HOST PLANT RESISTANCE TO TARNISHED PLANT BUG IN ARKANSAS: I. VARIATION AMONG COTTON GENOTYPES IN SMALL PLOTS

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Abstract

Tarnished plant bug (*Lygus lineolaris* Palisot de Beauvois) has become the number one insect pest in the Mid-south and U.S. cotton production. Development and identification of lines that have even partial resistance to TPB could reduce the amount of insecticides used to control this pest. We have been evaluating TPB resistance of cotton lines in small plots since 2003. Each year, a highly susceptible check (Frego-bract) line is planted in 4-row strips leaving 8-12 rows between strips (field adjacent to corn is preferred). About 3-4 weeks later (late May), small plot (1- or 2-row x 20 feet) tests are planted in the 8-12 rows (1-2 replication/row) with a susceptible check in each test. No insecticides are applied for TPB. When TPB damage can be readily seen in flowers of the susceptible check, examination for "dirty flowers" is made on up to six white flowers per day for 5 to 8 days. Accumulative % dirty flowers over sampling days is then calculated for each plot. Over the last 11 years, we have evaluated 1,473 lines in 59 different tests. Variation between check cultivars has been relatively consistent over tests. These data have been used to quantify the level of TPB resistance in breeding strains and in 43 germplasm lines and cultivars released from the UA Cotton Breeding Program. In addition, cultivars and breeding lines in the Arkansas Cotton Variety Test, the Regional High Quality Strain Test, and RBTN Test are annually evaluated for TPB resistance. Over years, nectariless and highly pubescent lines have consistently provided some TPB resistance. However, TPB resistance has also been found in some nectaried and glabrous lines. These findings suggest that different mechanisms for TPB resistance exist, and may be found by additional testing of lines.

Introduction

Tarnished plant bug (*Lygus lineolaris* Palisot de Beauvois) is the number one insect pest in the Mid-south and U.S. cotton production (Williams, 2013). Successful elimination of the boll weevil (*Anthonomus grandis* Boheman), wide-spread adoption of transgenic insecticidal cottons for control of caterpillar pests, and modified tillage practices implemented after adoption of herbicide-resistant cotton cultivars have all contributed to the increased attention to injury and economic damage from tarnished plant bug (TPB).

Currently, chemical control is the principal tactic used in TPB pest management programs; however, in the 1970's and 1980's, there was considerable effort by researchers to evaluate genetic lines of cotton that exhibited host plant resistance to TPB. This effort primarily focused on morphological traits as reviewed by Wilson (1982) and Jenkins (1982). Traits found to be associated with resistance to TPB include nectariless, pubescence leaves and stems, high glanding (gossypol glands in calyx crown – lower preference), and normal leaf shape (relative to okra leaf). The nectariless characteristic showed the most consistent TPB resistance. Extra-floral nectaries found on the leaves and at the base of the floral buds attract beneficial insects but also encourage TPB, thus potentially increasing crop susceptibility. A few nectariless cultivars (extrafloral nectaries are absent) have been commercially available (namely 'Stoneville 731N', 'Stoneville 825', and 'DP 0935ne'). When the first two cultivars were adopted in commercial production systems, the fields were typically sprayed with insecticides in the same fashion as nectaried cultivars (boll weevils and caterpillar pests required insecticide applications). Thus, the value of TPB resistance was not realized.

Resistance to TPB is usually not associated with the glabrous plant trait (Meredith and Schuster, 1979; Jenkins, 1982). Using the techniques of Maredia et al. (1994), Arkot 8110 (Bourland et al., 1997) was as resistant as 'DES 119' (a pubescent cultivar) and Stoneville 825 (a pubescent, nectariless cultivar) in two field tests conducted in 1988 and 1994. These results suggest that different sources of resistance to TPB exist.

In seedling cotton, the apical meristem is the preferred feeding site of the tarnished plant bug, but as cotton develops, bugs will feed on floral buds (squares). Small squares that have been fed upon will usually shed from the plant. When anthers are hardly visible, the bug feeds on the totality of the floral bud, and it sheds. As the square grows, the anthers reach a large enough size for the bug to feed on individual pollen sacks (Pack and Tugwell 1976). When feeding is localized to the anthers, a square rarely sheds, but the injury can been seen as discoloration and anther damage when the flower opens. Such flowers often are referred to as "dirty blooms."

Historically, the principal method used to assess TPB resistance of cotton cultivars has been to compare yield of lines in insecticide-free plots to their yield in sprayed plots. Maredia et al (1994) developed a method of evaluating TPB by slicing squares and examining damage to anthers. Examination of anthers in squares rather than in flowers was required to distinguish between boll weevil and TPB injury. Without boll weevils present, we began evaluation of lines in the University of Arkansas (UA) Cotton Breeding Program by examining the presence and degree of darkened anthers (dirty blooms) in white flowers in 2003. Examining white flowers requires much less time than slicing squares. The work was expanded to include evaluation of cultivars and lines in regional tests in 2006. Evaluation of breeding lines and cultivars have continued through 2013.

The objective of this paper is to review methods and results from the small-plot tests used to evaluate resistance to TPB in cotton genotypes that were conducted at Keiser, AR, from 2003 through 2013.

Materials and Methods

Each year since 2003, small 20-foot plots have been planted at Keiser to evaluate response of cotton genotypes to TPB. In 2003-2005, plots were 2-rows replicated 6 times; in 2006-2012, plots were 1-row replicated in 12 times; in 2013 plots were 1-row replicated 8 times. Each year, 4-row strips of a highly susceptible line (Frego-bract, Maredia et al., 1993) was planted 3-4 weeks prior to planting the tests. The tests were usually planted from mid- to late May. As the earlier-planted Frego-bract cotton matured, TPB populations were expected to move out of the Frego-bract cotton into the test plots. The tests were planted between the Frego-bract strips with replications arranged vertically to the Frego-bract strips. Each plot within a replication was then an equal distance from the early-planted Frego-bract cotton. The plots were managed using standard production practices except that no insecticides were applied to control TPB.

Each test included one to three Frego-bract (susceptible check) entries. When TPB damage could be readily seen in white flowers of the susceptible check, evaluation of “dirty flowers” was initiated. In 2003-2005, up to 10 white flowers per plot per day were examined and rated as “zero” (no darkened anthers), “light” (up to 50% darkened anthers), or “heavy” (more than 50% darkened anthers) TPB damaged. Accumulative counts over five days were evaluated for percent damaged (“dirty”) flowers (% light + % heavy) and percent damaged anthers ((no. light * 0.3) + (no. heavy * 0.8) / no. flowers). Within each test, percent damaged flowers and percent damaged anthers were found to be highly correlated ($r > 0.95$). Coinciding with the change in plot size and number of replications, sampling procedures were modified in 2006. Since then, up to 6 white flowers per plot per day were simply examined for the presence or absence of any damage anthers. Accumulative counts over five to six sample days were used to determine percent dirty flowers.

Results and Discussion

Extent of Testing

Since 2003, we have planted and evaluated almost 1,500 entries in 59 different tests for response to TPB (Table 1). Each year, entries in the Arkansas Advanced Strain Test and Arkansas New Strain Test (except 2003) were evaluated. Evaluation of entries in the Arkansas Cotton Variety Test and the Regional High Quality Strain Test was initiated in 2006, and the Regional Breeders’ Network Test (RBTN) was added tin 2007. Additional miscellaneous strain trials were evaluated in 2007-2010. Entries in each test included the Frego bract checks and many entries were evaluated for multiple years and/or in multiple tests per year. Yet, the 1,500 entries likely include about 600 different genotypes.

In these 59 tests over 11 years, the coefficients of variation (C.V.) and R-squares associated with the TPB measurement have been quite good. Over all the tests, C.V.’s have averaged 24.4% (±5.9%) and R-squares have

averaged 66.3% (±11.3%). All of the normal bract strains and cultivars have been more resistant (lower % dirty flowers) than the susceptible Frego-bract check. Also, nectariless lines have consistently shown good resistance, but generally not more resistant than the best nectaried lines. Two important conclusions from these data include: 1) variation in resistance to TPB exists in highly adapted genetic lines, and 2) more than one source of resistance appears to be operative since resistance was not resisted to nectariless lines.

Table 1. Number of entries (number of tests) and number of plots evaluated for response to TPB.

Year	Arkansas strain tests	Arkansas Variety tests	Regional strain tests	All tests	Total plots
	Entries (tests)	Entries (tests)	Entries (tests)	Entries (tests)	No.
2003	22 (1)	-	-	22 (1)	132
2004	44 (2)	-	-	44 (2)	264
2005	44 (2)	-	-	44 (2)	264
2006	44 (2)	90 (3)	25 (1)	159 (6)	1,908
2007	44 (2)	80 (2)	79 (4)	203 (8)	2,436
2008	52 (3)	54 (2)	70 (3)	176 (8)	2,112
2009	56 (3)	58 (2)	78 (3)	192 (8)	2,304
2010	66 (3)	59 (2)	60 (2)	185 (7)	2,220
2011	44 (2)	52 (2)	60 (2)	156 (6)	1,872
2012	44 (2)	44 (2)	58 (2)	146 (6)	1,752
2013	44 (2)	44 (1)	58 (2)	146 (5)	1,752
Sum	482 (23)	481 (16)	488 (19)	1,473 (59)	17,016

Performance of Check Cultivars

The same Frego-bract susceptible check was used in all of the TPB tests since 2003. DP393 and SG105 have been included as checks in the RBTN tests each year (Figure 1). In the UA New Strain and Advanced Strain Tests, DP393 has been included as a "moderately resistant check" since 2006. Prior to 2006, PSC355 was used instead of DP393. In tests that included both cultivars, PSC355 and DP393 responded similarly to TPB (date not shown). SG105 was used as the "moderately susceptible check" from 2003-2011. UA48 was substituted for SG105 in tests since 2011 because it provides an excellent fiber quality check. UA48 tends to be slightly more susceptible to TPB than SG105.

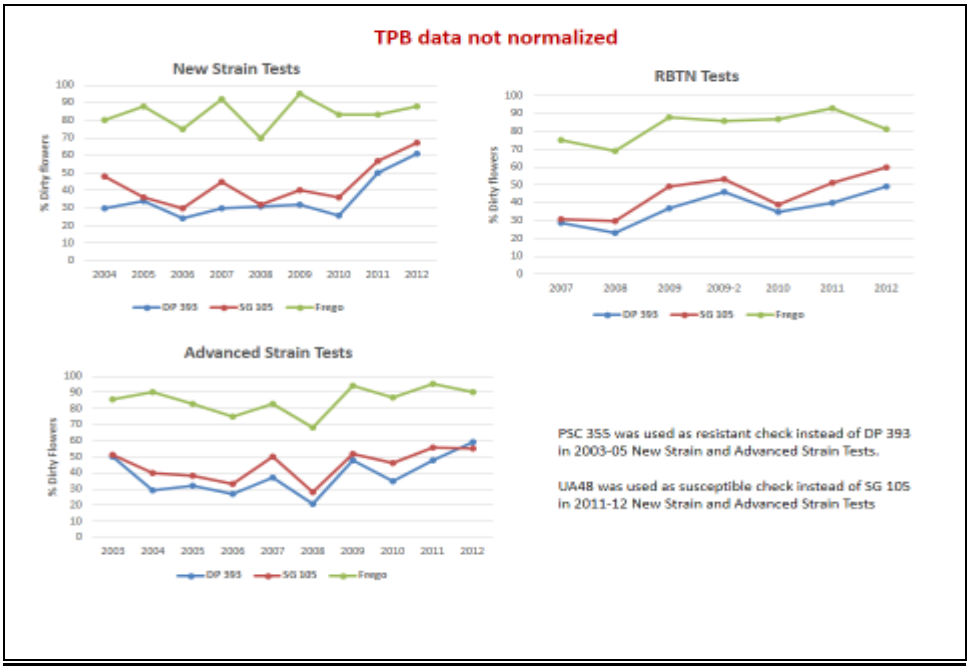

Figure 1. Percent dirty flowers in response to TPB for check cultivars in three tests at Keiser, AR, from 2003-2012.

In each of these tests, the Frego-bract check exceeded 70% dirty flower, which was much higher than either of the other checks (Figure 1). Except for the 2012 Advanced Strain Test, the moderately susceptible check had higher % dirty flowers than the moderately resistant check in every year and every test. The unexpected results in the one 2012 test may be due to a seeding mistake or simply experimental error. Except for that one test, the relative variation between the moderately susceptible and moderately resistant checks was similar each year.

In 2011 and 2012, % dirty flowers tended to increase for both the moderately resistant and moderately susceptible checks, but not for the highly susceptible Frego-bract check (Figure 1). This increase and the obvious genotype by year interaction hinders the validity of comparing raw % dirty flower values of lines across years. To facilitate comparison of multiple years of data, the % dirty flower data were first normalized by the Frego-bract check (Figure 2). This normalization tended to lessen (i.e. smooth) variation between the other two cultivars over years. However, it did not account for the substantial increase in % dirty flowers that occurred in 2011 and 2012. This inability may be due to a scale effect since the values for the Frego-bract check was consistently high every year.

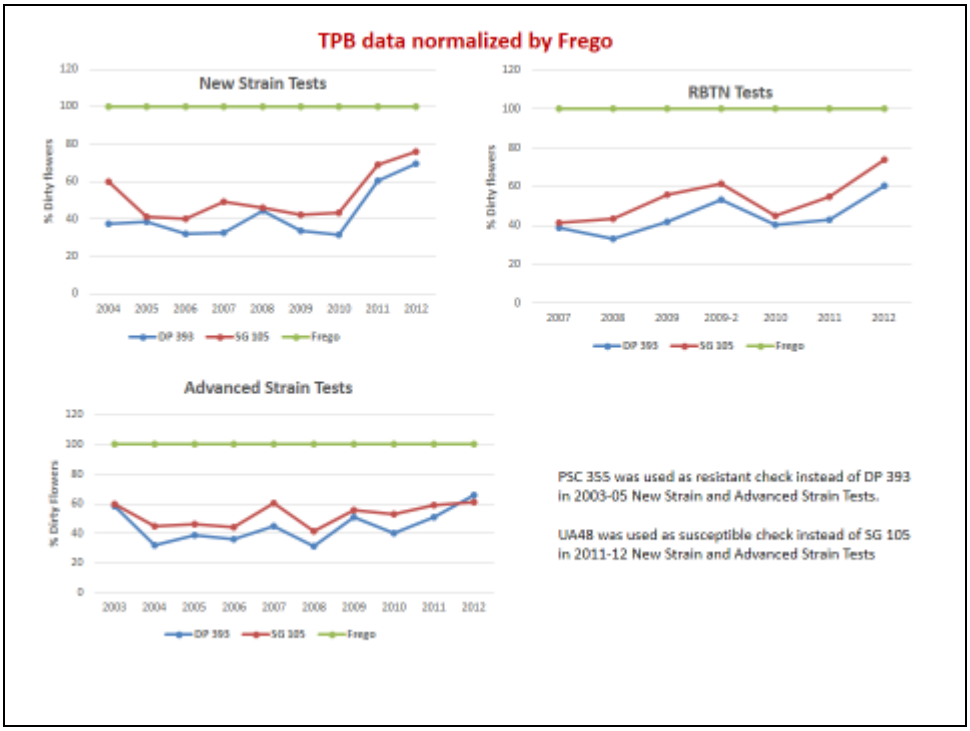

Figure 2. Percent dirty flowers in response to TPB for check cultivars in three tests at Keiser, AR, from 2003-2012 - normalized for highly susceptible Frego-bract check.

A second attempt to smooth the data was accomplished by normalizing the data by the moderately resistant check, DP393 or PSC355. This method appeared to provide relatively consistent values of the moderately susceptible check over years (Figure 3). The value for the Frego-bract check varies greatly with this normalization procedure. However, the relative normalized values for the Frego-bract check are not highly important since its relative susceptible is well-established, and may reflect the upper scale effect on this check. By decreasing the influence of years when TPB pressure is very high, a more reliable measure of TPB resistance over years may be attained. Yet, the best evaluation of TPB resistance is to compare lines that have been evaluated in the same tests over years. This is commonly done in the UA Cotton Breeding Program. Before a line is released, it is typically evaluated for TPB resistance for three years – one year as a New Strain and two years as an Advanced. Strain.

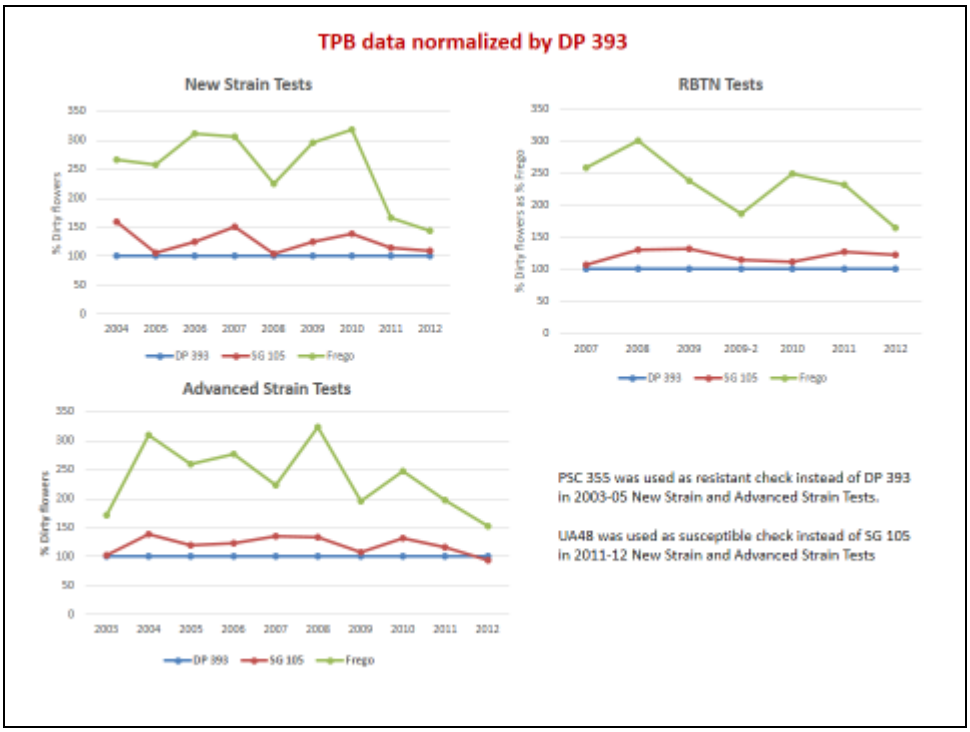

Figure 3. Percent dirty flowers in response to TPB for check cultivars in three tests at Keiser, AR, from 2003-2012 -- normalized for moderately resistant DP393 check.

TPB Resistance in UA Strains

In the University of Arkansas Cotton Breeding Program, 72 Preliminary Strains are evaluated in replicated tests at four locations each year. The best 18 of the Preliminary Strains are promoted and evaluated as New Strains for one year. Superior New Strains are promoted and evaluated as Advanced Strains for one or two years (Bourland, 2004, 2013). Since 2003, a total of 162 different New Strains have been evaluated for resistance to TPB. Only six of the 162 (3.7%) have been found to be more resistant than DP393; 86 (53%) have been equal to DP393; and 42 (26%) have been more resistant than SG105 (Table 2). Advanced Strains have shown slightly higher resistance than New Strains. Out of 180 lines tested, 15 (8.3%) have been more resistant than DP393; 112 (62.2%) have been equal to DP393; and 56 (31%) have been more resistant than SG105. This increase suggests that advance in TPB resistance is being made in this breeding program.

Table 2. Number of New and Advanced Strains in the University of Arkansas Cotton Breeding Program found to have greater or equal TPB resistance based on % dirty flowers compared to a moderately resistant check (DP393 PSC355 used in 2003-04) and a moderately susceptible check (SG105, UA48 used in 2011-12) cultivar.

Year	New Strains >DP393	New Strains =DP393	New Strains >SG105	Adv. Strains >DP393	Adv. Strains =DP393	Adv. Strains >SG105
2003	-	-	-	0	13	5
2004	0	9	8	0	11	4
2005	1	16	3	0	16	4
2006	1	4	4	9	9	17
2007	0	5	10	1	9	10
2008	2	15	3	0	12	4
2009	0	9	5	0	13	0
2010	0	0	0	0	8	8
2011	1	12	1	1	7	3
2012	1	16	8	4	14	1
Sum	6	86	42	15	112	56

Since 2005, 40 germplasm lines and three cultivars have been released from the UA Cotton Breeding Program (Bourland, 2013). TPB resistance of some of the early releases were evaluated for only two years, the rest were evaluated for three years. All of the released lines were more resistant than the highly susceptible Frego-bract check (Table 3). Twenty-two (51%) were more resistant than the moderately susceptible check, but only three lines were more resistant than the moderately resistant check. Twenty-four (56%) were at least equal to the resistant check, and all but one was at least equal to the moderately susceptible check. These data suggest that resistance to TPB is available in some of these line, but has not readily been achieved by selection in this program.

Table 3. Response to tarnished plant bug of lines released from the UA Cotton Breeding Program since 2005 in relationship to a moderately resistant check (PSC355 or DP393), a moderately susceptible check (SG105 or UA48), and a highly susceptible check (Frego-bract cotton).

Response	2005-08 Relative to PSC355	2005-08 Relative to SG105	2005-08 Relative to Frego-bract	2009-12 Relative to DP393	2009-12 Relative to SG105	2009-12 Relative to Frego-bract
Resistant	2	14	24	1	8	19
Equal	16	10	0	5	9	0
Susceptible	6	0	0	12	1	0

TPB Resistance in Cotton Cultivars

Cotton cultivars entered into the Arkansas Cotton Variety Test have been annually evaluated for resistance to TPB since 2006 (Table 1). Results of these annual tests are available at www.ArkansasVarietyTesting.com (under "Cotton Reports"). Comparison of these cultivars over years is difficult because the same cultivars are not evaluated each year, and the TPB intensity differs across years as indicated by variation in % dirty flowers (Figure 1). As suggested above, normalizing the data over years by a standard moderately resistant check appeared to provide better results than normalizing by the Frego-bract check. Unfortunately, DP393 was not included in the Main Variety Test in 2009, 2009 and 2012, and not in the 1st Year Variety Test in 2011 and 2012. To establish an estimate value for DP393 in these tests, % dirty flowers for DP393 from all available variety tests and the adjacent New Strain, Advanced Strain, and RBTN Tests were averaged. The DP393 mean % dirty flowers for 2007 through 2012 was 34.0, 25.8, 38.5, 36.2, 42.5, and 56.3, respectively.

When averaged over tests, the raw values of % dirty flowers varied from 36 to 59 (Table 4). Normalizing by the mean of DP393 may have exaggerated values since the calculated value for DP393 rose to 105%. Nevertheless, this normalizing method appears to have been effective for reducing yearly fluctuation in TPB intensity. The raw data and the two normalization methods produced similar cultivars in top and bottom of the lists. Based on these results, two relatively resistant cultivars (ST 5288 B2RF and SGS UA222) and two relatively susceptible cultivars (PHY 375WRF and AM UA48) were chosen for evaluation in a large plot study directed by Glenn Studebaker. Each two cultivar groups include a transgenic cultivar (with internal Bt toxin produced) and a conventional cultivar.

Table 4. Response to tarnished plant bug over years for cultivars in the 2012 Arkansas Cotton Variety Test. Response indicated by raw mean % dirty flowers and % dirty flowers expressed as percent of a moderately resistant check (DP393) and as a percent of a highly susceptible check (Frego-bract cotton).

Cultivar	Number of tests	% dirty flowers	% dirty, rank	% DP393[1]	% DP393, rank	% Frego	% Frego, rank
NG 5315 B2RF	2	37	4	72	1	43	4
DB 2610 B2RF	2	39	8	78	2	45	6
ST 5288 B2RF	5	32	1	79	3	38	1
AM 1511 B2RF	3	36	3	80	4	44	5
SGS UA222	3	36	2	81	5	43	3
CG 3787 B2RF	2	41	13	84	6	48	13
PHY 367 WRF	4	37	5	85	7	43	2
DG 2595 B2RF	3	39	9	86	8	47	10
DP 0912 B2RF	5	38	6	88	9	46	9
PX433915WRF	2	43	14	88	10	50	15
DP 0920 B2RF	4	40	10	93	11	46	8
AM 1550 B2RF	6	38	7	100	12	46	7
DP 1133 B2RF	3	45	16	100	13	54	17
PHY 499 WRF	3	46	17	103	14	56	19
DP 1219 B2RF	2	51	21	103	15	59	20
ST 5458 B2RF	7	41	12	104	16	47	12
PHX4339CB	2	51	23	104	17	60	21
DG 2570 B2RF	6	40	11	104	18	47	11
DP 393[2]	5	36	*2*	105	*19*	44	*5*
FM 1740 B2F	5	44	15	109	19	52	16
SGS UA103	2	50	20	109	20	61	22
DG 2450 B2RF	3	51	22	114	21	61	23
SGS HQ210	3	48	19	118	22	49	14
PHY 375 WRF	8	46	18	119	23	54	18
AM UA48	4	59	24	140	24	68	24

1/ DP393 was included in main test in 2007, 2010 and 2011; in the 1st year test in 2009, 2009, and 2010; and in the New Strain, Advanced Strain, and Regional Breeders' Network Tests each year (2007-2012). % dirty flowers for each cultivar is expressed as a percent of the average of DP393 in all tests within a year.
2/ Rank of DP393 is expressed in relation to the cultivars included in the 2012 Arkansas Cotton Variety Test.

Experience in 2013 Tests

The 2013 season was highly troublesome at Keiser. Wet conditions delayed planting of all tests. Planting of cotton variety, strain, and breeding tests were delayed until the last few days of May. Demand for the plot planter and subsequent rains delayed planting of the TPB tests until June 14. The plots achieved good stands, but plant development was subsequently slowed by cloudy conditions. Measureable rainfall was received on 12 of 14 days from July 31–August 13. Under these conditions, historic high TPB populations were experienced. Consequently, some lines produced very few flowers and appeared to have been mechanically stripped after defoliation (Figure 4).

Figure 4. TPB tests at Keiser, AR, in 2013 prior to any harvest, compared to a typical year.

High tarnished plant bug populations in these late-planted tests obviously overwhelmed square and flower development. At attempt to determine % dirty flowers was made using six daily examinations of the plots for white flowers. However, total flowers per plot (approximately 20 row-feet) over the six sample dates ranged from less than 1 to 21. After defoliation, the number of open and unopened, green bolls per 2m sample in each plot were counted, and evaluated for number of total bolls, number of open bolls, and % open bolls. Accumulative number of white flowers over the six days was the only measurement to have R-square to exceed 50% in each test (Table 5).

Table 5. R-squares associated with five measurements in five TPB tests at Keiser, AR, in 2013.

2013 TPB Test	% dirty flowers	No. flowers over 6 days	Total bolls per 2m	Open bolls per 2m	% open boll
Arkansas Variety Test	24.3	50.1	32.5	39.8	20.9
Regional High Quality	18.0	65.7	74.3	67.7	26.3
RBTN Test	22.0	66.7	27.0	23.5	20.7
New Strain Test	25.1	50.6	50.2	45.0	21.5
Advanced Strain Test	19.0	71.5	54.7	51.8	11.2

Total number of white flowers per 20-foot plot over 6 samples dates provided some indication of response to tarnished plant bug. Varieties deemed to have high and low resistance to TPB in previous tests produced the highest and lowest number of white flowers in 2013 (data not shown). However, variation among varieties between these extremes did not appear to be highly consistent with previous findings. This inconsistently may be related to non-discreet differences among the cultivars or to experimental difficulties experienced in 2013.

In the 2013 RBTN and Advanced Strain Tests, nectariless lines consistently produced relatively high numbers of white flowers (Table 6). One strain, Ark 0504-4 ne, was particularly outstanding in both tests, producing almost two and three times as many flowers as the second highest entry in the Advanced Strain and RBTN Tests, respectively. Whether the nectariless trait has been combined with an additional source of resistance in this strain will be determined in additional tests.

Table 6. Number of white flowers per plot over six sample dates for selected entries in the 2013 RBTN and Advanced Strain TPB Tests at Keiser.

RBTN Test - Strain	No. of flowers	Rank	Adv. Strain Test - Strain	No. of flowers	Rank
Ark 0504-4 ne	21.0	1	Ark 0504-4 ne	19.0	1
LA09309116	7.4	2	Ark 0517-28 ne	11.0	2
Ark 0506-47	6.8	3	Ark 0403-27 ne	8.3	3
MD25-26 ne	6.8	4	Ark 0403-3 ne	6.6	4
Ark 0517-32 ne	6.5	5	Ark 0506-47 ne	6.5	5
SG 105 check	6.5	5	Ark 0410-21 HG	5.6	6
DP 393 check	3.9	15	DP 393 check	3.7	11
Low of other 28	0.9	32-34	Low of other 14	1.1	20
Frego checks (2)	0.3	35-36	Frego check (2)	0.3	22-22
LSD0.10	2.1		LSD0.10	2.4	
R^2*100	66.7		R^2*100	71.5	

Conclusions

As the mechanisms of these differences are established, benefits of existing levels of resistance can be fully realized. Utilizing partial resistance to TPB should considerably reduce insecticide use and crop injury. A sound basis for relaxing TPB treatment thresholds might be established based on differential responses of cotton lines. Additional benefits would accrue as higher levels of resistance are identified. Based on our results above, we conclude:

1. Our methods for evaluating response of cotton genotypes to TPB in small plots were effectively used in 10 of 11 years.
2. Using these established methods and the dirty flower technique, genetic variation in response to TPB can be measured in small plots.
3. Nectariless and dense pubescence morphological traits confer some degree of TPB resistance, but similar levels can be found in some nectaried, glabrous types – suggesting different mechanisms of resistance.
4. Lessons from 2013: Very high TPB populations can eliminate flowers and measurement of % dirty flowers. If planting is done very late, TPB populations should be carefully monitored and controlled if needed.

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TPB, Small Plot Methods

Plant 4-row strips of Frego early, allowing space between strips for tests.
TPB should build up on Frego, then move out (or bleed) into tests as Frego matures.
Plant test with replications going down row, each plot equal distance from Frego.
At approximately peak flower, examine white flower for darkened anthers (tpb damage).

2004-2006

- 2 rows (20 feet) by 6 reps
- Examined up to 10 flowers per plot per day for about 6 days.
- Determined number of flowers with no damage, <50% damage (light), & >50% damage (heavy)
    - Anther damage = 100 * (((heavy*0.8) + (light*0.3)) / no. flowers)
    - % dirty flowers = 100 * ((heavy + light) / no. flowers)
    - Anther damage and % dirty flowers found to be highly correlated (r > 0.9)

2007-2012

- 1 row (20 feet) by 12 rep
- Examined up to 6 flowers per plot per day for about 6 days
- Determined number of flowers with any discolored anthers (damaged)
    - % dirty flowers = 100 * (no. damaged / no. flowers)

2013 – special circumstances

TPB Strain Tests -2004 through 2013

18 entries in New and Advanced Strain Tests were evaluated, along with two Frego bract (highly susceptible) checks and two cultivar checks. Checks:

Year	DP393	SG105	PSC355	UA48	LA85fg	RBCHfg
2004		x	x		x	x
2005		x	x		x	x
2006	x	x			x	x
2007	x	x				xx
2008	x	x				xx
2009	x	x				xx
2010	x	x				xx
2011	x			x		xx
2012	x			x		xx
2013	x			x		xx

Points:
Show means, ranges,
Consistency of check cultivars over years
Normalize data as "% of fg" to evaluate over years.

Does %fg for checks vary among years.
Have examined 180 different strains, 38 have been released
Show variation in released lines.

TPB Variety Tests -2006 through 2013 (no. of non-fg entries)

No. of entries:

Year	V1	V2	V3	V4	V6
2006	28	28	28	23	
2007	37	38		22	34
2008	30	20		20	34
2009	31	21		21	32
2010	32	23		22	34
2011	24	24		22	31
2012	20	20		20	33
2013	40			20	34