INFLUENCE OF BAHIAGRASS (*PASPALUM NOTATUM* FLUEGGE) ROTATION IN THE SUPPRESSION OF TOMATO SPOTTED WILT OF PEANUT IN QUINCY, FL.

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Abstract

Rotation plots were established in Quincy, FL during 2000 to study the impact of a conventional Peanut-Cotton-Cotton-Peanut rotation (PCCP), and a Cotton-Bahiagrass-Bahiagrass-Peanut (CBBP) rotation on peanut diseases. Disease monitoring from 2003-2006 established that growing peanut after two years in rotation with bahiagrass significantly reduced TSW incidence and severity as compared to peanut in a conventional rotation involving two years of cotton. Incidence of TSW on peanut ranged 5.5-16.3, 23.5-37.5, 20.8-36.7, 18.3-25% in 2003, 2004, 2005, and 2006 respectively in a CBBP rotation, whereas the incidence ranged 15.3-24.4, 27.5-72.5, 28.3-76.7, 38.8-53.1% in 2003, 2004, 2005, and 2006 respectively in a PCCP. TSWV is vectored by thrips. Peanut seedlings suffered more severe thrips feeding damage, 100% incidence, under the PCCP rotation as compared to 45% incidence under the CBBP rotation. Thrips population on peanut seedlings were similarly higher on the PCCP than the CBBP rotation in 2005. Other peanut diseases were lower in the CBBP than the PCCP rotation in all years. Peanut pod yield was higher in the rotation of peanut with bahiagrass, 3,353 kg/ha than in the conventional system 2,633 kg/ha averaged across all four years. Other benefits of the bahiagrass rotation system will be presented.

INTRODUCTION

Tomato Spotted Wilt, caused by the TSW Virus (TSWV), a tospovirus in the Bunyaviridae family, is one of the major peanut diseases in the southeastern US. TSW of peanut is difficult to manage for various reasons: 1) insect (thrips) transmitted, 2) unavailability of effective chemical control options, 3) limited availability of plant resistance, and 4) increasing cost of peanut production with decreasing commodity prices. Tobacco thrips [*Frankliniella fusca* Hinds (Sakimura)] and western flower thrips *F. occidentalis* (Pergande) are confirmed vectors of peanut TSW and these insects are prevalent in the southeastern US (Todd et al., 1993; Todd et al., 1995).

Use of minimum tillage in peanut has been reported to reduce the impact of TSW and early leaf spot (ELS) (*Cercospora arachidicola* S. Hori,), late leaf spot (LLS) [*Cercosporidium personatum* (Berk. & M.A. Curtis) Deighton], and rust (*Puccinia arachidis* Spegg) as compared to conventional tillage (Baldwin et al., 2001; Johnson et al., 2001; Monfort, 2002). The most prevalent peanut cropping system in southeastern US is two years of cotton followed by peanut with a winter small grain (wheat, oats) cover crop. All of these crops are hosts to several species of thrips [*Frankliniella fusca* Hinds (Sakimura)]; *Frankliniella occidentalis* (Pergande); *Thrips tabaci*). Cotton seedlings are often affected by thrips, particularly tobacco thrips (*F. fusca*), which also is the predominant species on peanut during the seedling stage. Management of peanut TSW poses tremendous challenges since chemical control of thrips have not been shown to effectively manage TSW on peanut as reported by Todd et al. (1996), possibly due to the mode of virus transmission and vector mobility. In-furrow application of phorate has been reported to suppress TSW epidemics on peanut. Ames (2007) reported that spraying foliar insecticide in an addition to phorate application could successfully manage TSW, though the plant growth stage at application was not indicated.

No-till and minimum tillage systems for peanut have become an economic option for peanut cultivation in the southeastern US. Cantowine et al. (2006) reported the interacting effect of cultivar and tillage method on the suppression of leaf spot and TSW. Tillage systems have significant influence on thrips populations as well as feeding injury with less of both occurring in a strip-till and no-till system (Brown et al., 1996; Campbell et al., 1985). However, the role of soil type and rotation crops in the survival of thrips and their impact on TSW has not been thoroughly studied. Barbour et al. (1994) found fewer thrips emerging from soils than those collected on open-sticky cards in North Carolina, and concluded that soils from peanut fields were not a major source of thrips. Combined treatment of aldicarb and flutolanil or aldicarb alone significantly reduced thrips feeding damage but there was no significant difference for rotation (Timper et al., 2001). Culbreath et al. (2003) proposed the integration of chemical, genetic, and cultural practices involving planting date, manipulation of plant population, tillage practices, and row pattern as well as in-furrow insecticide application among other options in the management of TSW on peanut. The recommendation to manipulate plant population resulted in the adoption of the twin-row planting system to enhance early canopy closure (Culbreath et al., 2003).

Long-term management of TSW will require the use of TSWV-resistant varieties. Magbanua et al. (2000) reported that the nucleocapsid (N) gene of TSWV have been used to impart resistance to plants, and the first use of such approach was reported by Gielen et al. (1991) for engineered resistance to TSWV in tobacco. Sreenivasulu et al. (1991) attempted transforming peanut for resistance by using the N gene obtained from lettuce. Magbanua et al. (2000) successfully transformed peanut with the N gene and found that infection of plants with the N gene were lower in the transgenes than in untransformed plants. Chemical applications could also initiate a series of metabolic and genetic changes in plants, and Gallo-Meagher et al. (2001), reported that the mechanism of TSW control in phorate-applied peanuts appeared to be due to defense gene activation. Though genetic resistance holds promise to manage most peanut diseases, incorporating of resistance to all the economic diseases of peanut with acceptable yield and quality is a major challenge. For instance, a variety such as Georgia Green, which is widely planted in Florida and Georgia, gives good yield and field resistance to TSWV; however it is susceptible to both early and late leaf spot fungi (Cantowine, 2006). The advantages of using perennial grasses such as bahiagrass in peanut disease management has been well documented for leaf diseases and leaf spot diseases (Brenneman et al., 1995; Timper et al., 2001). However there is little information of the same system in the management of TSW.

The objectives of this research were to; 1) to assess the potential ability of bahiagrass rotation in peanut on TSW epidemics, 2) investigate possible mechanisms of TSW suppression.

MATERIALS AND METHODS

Rotation and Cultural Practices- Experiments were conducted at the North Florida Research and Education Center in Quincy, Florida from 2003 to 2006. Rotation plots were first established in year 2000 and consisted of a Bahiagrass rotation with peanut and a conventional rotation for peanut. Except for 2005 where some plots were in one year bahiagrass rotation (PCBP), and two years of consecutive peanut (CCPP), 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 cultivated 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). Weed and other crop management practices were done based on the Florida Cooperative extension Services recommendations. Each plot measured 22.8 m in length by 18.4 m (20 peanut rows).

Tomato Spotted Wilt Assessment. Peanut plants were assessed 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 1-3: where 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.

Thrips infestation studies- Other rotations cotton-cotton-peanut-peanut (CCPP) and peanut-cotton-bahiagrass-peanut (PCBP) besides CBBP and PCCP were monitored during 2005 During 2005 thrips feeding injury as well as population on peanut seedling was assessed by sampling peanut seedlings 14 and 45 DAP for each rotation.

RESULTS

Hitherto all the beneficial effect of bahiagrass rotations to suppress diseases in peanut has only been directed at the leaf spot and soil-borne diseases, but has not been thoroughly studied for TSW. Tomato spotted wilt (TSW) epidemics in these fields were variable each year, however it remained significantly ($P \leq 0.05$) higher in the PCCP rotated peanut than the CBBP peanut in all four years irrespective of which variety was grown (Fig. 1). Similarly, TSW severity across years (2003-2006) regardless of the variety was significantly higher ($P \leq 0.05$) in the PCCP than the CBBP rotation. The progression of TSW in 2003 is shown in Fig. 2. with significant differences between the rotations observed for both incidence and severity 32 DAP, with the peanut in the PCCP rotation having 39% incidence vs. 22% (LSD = 16.2) in the CBBP rotation. TSW severity was similarly higher in the PCCP rotation than in the CBBP rotation at all times. TSW progression over time during 2004 is represented in Fig. 3. Peanut seedlings first exhibited thrips feeding damage as was observed in 2003 and were clearly visible two weeks after planting. Incidence of TSW 40 DAP was significantly different ($P \leq 0.05$) between the two rotations; 38 and 24 % respectively on PCCP and CBBP rotations.

Epidemics of TSW on peanut during 2005 under the different rotations are presented in Fig 4. with disease progression for CCPP and PCCP comparable as was for PCBP and CBBP. TSW incidence and severity was consistently higher and significantly different ($P \leq 0.05$) at each time of assessment on peanut in the PCCP than the CBBP rotation as represented in Figs. 4. during 2005 on AP3 variety. Progression of TSW incidence on AP3 peanut in the rotations during 2006 is presented in Fig. 5. Throughout the season, incidence and severity of TSW was significantly higher ($P \leq 0.05$) in the PCCP rotation than in the CBBP rotation.

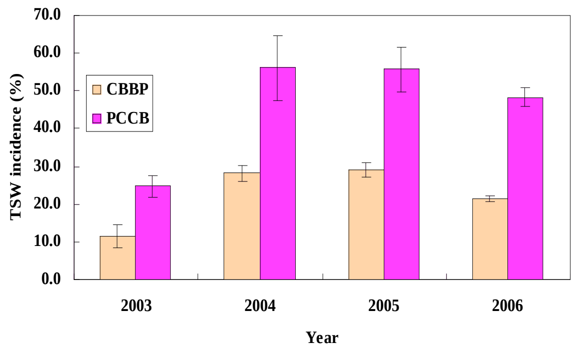

Fig. 1. Effect of rotations on incidence of TSW on peanut in Quincy, FL from 2003-2006. The standard error bars are displayed in the chart and represent 4-7 assessment times within a cropping cycle. B = bahiagrass, P = peanut, C = cotton.

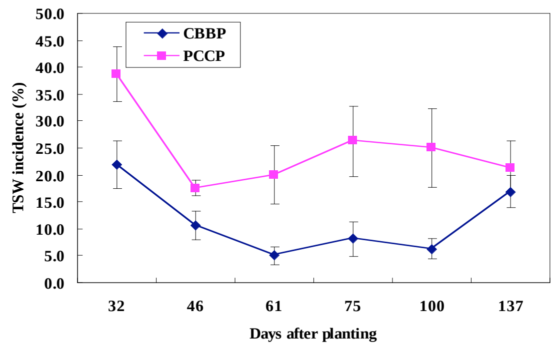

Fig. 2. Effect of bahiagrass (CBBP) and conventional (PCCP) rotation on progression of TSW incidence on Georgia Green peanut during 2003 in Quincy, FL. Treatment means of 20 plants for 8 or 4 replications and the standard error bars are shown for each assessment date.

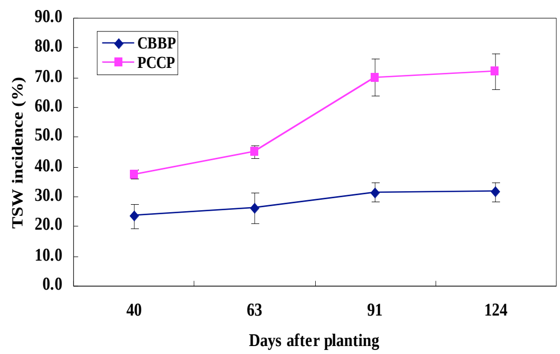

Fig. 3. Effect of bahiagrass (CBBP) and conventional (PCCP) rotation on progression of TSW incidence on Georgia Green peanut during 2004 in Quincy, FL. Treatment means of 20 plants for 10 or 4 replications and the standard error bars are shown for each assessment date.

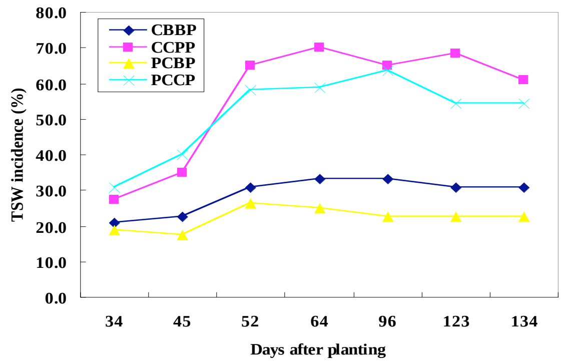

Fig. 4. Effect of different cropping sequences on progression of TSW incidence on AP3 peanut during 2005 in Quincy, FL. Treatment means of 20 plants for 6 replications. Cropping sequences are represented by: B = bahiagrass, C = cotton, P = peanut.

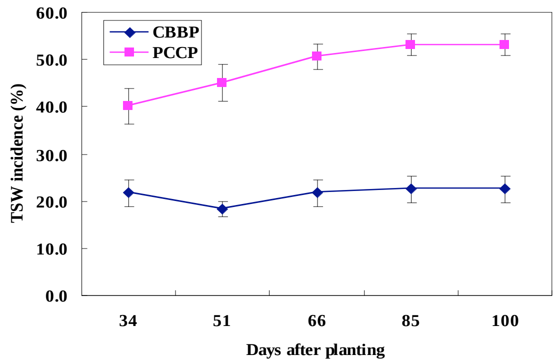

Fig. 5. Effect of bahiagrass (CBBP) and conventional (PCCP) rotation on progression of TSW incidence on Georgia Green peanut during 2006 in Quincy, FL. Treatment means of 20 plants for 6 or 8 replications and the standard error bars are shown for each assessment date.

Monitoring of thrips population, feeding damage and its impact on TSW on peanut- Thrips feeding began early on peanut seedlings just as the hypocotyl was breaking the soil surface resulting in feeding scars. Peanut in the CCPP rotation had higher numbers of thrips per plant (42); PCCP (22); CBBP (6); and PCBP (4) (Fig. 6). The number of seedlings exhibiting feeding damage is shown in Fig. 7, with a later correspondence to final TSW incidence on plots (Fig. 4). Thrips feeding damage was variable on the rotations in 2005 with the most damage on the PCCP, followed by CCPP, CBBP, and PCBP with averages of 19, 12, 8, and 5 damaged plants respectively out of the twenty plants sampled (Fig. 7). Correspondingly, the incidence of TSW followed a similar trend with the highest observed on CCPP and the least on PCBP (Fig. 4). The above trend observed was equivalent to the generation of differential epidemics. Differences in the feeding damage correlated with the number of thrips per plant, (r = 0.60, Pearson correlation). Similarly there was a stronger correlation, r = 0.94, between the number of thrips per seedling and the final TSW incidence. On average 13 out of 20 plants showed damage on the CCPP rotation and resulted in higher final 61% TSW incidence, compared with 5 damaged plants on PCBP with a final TSW incidence of 23% (Fig. 4). The number of thrips per peanut plant had a significant impact on the final incidence of TSW with a correlation coefficient, r = 0.94. The PCCP rotation mimicked what was found on the CCPP plots with 22 thrips per plant and a final TSW incidence of 54%.

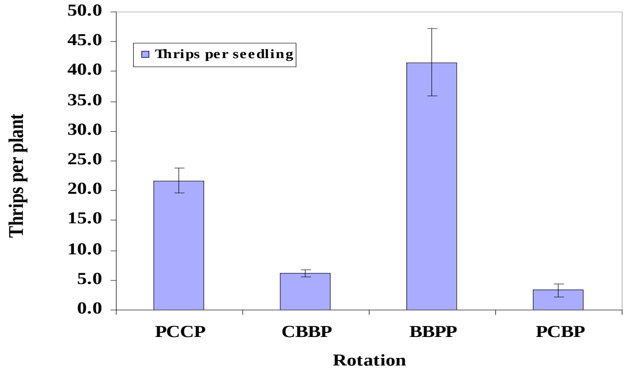

Fig. 6. Effect of different cropping sequences on thrips population on AP3 peanut seedlings during 2005 in Quincy, FL. Treatment means of 20 plants for 6 replications. Cropping sequences are represented by: B = bahiagrass, C = cotton, P = peanut.

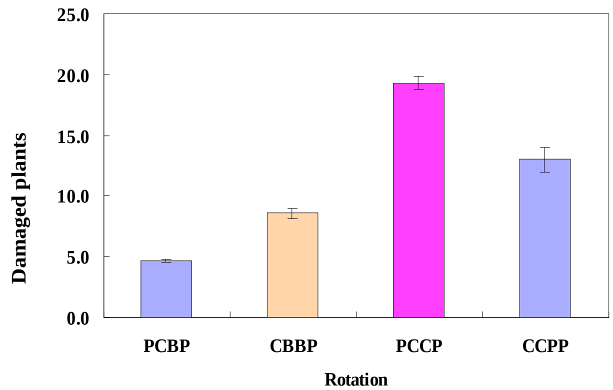

Fig. 7. Effects of rotations on thrips feeding damage on peanut seedlings in Quincy FL during 2005. Points represent average number of plants damaged out of 20 in plots with different cropping sequences represented. Points represent mean number of plants assessed 14 and 54 DAP. Cropping sequences are represented by: B = bahiagrass, C = cotton, P = peanut.

DISCUSSION

TSW incidence and severity 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) in a consistent manner. Brenneman et al. (1995) reported that a one year rotation in bahiagrass suppressed leaf spot as equally well as a two-year system and reduced stem rot of peanut, and limb rot could as well be a good alternative, though the data on TSW epidemics was not reported. It was observed in this experiment that, one year rotation in bahiagrass also suppressed TSW epidemics by reducing thrips population, and feeding damage, thus confirming the reports of Brenneman et al. (1995) that one year of bahiagrass rotation has some advantages comparable to a two-year bahiagrass rotation. Incidence and severity of TSW varied between years but was consistently higher on the PCCP rotation than in the CBBP rotation. The TSW suppressive effect of bahiagrass rotation had not been thoroughly researched, though its advantages in the management of soil-borne, and leaf spot diseases have been shown (Timper et al., 2001; Brenneman et al., 1995). TSW incidence remained in the range 12-32% in the CBBP rotation, compared to the PCCP rotation of 21-72% across years, with the highest severity in 2004 for both rotations.

TSW on peanut is transmitted by thrips hence their population dynamics on peanut play significant role in disease incidence and severity. Based on thrips population and damage data in 2005, it appeared the initial damage at the seedling stage could be one of the most important factors in determining the incidence and severity of TSW over time. In this study thrips damage as a result of feeding did not have a high correlation with thrips population($r = 0.60$); however it could be explained by the fact that a single thrips is capable of causing multiple damage on plants by virtue of their mobility. Number of plants damaged was highly correlated (0.84) with the final incidence and severity of TSW. The high correlation coefficient ($r = 0.94$) observed between number of thrips per seedling and the final TSW incidence is consistent with the general assumptions of the influence of thrips population on TSW incidence (Culbreath et al., 1999). This research suggests that the initial thrips population on the field even before seedling emergence could significantly affect TSW incidence and may be supported by the number of thrips per seedling in the CBBP rotation was low in both 2005 that resulted in lower final spotted wilt incidence. Similarly, higher population of thrips in the PCCP rotation resulted in higher TSW incidence.

Differences in the population of thrips on PCCP and PCBP plots that were adjacent to each other that resulted in lower feeding damage and TSW incidence may be attributed to the following; 1) bahiagrass might have not been a good host as evidenced in the low number of thrips recorded on it and thus did not support thrips reproduction when compared to oats, 3) decomposing bahiagrass residue may have been releasing some volatile compounds that could serve to repel thrips from such plots. The contribution of volunteer peanuts in adjacent plots to TSW epidemics have been suggested but not quantified hence their role could be aggravated when there is already an existing reproductive host. Strip tillage has been investigated and reported to suppress diseases in peanut (Monfort et al., 2004) and Cantowine et al. (2006) also reported the reduction of TSW and leaf spots diseases in peanut under a strip tillage system compared to the conventional tillage system and attributed the reduction to the mechanisms suggested by Culbreath et al. (1999). Culbreath et al. (2003) hypothesized that, reduction in TSW on peanut under a strip tillage system could be attributed to modifications in thrips recognition of peanuts by virtue of the presence of stubble. It should be noted that the plots under study in this research were strip tilled, yet revealed significant differences in TSW epidemics in the two systems, suggesting that other mechanisms could be in play in TSW suppression in the CBBP rotation. Bahiagrass rotation has been reported to influence other soil properties (Katsvairo et al., 2007), such as better root system that could enhance plant vigor and tolerance to pest and disease attack and influence yield.

During 2005, and 2006 when AP3 variety was planted in a twin-row pattern, the percentage increase in yield between the PCCP and CBBP rotations were less than in 2003 and 2004 when GA Green variety was planted in a single-row pattern. This trend suggested that the twin-row pattern did reduce the impact of yield loss due to TSW, confirming the recommendations of Culbreath et al. (2003). The mechanism employed by the twin-row system in affecting TSW epidemics was reported to be possibly due to visual interference of migrating thrips in host recognition (Culbreath et al., 2003). Since the plots studied in this experiments were all strip tilled, and planted in a twin-row pattern in 2005 and 2006, the low percentage increase in yield (data not presented) between the PCCP and CBBP rotations could be attributed to plant compensation, in which severely stunted plants in the rotation were smothered by other healthy plants thus reducing the impact of TSW severity in the PCCP plots. Under these circumstances there are other yield qualities such other kernels (data not presented), which was significantly higher in the PCCP rotations could better reflect the severity of spotted wilt on the PCCP rotation than the actual harvestable and grades of the pods.

In conclusion, planting peanuts after two years of bahiagrass consistently reduced peanut TSW epidemics and improved yield. Bahiagrass rotation reduced number of thrips per peanut seedling, number of damaged peanut seedlings and TSW incidence and severity. This reduction in thrips and TSW may have contributed to the observed increase in peanut yield and quality.

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