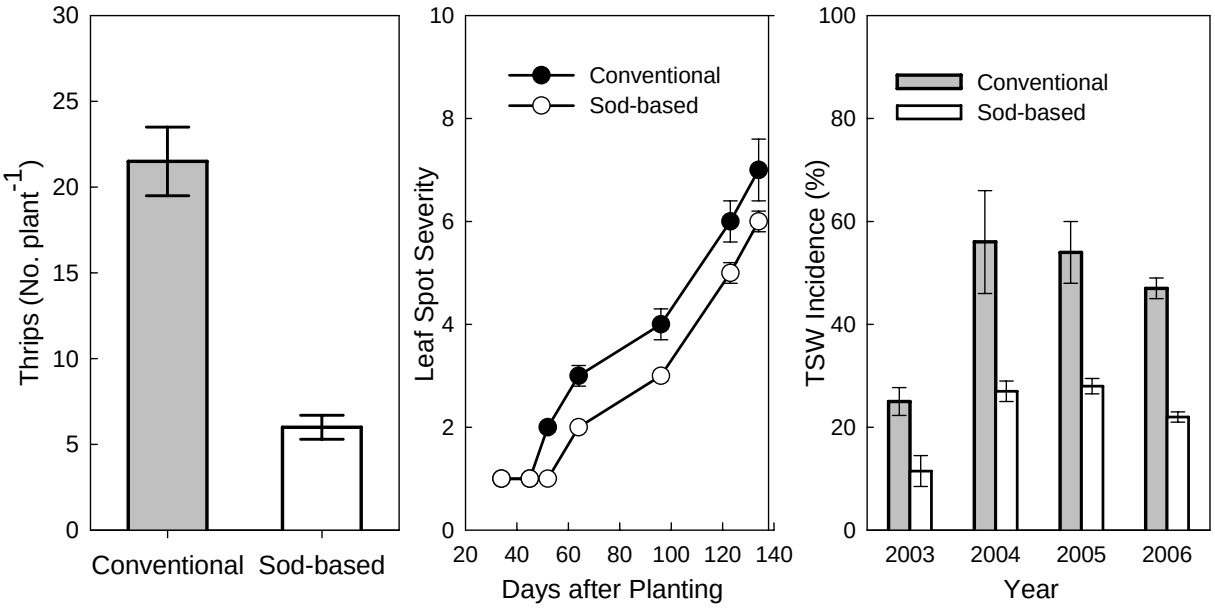

Fig. 2. Comparison of seedling thrip population, leaf spot severity, and tomato spotted wilt (TSW) incidence of peanuts grown in conventional and sod-based crop rotations in Quincy, FL.

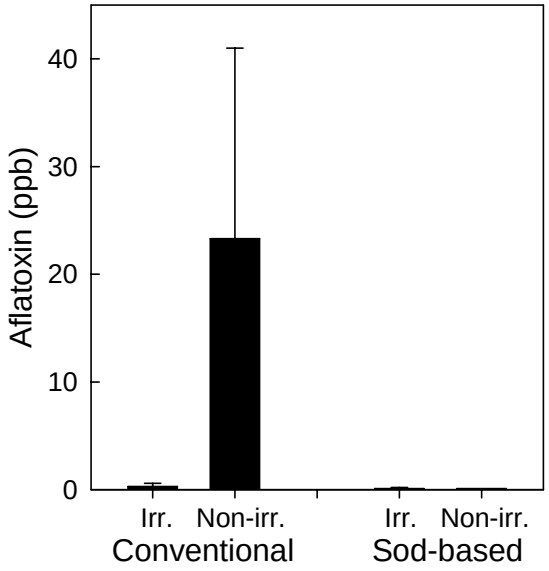

Fig. 3. Effects of irrigation and crop rotation on peanut kernel aflatoxin concentration in Quincy, FL in 2007. Note: 2007 was a very drought year in the Southeast.

Cotton

Florida mean cotton lint yield fluctuates around 700 lbs. acre^{-1} (USDA, 2005), whereas cotton lint yield in our sod-based rotation has reached 1510 lbs. acre^{-1} (Zhao et al., 2008a). Because sod based rotation improves soil quality, especially soil organic matter, nutrients, and water holding capacity, it is necessary to refine N fertilizer rate and reduce irrigation. Avoiding rank cotton

growth by adjusting N, irrigation and application of Pix is the key step for high yield of the sod based cotton.

Currently, we found that the sod based rotation can greatly reduce cotton seedling disease, such as Rhizoctonia root rot compared to conventional cotton (Fig. 4). Additionally, the sod based cotton has significantly less weed, especially morningglory population than the conventional cotton (Fig. 4).

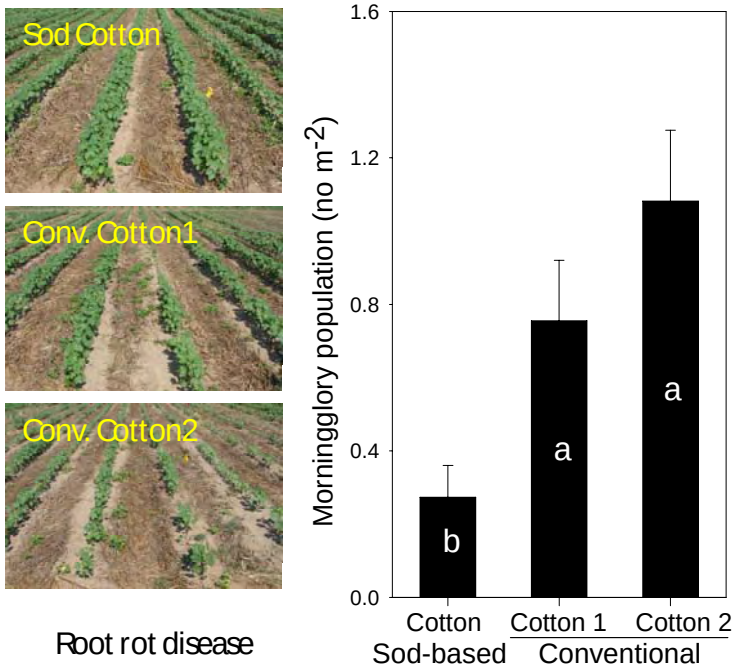

Fig. 4. Cotton Rhizoctonia root rot disease and morningglory population of the sod based and conventional cotton at Quincy, FL. in 2008.

o Economic analyses carried out on a sod-based rotation have shown profits are 2-4 times greater when the rotation is fully implemented as compared to the conventional rotation system. We expect that this system has the potential to add \$100-200 acre^{-1} profit for producers. A business management model for the sod-based rotation has been developed (Marois et al., 2001; Marois, 2003b) and modified based on our research data and farmer input. The model is available at the University of Florida's website (nfrec.ifas.ufl.edu/**sodrotation**.htm) for downloading. Typically, the model shows increased profits due to fewer inputs of irrigation, fertilization, pesticide and herbicide applications, and increased yields on row crops (Marois et al, 2001) and water use efficiency. The long-term positive impacts of the sod-based rotations on soil quality, environment, climate change, and agricultural sustainability are even more significant.

Bahiagrass and winter cover crops

Average yields (i.e. forage biomass) of first- and second-year bahiagrass in the sod based rotation are approximately 2200 and 7600 lb acre^{-1}, respectively. Oat winter cover crop shoot biomass at pre-heading stage can reach 4000 to 6000 lb acre^{-1}. Forage can be used for hay or grazing by cattle. Therefore, bahiagrass and cover crops can add value to the sod based system.