IMPACT OF SOD-BASED ROTATION ON PEANUT DISEASES USING CONSERVATION TECHNOLOGY

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ABSTRACT

Perennial grass used in rotation with peanuts using conservation tillage has shown positive impacts on peanut disease reduction as compared to conventional rotations. The onset of disease was delayed and the rate of disease increase was reduced in peanuts planted after bahia grass compared to peanuts planted after cotton in a conservation tillage system. Under drought conditions aflatoxin production was also reduced or eliminated in peanuts after bahia grass. Other parameters such as leaf area index, water potential and root biomass were improved.

INTRODUCTION

In the southeast USA, peanut, cotton and corn are predominate summer agronomic crops. The major challenges to an economically viable and sustained production system are multiple pests, infertile soils, low soil organic matter, and low soil water holding capacity. A series of studies begun in 1999 attempted to address these challenges by integration of perennial grasses, bahia grass, into the current rotation system of peanut and cotton (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 (Tsigbey, et al, 2009). Many aspects of the production system have been and are being studied. In this paper we address the impact of the rotation on peanut plant diseases.

MATERIALS AND METHODS

Experiments were conducted in field plots at the IFAS NFREC facilities in Quincy and Marianna, Florida. The general experimental design was replicated plots that consisted of bahiagrass (cv. Pensacola) rotation with peanut and a conventional cotton-peanut rotation for peanut. The cropping sequence for the bahiagrass rotation involved the growing of cotton in the first year and then followed by bahiagrass for two consecutive years and in the fourth year the plots were planted to peanut for one year (CBBP), whereas the conventional rotation consisted of growing peanut in the first year with cotton in the two subsequent years followed by peanut in the fourth year (PCCP). Each plot in the rotation cycle was split into a fungicide spray and non-sprayed sections resulting in a split-plot design. Plots received scheduled applications of irrigation water according to standard extension recommendations for peanut production in Florida. Weed and other crop management practices were done based on the Florida Cooperative Extension Services recommendations for peanut. Each sub-plot (rotation* fungicide) was 22.8m in length by 9.2 m (10 peanut rows).

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Tomato spotted wilt. Plots were surveyed by examining twenty plants within two rows at each time of assessment, and different rows were assessed at each point in time. Plants were examined at 2 m intervals within rows for TSW symptoms on leaves and scored using a modified scale of 0-3: where 0 = no visible symptoms; 1= presence of TSW symptoms on at least one leaf on the plant; 2 = symptoms on majority of leaves with moderate stunting of plant; and 3 = severe stunting of plant and associated death. This method of assessment was chosen in order to assess the progression of TSW over time. TSW incidence was determined as the number of peanut plants showing visible symptoms on the twenty plants assessed on each plot and rotation, expressed as a percentage. TSW severity index was then computed from severity ratings; [Severity Index = $\{\Sigma(\text{Ratings for 20 plants})/20\} * 100$], and was used to compute the Standard Area Under the Disease Progress Curve (SAUDPC) over the period of assessment. In 2008 a trial was conducted in Quincy and Marianna where peanuts were planted after bahia grass or fallow field the middle of April and May to determine if the reduced TSW pressure would allow for farmers to return to their traditional earlier planting.

Southern Stem Rot: In 2003 southern stem rot occurred in the plots. SSR incidence was assessed by examining twenty plants for signs of the pathogen, *Sclerotium rolfsii*

Peanut Leaf Spots: Early leaf spot (ELS) and late leaf spot (LLS) were assessed in all four years using the Florida 1 -10 scale (where 1 = no leaf spot; 2 = very few spots on leaves with none on upper canopy leaves; 3 = few lesions on the leaves, very few on upper canopy; 4 = some lesions with more on the upper canopy, 5 % defoliation; 5 = lesions noticeable on upper canopy, 20% defoliation; 6 = lesions numerous and very evident on upper canopy, 50 % defoliation; 7 = lesions numerous on upper canopy, 75 % defoliation; 8 = upper canopy covered with lesions, 90 % defoliation; 9 = very few leaves remaining and those covered with lesions, 98 % defoliation; and 10 = plants completely defoliated and killed by leaf spot). Twenty plants were randomly scored in all plots. Disease severity data were analyzed separately for each year for the non-fungicide sprayed plots, and area under the disease progress curve (SAUDPC) was computed. Disease assessments were converted into proportions [y = (Florida rating – 1) / 9], and transformed using the linearizing transformation for the logistic model, which consistently had the highest R^2 value. Effects of rotation on SAUDPC and r were determined for each rotation and year separately.

Root Knot Nematode: Plant-parasitic nematode population densities were monitored at peanut harvest in October of each year by randomly collecting 10 soil cores (2.5-cm-diam) to 20 cm deep and in-row from each plot. The 10 soil cores were combined, mixed well, and nematodes were extracted from a 100 cm^3 sub-sample from each plot by centrifugal flotation. Nematodes were counted under a stereo-microscope using a 2 mm gridded (60 x15 mm) Petri dish Corning® (Corning, New York). Identification of nematodes to species was done at the Florida Department of Agriculture Division of Plant Industry.

RESULTS

Epidemics of TSW. Although TSW epidemics varied each year, the incidence (Fig. 1) and severity (Fig. 2) were consistently and significantly greater in the PCCP rotation than in the CBBP rotation regardless of which variety was planted (Table 1).

Table 1. Effect of rotations on final TSW incidence and SAUDPC, on peanut in Quincy in 2003-2006.

Year	Variety/Rotation[a]	Final TSW incidence (%)[b]	SAUDPC[c]
2003	Georgia Green		
	CBBP	16.9	10.7
	PCCP	21.3	28.5
	LSD ($P < 0.05$)	12.3	4.4
2004	Georgia Green		
	CBBP	31.7	44.5
	PCCP	71.9	103.7
	LSD ($P < 0.05$)	13.7	43.7
2005	Georgia Green		
	CBBP	30.8	59.6
	PCCP	59.2	121.1
	LSD ($P < 0.05$)	18.6	29.2
2006	Georgia Green		
	CBBP	22.5	33.6
	PCCP	53.1	90.1
	LSD ($P < 0.05$)	7.1	30.4

[a] CBBP = Cotton followed by two years of bahiagrass then peanut and PCCP = Peanut followed by two years of cotton then peanut.

[b] Incidence represents the proportion of twenty plants assessed for TSW symptoms on a scale of 0-3: where 0 = no visible symptoms; 1= presence of TSW symptoms on at least one leaf on the plant; 2 = symptoms on majority of leaves with moderate stunting of plant; and 3 = severe stunting of plant, and associated death. Means in the same column for the same year with the same letter do not differ at 5% level.

[c] Standardized area under the disease progress curve throughout the assessment period. Means in the same column for the same year with the same letter do not differ at 5% level.

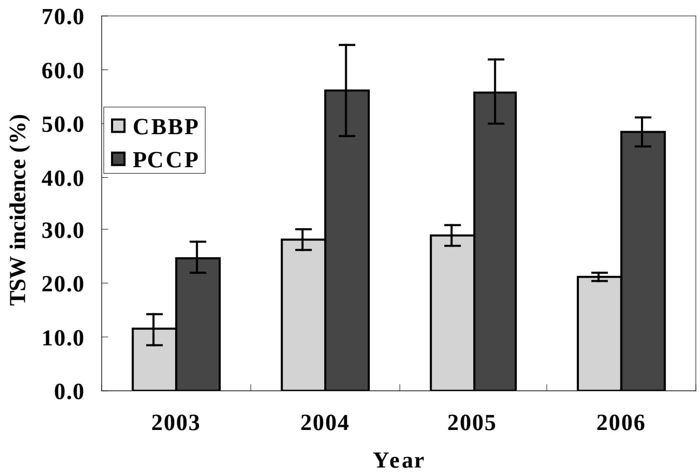

Figure. 1. Effect of rotations on the average incidence of TSW on peanut. From a minimum of 4 assessment dates within a cropping cycle. CBBP = Cotton followed by two years of bahiagrass then peanut. PCCP = Peanut followed by two years of cotton then peanut

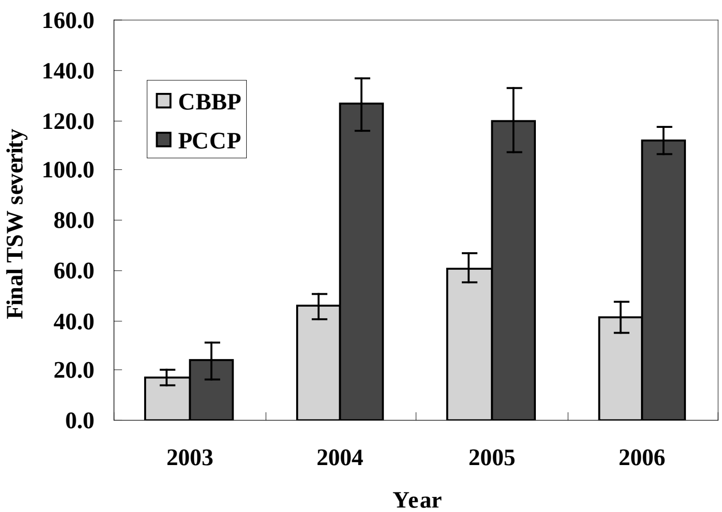

Figure 2. Effect of rotations on the final TSW severity on peanut. CBBP = Cotton followed by two years of bahiagrass then peanut. PCCP = Peanut followed by two years of cotton then peanut.

Southern Stem Rot: SSR was severe only in 2003. However, there was a significant reduction in disease in the bahia grass rotations (Fig. 3). This was consistent with previous studies on the ability of bahiagrass to suppress peanut SSR (Johnson et al., 1999; Brenneman et al., 1995). Incidence of SSR was significantly lower on the CBBP than the PCCP rotation for most part of the season, and the fluctuations was attributed to changing weather during the growth period. The sharp decline in incidence between 75 and 100 DAP was attributed to pronounced dry period. However, the improved leaf retention by peanut in the CBBP rotation 100 DAP produced a conducive microclimate for survival of *S. rolfsii* even though there was a dry period, thus resulting in the slightly higher incidence on the CBBP rotation. Pathogen signs on peanut in the field under the CBBP rotation were atypical for SSR, as they showed signs of degeneration.

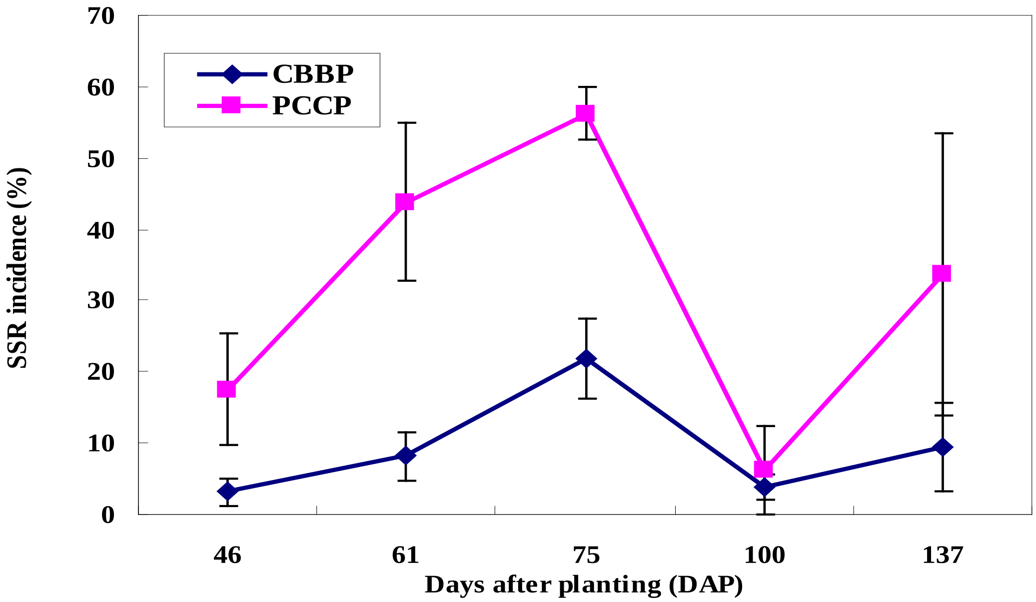

Figure 3. Effect of bahiagrass (CBBP) and conventional (PCCP) rotation on the incidence of southern stem rot (SSR) in Quincy, FL during 2003. Incidence represents the percentage number of plants out of 20 showing pathogen signs. Data represents means of 8 and 4 replications. Standard error bars are displayed for each rotation and assessment time.

Peanut Leaf Spot: Two years of a bahiagrass rotation (CBBP) significantly reduced ELS and LLS when compared to the conventional (PCCP) system. The increase in disease severity over time was best described by the logistic model for each plot rotation in all years; R^2 = 0.92 and 0.91 for the PCCP an CBBP rotations, respectively. ELS in 2003 began appearing on plants barely 32 DAP (Fig. 4), and progressed gradually over time. Estimates of the apparent infection rate of epidemics (r) computed from the slope of the linearized logistic model was comparable for both rotations but slightly higher (0.024) for the PCCP than (0.019) for the CBBP rotation. Leaf spot epidemics measured by the standardized area under the disease progress curve (SAUDPC) was not significant for either rotation (Table 2). Initial infections on peanuts were found to be ELS which later were predominated by LLS which started showing three months after planting and became the predominant disease until harvest throughout the four years of the study. Since no distinctions were made during the scoring between ELS and LLS, the mean severity was a combined score for both types and hereafter referred to as leaf spots. Leaf spot assessment on Georgia Green peanut in the rotation were done 32, 46, 61, 75, 100, and 137 DAP. There was no significant difference in severity rating between the CBBP and PCCP peanuts at earlier dates of disease assessment, but thereafter was consistently significant ($P \leq 0.05$) until harvest (Fig. 4). Similarly, the proportion of plants showing higher ratings were more in the

PCCP rotation than in CBBP rotation resulting in a significantly ($P \leq 0.05$) higher proportion of disease throughout 2003. Similar to the observations in 2003, leaf spot in 2004 appeared to have started significantly earlier ($P \leq 0.05$) on the PCCP rotation compared to the CBBP rotation (Fig. 4). Except at 132 DAP, severity ratings were higher on the PCCP rotation than on the CBBP, and were significantly ($P \leq 0.05$) different until harvest. Estimates of the apparent infection rate of epidemics (r) computed from the slope of the linearized logistic model was significantly ($P \leq 0.05$) higher in 2004 than 2003 and was comparable for the PCCP and the CBBP rotation (Table 2). Leaf spot epidemics measured by the standardized area under the disease progress curve (SAUDPC) was not significant for either rotation (Table 2). There was a significantly higher disease in the PCCP rotation on the individual assessment dates.

Table 2. Effect of rotations on final severity (Florida 1-10 scale), apparent infection rate (r) and SAUDPC on peanut during 2003-2006.

Year, Variety	Rotation[a]	Final severity rating[b]	r[c]	SAUDPC[d]
2003, Georgia Green	BBP	5	0.019	72.3
	CCP	7	0.024	92.7
2004, Georgia Green	BBP	6	0.039	35.8
	CCP	8	0.04	52.6
2005, AP3	BBP	6	0.047	38.8
	CCP	7	0.05	52.6
2006, AP3	BBP	6	0.04	70.4
	CCP	8	0.044	92.5

[a] B = bahiagrass; C = cotton; P = peanut represents the yearly rotation of the crop
[b] Severity represents the proportion of twenty plants assessed
[c] Epidemic rate determined from the slope of the linearized disease progress curve
[d] Standardized area under the disease progress curve throughout the assessment period

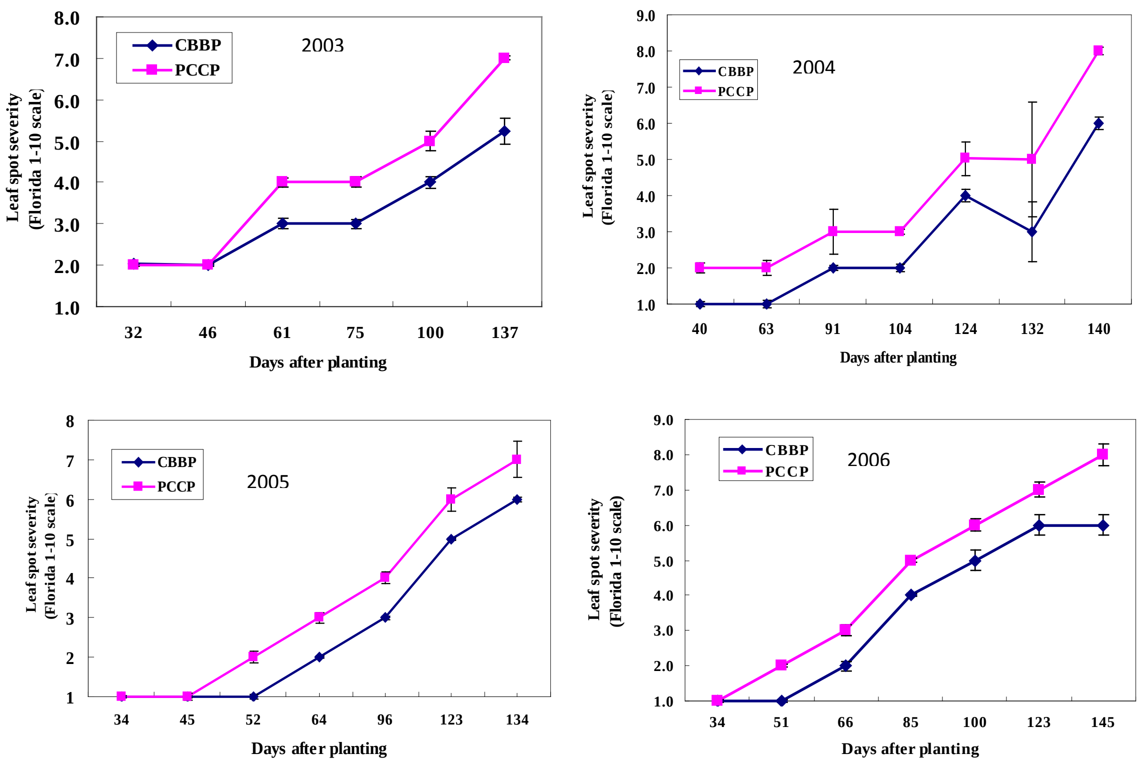

Figure. 4. Effect of bahiagrass (CBBP) and conventional (PCCP) rotation on disease progress leaf spot severity measured using the Florida 1-10 scale, over time.

Nematodes: Soil population densities of ring (*Mesocriconema ornatum*), spiral (*Helicotylenchus dihystera*), reniform (*Rotylenchulus reniformis*), and root-knot nematode (*Meloidogyne incognita* race 3) in the rotations varied from year to year. Populations of spiral, reniform, and root-knot nematodes remained consistently greater in the PCCP than in CBBP rotation soils throughout the four years. With the exception of 2004, populations of ring nematodes were significantly ($P \leq 0.05$) greater in the bahiagrass (CBBP) rotation than in the conventional (PCCP). Across the four years (2003-2006), populations of ring nematodes were greater following bahiagrass than cotton in the conventional rotation. Across the four years, both reniform and root-knot nematodes were lower in the bahiagrass rotation than in the conventional rotation.

DISCUSSION

Tomato spotted wilt: TSW incidence and severity measured by the SAUDPC on peanut was significantly suppressed by two years of bahiagrass rotation (CBBP) compared to the conventional (PCCP) rotation system over the course of four years (2003-2006). Incidence and severity of TSW varied between years but was consistently higher for the PCCP rotation than on the CBBP rotation. TSW was particularly severe in 2004 and 2005 for the PCCP rotated peanut but remained significantly less in the CBBP peanuts in those years. The lowest incidence and disease severity in both rotations was recorded in 2003. The disease was suppressed in the

CBBP rotation throughout 2003-2006 (12-32%) compared to the PCCP rotation (21-72%), with the highest severity in 2004 for both rotations. Except for 2003, when TSW incidence was high 32 DAP and suddenly dropped at 46 DAP, incidence in all other years increased more rapidly in the PCCP rotation compared to the CBBP rotation. The sudden decrease in 2003 May was due to the death and decay of highly infected plants, thus removing them from the assessment.

Peanut Leaf Spot: In this study, epidemics of peanut leaf spot were suppressed by three years of a cotton- bahiagrass rotation (BBP) when compared to a conventional two-year cotton-peanut (CCP) rotation. Under a no fungicide spray regime, the cotton-bahiagrass rotation significantly reduced the severity of leaf spots on peanut delaying disease onset when compared to the CCP system. Although leaf spot disease suppression in a bahiagrass rotation has been extensively reported, such studies involved bahiagrass plots that were either burned before planting peanut or the peanuts were sprayed with fungicide, making it difficult to estimate the actual contribution of bahiagrass rotation to leaf spot suppression since there were confounding effects due to the fungicide spray or burning. The fluctuations in disease severity across years could be attributed to weather variations among years. Rainfall and relative humidity varied greatly across and within years. The epidemic rate parameter (r) calculated from the logistic transformation was similar for both rotations. Fluctuations in leaf spot severity as a result of environmental conditions could have lowered the epidemic rate in the logistic model. The influence of rotation on leaf spot severity was most noticeable in 2006 when disease severity was high in the CCP rotation and the BBP rotations still had moderate disease. Nearly 60% defoliation occurred in the BBP in 2006 compared to nearly 90% for the CCP rotation. Since the rate of disease increase was comparable for both rotations in all four years, the impact of the rotations on leaf spot severity was mainly due to the delayed onset in the BBP rotation based on the disease progress curve.

Southern Stem Rot: Reduction of SSR observed here is consistent with previous studies on the ability of bahiagrass to suppress peanut SSR (Johnson et al., 1999; Brenneman et al., 2003). Incidence of SSR was significantly lower on the CBBP than the PCCP rotation for most part of the season, and the fluctuations was attributed to changing weather during the growth period. The sharp decline in incidence between 75 and 100 DAP was attributed to pronounced dry period. However, the improved leaf retention by peanut in the CBBP rotation 100 DAP produced a conducive microclimate for survival of *S. rolfsii* even though there was a dry period, thus resulting in the slightly higher incidence on the CBBP rotation. Pathogen signs on peanut in the field under the CBBP rotation were atypical for SSR, as they showed signs of degeneration.

Nematodes: Plant-parasitic nematode population densities were lower in the bahiagrass (CBBP) than the conventional (PCCP) rotation, particularly in relation to J2 of *M. incognita* race 3. Previous studies have demonstrated population reductions of both *M. incognita* and *M. arenaria* after bahiagrass rotation (Rodríguez-Kábana *et al*., 1994; Johnson et al., 1999; Sumner *et al*., 1999). Mechanisms of *Meloidogyne* population reduction under a bahiagrass rotation were attributed to the non-host status of bahiagrass and the possible stimulation of nematode antagonists such as *Pasteuria penetrans* (Timper *et al.*, 2001). The bahiagrass rotation did not suppress the ring (*M. xenoplax*) nematode populations, although it has previously been used to suppress populations of ring nematode in young peach orchards (Nyczepir and Bertrand, 2000). Similarly, Zehr *et al*. (1990) reported that bahiagrass did not support *M. xenoplax* population under greenhouse conditions when seedlings were inoculated with the nematode. The high population of ring nematode could not be explained from these present data.

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