EFFECT OF BOLL WEEVIL ON THE YIELD AND FIBER QUALITY ON THE SOUTH PLAINS OF TEXAS

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Abstract

The cotton boll weevil *Anthonomus grandis* (Boheman) has caused significant economic losses to Texas High Plains cotton *Gossypium hirsutum* (L.) since population densities drastically increased over the last four years. During 1997 and 1998, a replicated field study was conducted at Lubbock, TX to: 1) determine if 28 cotton varieties adapted to Texas High Plains growing conditions, could tolerate high boll weevils densities in terms of yield and fiber quality; 2) determine the effect of high boll weevil infestations on fiber quality and 3) to improve techniques for the field evaluation of genetically altered cotton for boll weevil damage assessment. This study showed that failure to control boll weevil under high densities caused severe economic losses in lint yield, but did not reduce fiber quality components as measured by High Volume Indexing (HVI) analysis. None of the 17 commercial varieties or 11 mutant lines evaluated under heavy boll weevil infestation were found to have useful levels of tolerance based on yield and fiber quality. The split-plot design of multiple insecticide applications versus no-applications for the same varieties provided an economic screen for boll weevil damage assessment. Accounting for whole-plant insect densities, boll shed versus boll injury and increasing the number of replications should improve statistical outcome in the evaluation procedure.

Introduction

The cotton boll weevil *Anthonomus grandis* (Boheman) is a serious pest of cotton *Gossypium hirsutum* (L.) across the US causing the loss of nearly half a million bales in 1996 (Williams, 1997). It is estimated that this insect pest could reduce net farm income on the Texas High Plains by over $194 million annually (Anonymous, 1997). The potential economic loss across the region could approach $500 million. The Texas High Plains has historically not had serious problems with this pest because of a successful suppression program (Haldenby, 1992) and because the Texas High Plains did not serve as a conducive environment for overwintering (Rummel and Summy, 1997). The increased use of perennial grass as part of the conservation reserve program (Carroll et al., 1993) in combination with milder winters has led to increased resident boll weevil populations and damage (Bodden, 1997 and Rummel, et al., 1998).

The eradication program needed to control boll weevils on the Texas High Plains has an associated cost and strong proponents and opponents (Anonymous, 1997 and Bodden, 1997). Development of Texas High Plains varieties with high levels of tolerance or resistance could provide an efficient mechanism to reduce the damage caused by this insect pest. Earlier research on developing host plant resistance to boll weevils concentrated on measuring oviposition preference (Buford et al., 1967). This test was used to demonstrate genetic differences between lines such as ‘Seaberry Sea Island,’ which had lower levels of boll weevil oviposition (Buford et al., 1968). Subsequent research showed that there were only low levels of resistance available in commercial varieties (Lambert et al., 1980) and that only moderate levels of resistance could be found even in primitive race stocks of cotton (McCarty et al., 1982). Transferring this resistance into commercial cotton varieties was difficult since simultaneous selection had to be practiced for both insect tolerance and day-neutral growth habit (McCarty et al., 1987). The mechanism responsible for this type of resistance had not been fully described. Additional genetic studies showed that the okra-leaf and frego-bract traits had significantly fewer boll weevil feeding punctures and ovipositional scars compared to broad-leaf and normal-bract cotton (Pieters and Bird, 1977). This agreed with earlier research in which several cotton lines selected for resistance to boll weevils had the frego-bract trait (Jenkins et al., 1969). In recent years there has been increased interest in using molecular biology to develop transformed cotton lines carrying specific genes for boll weevil resistance (Greenplate et al., 1997). One of the most promising of these genes forms higher levels of the enzyme cholesterol oxidase in plants, which is reported to significantly reduce egg production in females and have larvicidal activity (Greenplate et al., 1995 and Purcell, et al., 1993).

Research at Texas Tech University in 1995 and 1996 screened chemically mutated cotton populations for potential sources of boll weevil tolerance (Auld et al., 1998). During 1997 and 1998, a study was conducted at Lubbock, Texas to: 1) determine if significant differences in boll weevil damage could be detected in 17 cotton varieties and 11 selected mutant lines adapted to the Texas High Plains; 2) determine the effect severe boll weevil infestations on fiber quality; and 3) to develop techniques to evaluate genetically enhanced populations for tolerance to boll weevils.

Seventeen commercial varieties and 11 mutant lines were planted in late May of 1997 and 1998 on the Texas Tech University Plant Stress Field Laboratory. Each plot consisted of two rows 5 m in length spaced 1 m apart. Furrow irrigation was used to supply approximately 300 mm and 380 mm of supplemental moisture in 1997 and

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1998, respectively. The study site received 2100 mm of natural precipitation in 1997 and 998 mm in 1998. Seven insecticide applications were made in 1997 and six in 1988 to control weevil in the treated plots (Table 1). In late November of each year, lint was harvested from 1 m of both rows in each plot and ginned. Fiber was evaluated at the Texas Tech University International Textile Center to determine fiber quality using High Volume Indexing. The experiment was conducted as a randomized completed block design with insecticide treatments as main plots and varieties/mutant lines as subplots. Data for all indices were subject to analyses of variance where insecticide treatment, varieties and insecticide treatment x varieties were compared using F tests (PC SAS, 1996). Yield and fiber quality means were separated using Fisher's Protected LSD Test at the 0.05 level of probability.

Results and Discussion

Insecticide application had a statistically significant effect on yield in 1997, fiber uniformity in 1997 and 1998, and fiber strength in 1997 (Table 2). Even in 1998 where statistical differences were not detected, average lint yield was reduced by 338 pounds per acre without boll weevil control (Table 3). Differences between varieties were highly significant for all indices except yield in 1997 (Table 2). All treatment X variety comparisons were not statistically significant.

In 1997, mean lint yield was significantly higher for insecticide treated entries (143 pounds) compared to identical entries with no insecticide applications (Table 3). The insecticide treated lines in 1998 averaged 338 pounds more lint compared to the untreated plots, however the coefficient of variation was 65.8%. No significant differences in lint yield were detected at least partially due to the 1998 drought, the additional application of irrigation water and extended warm weather. Boll weevil trapping (Fig 1.) shows that 1997 had greater initial weevil population, but with the warm temperatures of 1998, boll weevil activity was extended, possibly resulting in greater net boll damage. In an extended growing season, more immature bolls will make it to maturity with a longer period for boll weevils to infest them.

In most comparisons, uniformity and strength were higher for fiber harvested from varieties not treated with insecticide (Table 4). These differences were small and probably not economically significant. The slight improvements in fiber uniformity and strength may have been due to the increased availability of photo assimilates available for fiber formation in non-infested bolls in the untreated plots.

References

Anonymous. 1997. Assessment of the economic impact of the boll weevil in the Texas High Plains. Texas A&M University and Texas Tech University Special Report 97-1: 31.

Auld, D. L. M. D. Ethridge, J. K. Dever, and P. D. Dotray. 1998. Chemical mutagenesis as a tool in cotton improvement. Proc. Beltwide Cotton Conferences. p. 550-551. National Cotton Council, Memphis, TN.

Bodden, E. A. 1997. The spread and establishment of the cotton boll weevil in the Texas High Plains. M.S. Thesis. Texas Tech University.

Buford, W. T., J. N. Jenkins, and F. G. Maxwell. 1967. A laboratory technique to evaluate boll weevil oviposition preference among cotton lines. Crop Sci. 7: 579-581.

Buford, W. T., J. N. Jenkins, and F. G. Maxwell. 1968. A boll weevil oviposition suppression factor in cotton. Crop Sci. 8: 647-649.

Carroll, S. C., D. R. Rummel, and E. Segarra. 1993. Overwintering by the boll weevil, (C*oleoptera: Curculionidae*) in conservation reserve program grasses on the Texas High Plains. J. Econ. Entomol. 86: 382-393.

Greenplate, J. T., D.R. Corbin, and J. P. Pucell. 1997. Cholesterol oxidase: Potential boll weevil larvicidal and oostatic agent suitable for transgenic cotton development. Proc. Beltwide Cotton Conferences. p. 877-879. National Cotton Council, Memphis, TN.

Greenplate, J. T., N.B. Durk, J. C. Persheng and J. P. Parcell. 1995. Cholestrol oxidase: An oostatic and larvicidal agent active against the cotton boll weevil, *Anthonomus grandis*. Entomologia Experimtalis et Applicata74: 253-258.

Haldenby, R. K.. 1992. Keeping the High Plains free of boll weevil; a quiet success story; 28 years of containment. Proc. Beltwide Cotton Conferences. p. 713-714. National Cotton Council, Memphis, TN.

Jenkins, J. N., F. G. Maxwell, W. L. Parrot, and W. T. Buford. 1969. Resistance to boll weevil (*Anthonomus grandis* Boh.) oviposition in cotton. Crop Sci. 9: 369-372.

Lambert, L., J. N. Jenkens, W. L. Parrott, and J.C. McCarty. 1980. Evaluation of foreign and domestic cotton cultivars and strains for boll weevil resistance. Crop Sci. 20: 804-806.

McCarty, J. C., J. N. Jenkins, and W. L. Parott. 1982. Partial suppression of boll weevil oviposition by a primitive cotton. Crop Sci. 22: 490-492.

McCarty, J. C., J. N. Jenkins, and W. L. Parrott. 1987. Genetic resistance to boll weevil oviposition in primitive cotton. Crop Sci. 27: 263-264.

Parcell, J. P., et al. 1993. Cholesterol oxidase: A potential insecticide protein active against boll weevil larvae. Biochemical and Biophysical Research Comm. 196: 1406-1413.

Pieters, E. P., and L. S. Bird. 1977. Field studies of boll weevil resistant cotton lines processing the okra leaf-frego bract characteristics. Crop Sci. 17: 431-433.

Rummel, D. R., and K. R. Summy. 1977. Ecology of the boll weevil in the United States cottonbelt. Southwest Entomol. 22: 356-346.

Rummel, D. R., et al. 1998. Boll weevil management in the Texas High Plains. Plains Cotton Growers, Entomology Fact Sheet. Lubbock, TX. p. 7.

SAS Institute, Inc. 1996. SAS/STAS Users Guide, Version 6. 4th Ed. Cary, NC.

Williams, M. R., 1997. Cotton insect losses – 1979-1996. Proc. Beltwide Cotton Conference. P. 854-856. National Cotton Council, Memphis, TN.

Table 1. Insecticide applications applied for boll weevil control in 1997 and 1998 at Lubbock, Texas.

Application Date	Common Name	Chemical Name	Application Rate
1997:			
6/25	Oxamyl	Vydate C-LV	3.0
7/1	Oxamyl	Vydate C-LV	3.0
8/8	Oxamyl	Vydate C-LV	8.0
	Thiodicarb	Larvin	12.0
8/19	Lambda-cyhalothrin	Karate	3.2
8/22	Dicrotophos	Bidrin 8	8.0
8/29	Phosporodithioate	Guthion	16.0
9/3	Dicrotophos	Bidrin 8	8.0
1998:			
6/22	Oxamyl	Vydate C-LV	2.0
6/29	Oxamyl	Vydate C-LV	3.0
7/20	Oxamyl	Vydate C-LV	8.0
7/27	Lambda-cyhalothrin	Karate	3.2
8/3	Lambda-cyhalothrin	Karate	3.2
8/7	Oxamyl	Vydate C-LV	8.0

Table 2. Impact of boll weevils on lint yield and fiber quality of 28 varieties of cotton in 1997 and 1998 at Lubbock, Texas.

Year Indice	Spray Treatment 1997/1998	Variety 1997/1998	Trmt x Var 1997/1998
	--------------------Significance of F Value-----------		
Yield	**/ns	ns/*	ns/ns
Turn Out	ns/ns	**/**	ns/ns
Micronaire	ns/ns	**/**	ns/ns
Length	ns/ns	**/**	ns/ns
Uniformity	*/*	**/**	ns/ns
Strength	**/ns	**/**	ns/ns
Elongation	ns/ns	**/**	ns/ns

ns, *,**---non significant and significant at the 0.05 and 0.01 level of probability respectively

Table 3. Impact of boll weevil control on lint yield and turn out of 28 cotton varieties at Lubbock, Texas in 1997 and 1998.

Year Treatment	Lint Yield	Turn Out
	--lbs/acre--	--%--
1997:		
Sprayed	1017 a	37.6 a
Not-Sprayed	874 b	38.7 a
Loss	(-143)	(+1.1)
CV%	8.8	17.6
1998:		
Sprayed	1412 a	36.6 a
Not-Sprayed	1074 a	37.4 a
Loss	(-338)	(+0.8)
CV%	65.8%	9.3%

† means not followed by the same letters differ by F values at 0.05 level of probability

Table 4. Impact of boll weevil control on fiber quality of 28 varieties of cotton at Lubbock, Texas in 1997 and 1998.

Year Treatment	Uniformity	Strength
	--%--	g/tex
1997:		
Sprayed	79.7 b†	33.5 a†
Not-Sprayed	80.5 a	33.0 b
Loss	(+0.8)	(-0.5)
CV%	1.2%	0.8%
1998:		
Sprayed	83.1 b†	30.2 a†
Not-Sprayed	83.4 a	29.1 a
Loss	(+0.3)	(-1.1)
CV%	0.4%	8.7%

† means not followed by the same letters differ by F values at 0.05 level of probability

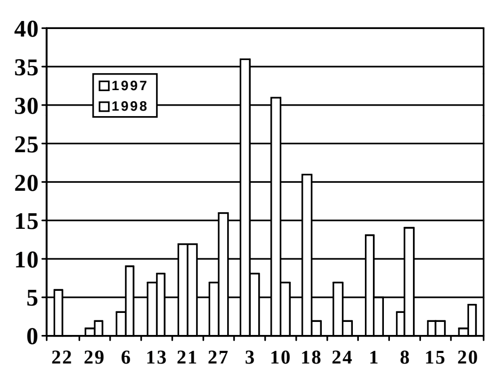

Figure 1. Boll weevil trap counts at the Texas Tech University farm at Lubbock, Texas during 1997 and 1998.