ECONOMIC EVALUATION OF CULTIVAR, ROW SPACING, AND INSECTICIDES FOR BOLL WEEVIL MANAGEMENT

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Abstract

A full-season, threshold-based insecticide control program, primarily for boll weevils, *Anthonomus grandis grandis* Boheman, was compared to no insecticide control in irrigated cotton in the northern Texas Rolling Plains from 1993 to 1995. These two insecticide-use options were compared in three cotton varieties (Paymaster HS-26, TAMCOT HQ95, All-Tex Quickie) and two row spacings (30" and 40"). Cotton was planted in late April - early May each year. Net returns per acre were calculated for each treatment and used to determine the most cost-effective chemical and row spacing management option for each cultivar. Of the 29 insecticide applications for thrips, boll weevils, bollworms, *Helicoverpa zea* (Boddie), and cotton aphids, *Aphis gossypii* Glover, during the 3-year study, 23 (79%) were for management of boll weevils. Boll weevil damage was lowest in HS-26 in the 30" spacing and in Quickie in the 40" spacing; these cultivars produced fewer squares, and received less boll weevil damage, in these two row spacings, respectively, than did the other two cultivars. Average yields were higher in treated plots, but average net income was higher in untreated cotton. In the 30" row spacing, highest net return was obtained from untreated Quickie ($65.22/acre), while in the 40" row spacing, highest net return was obtained in treated HS-26 ($70.63/acre). In all other comparisons between treated and untreated cultivars, net returns were numerically higher in untreated plots. Insecticidal control of boll weevils should be tailored to the cultivar and row spacing utilized.

Introduction

The boll weevil, *Anthonomus grandis grandis* Boheman, is the key insect pest of cotton in the Texas Rolling Plains. Even though utilization of delayed, uniform planting has been adopted by a majority of cotton producers in the Rolling Plains for boll weevil management, there are indications that the percentage of producers using this control technique is beginning to decline. Fuchs et at. (1998) provided the following reasons for this decline. There has been a shift in choice of cotton varieties from short-season, early maturing types to more indeterminate types in an effort to achieve higher yields. Seasonal precipitation patterns have changed in recent years; historically the probability of receiving rainfall amounts exceeding 2" was only 1-2% from late May to early July, the preferred delayed, uniform planting period. Since 1979, the probability has increased to about 23% in late May. Excessive rainfall during late May often delays planting into June. The only real option is to plant earlier, rather than later, because yields are very low when cotton is planted after mid-June.

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Planting in late April or early May in the Rolling Plains lengthens the growing season and increases boll weevil populations and damage (Slosser 1978); thus, crop production strategies are needed to hasten the onset and rapidity of fruit set. Niles et al. (1978) reviewed various mechanisms to hasten crop maturity, and among the options given were the use of rapid fruiting, determinate varieties and narrow-row spacing. When planting early, mechanisms which advance plant maturity allow the crop to escape, or avoid, high weevil population levels in late August and early September. Walker and Niles (1971) demonstrated that rapid fruiting cultivars set an acceptable fruit load before weevil populations reach levels that will reduce yields, and early crop maturity enables earlier harvest and crop destruction, which reduces the food supply (squares and small bolls) required by boll weevils to enter diapause and successfully overwinter. Walker et al. (1976) and Parker et al. (1980) subsequently demonstrated that yields and net income could be increased by planting early-maturing varieties in narrow-row spacings (25-27"). Little research has been conducted on cotton planted prior to late May in the Rolling Plains; therefore, the primary goals of the research reported herein were to evaluate the economics of boll weevil management in early-planted, irrigated cotton as influenced by cultivar and row spacing in the Texas Rolling Plains.

Materials and Methods

The study was conducted at the Texas Agricultural Experiment Station at Munday from 1993 to 1995. Cotton was irrigated twice in 1993; five times (includes one irrigation prior to planting) in 1994, and twice (includes one irrigation immediately after planting) in 1995. Total amount of irrigation water plus rainfall during June - August was 15.6, 20.12, and 20.9" for 1993, 1994, and 1995, respectively. Trifluralin (Treflan E.C. [Emulsifiable Concentrate], DowElanco, Indianapolis, IN) was applied for weed control prior to planting at 1.5 pt./acre. Fertilizer (50-25-0 lb./acre of N-P-K, respectively) was applied immediately before planting on 26 April 1993, 25 April 1994, and 25 April 1995. A poor stand necessitated replanting on 11 May 1995. Planter settings were chosen to drop, as closely as possible, the same number of seeds per acre. This resulted in seeding rates of 4.7 seeds/ft and 5.9 seeds/ft in the 30" and 40" spacings, respectively.

A randomized complete block design with a split plot treatment arrangement and three replications was employed each year. Whole plots were row spacings of 30" and 40".

Cotton cultivars and insecticide treatments were randomized subplots within row spacings. The three cotton cultivars were Paymaster HS-26, TAMCOT HQ95, and All-Tex Quickie; HQ95 and Quickie are classed as relatively fast maturing while HS-26 is a slower, more indeterminate cotton (Gannaway et al. 1996). The two insecticide treatments for each cultivar included an untreated check and an appropriate insecticide application for any pest that reached its damage threshold, as provided by Texas Agricultural Extension Service guidelines (Fuchs et al. 1993).

Pests requiring insecticidal control included thrips, a complex of 15 species of which the western flower thrips, *Frankliniella occidentalis* (Pergande), is dominant in this area (Karner & Cole 1992), bollworms, *Helicoverpa zea* (Boddie), cotton aphids, *Aphis gossypii* Glover, and boll weevils. Thrips and boll weevils were controlled with azinphos-methyl (Guthion 2L [Emulsifiable Liquid], Mobay, Kansas City, MO) at 0.125 and 0.25 lb.[AI]/acre, respectively. Cypermethrin (Ammo 2.5 EC [Emulsifiable Concentrate], FMC, Philadelphia, PA) at 0.04 lb.[AI]/acre was used to control bollworms or a combination of bollworms and boll weevils. Carbofuran (Furadan 4F [Flowable], FMC, Philadelphia, PA) at 0.25 lb.[AI]/acre was used to control cotton aphids in 1993 and 1994, while dicrotophos (Bidrin 8 [Water Miscible], Du Pont, Wilmington, DE) at 0.50 lb.[AI]/acre and endosulfan (Thiodan 3 EC [Emulsifiable Concentrate], FMC, Philadelphia, PA) at 01.50 lb.[AI]/acre were used in 1995.

Early season pests, those from plant emergence to development of 1/4" diameter squares, included thrips, cotton fleahoppers, and overwintered boll weevils. These three pests were sampled only in the designated untreated plots of each cotton cultivar and only in the 40" row spacing. Mid- and late season pests included boll weevils, bollworms, and cotton aphids. Sampling for boll weevils and bollworms began after the first, 1/4" diameter squares appeared on the plants. Samples were taken at weekly intervals from 8 July to 16 August, 1993 (n=7); from 19 July to 16 August, 1994 (n=6); and from 10 July to 29 August, 1995 (n=8). All plants in 6.5 ft of row at 2 locations per plot were examined for boll weevils, bollworms, and their damage, to squares and bolls, through 12 July, 1993, 1 August, 1994, and 31 July, 1995. After these dates, sample size was reduced to one, 6.5 ft sample per plot. Total numbers of squares $\geq$1/4" diameter (1/3-grown) and soft bolls $\leq$1" diameter (these are the age classes most susceptible to bollworm and boll weevil damage) were determined in addition to damage to these fruiting forms caused by bollworms and boll weevils. Sampling was discontinued each year when plants reached cut-out stage as indicated by few squares and soft bolls remaining on the plants. Cotton aphids were sampled when numbers became noticeable after early August. Aphids were counted on 10 leaves picked from the top-half and on 10 leaves from the bottom-half of the plant; sample size was reduced to 5 top-half and 5 bottom-half leaves when aphid numbers became too numerous to count individually. Data were summarized immediately to determine need for insect control, and, if required, insecticides were applied within 24 hours.

Plant growth was chemically terminated about 2 weeks prior to harvest each year. A mixture of tribufos (DEF 6 [Emulsifiable Concentrate], Mobay, Kansas City, MO) at 0.75 lb.[AI]/acre and ethephon (Prep 6 [Liquid Concentrate], Rhone-Poulenc, Research Triangle Park, NC) at 1.0 lb.[AI]/acre was applied in 1993 and 1995. A mixture of ammonium sulfate, at 0.50 lb./acre, and paraquat (Cyclone 2 [Soluble Concentrate], ICI Americas, Wilmington, DE) at 0.375 lb.[AI]/acre was used in 1994. Seed cotton was hand-picked from 13 ft. of row in two locations in each plot each year. Seed cotton was ginned and lint quality was determined at the International Textile Research Center, Texas Tech University, Lubbock, TX.

An enterprise budget (Bevers et al. 1995) was created for each treatment plot each year. Net income per acre was calculated by determining the gross income for each treatment and then subtracting actual costs, or typical costs, associated with each production practice. The quality-adjusted loan rate was used for the market price. The average annual Texas cottonseed price for each year of the study was used to determine cottonseed income (Texas Agricultural Statistics Service 1997). Tillage operations were recorded each year and were used to calculate fuel requirements. Average Texas fuel prices were used to determine fuel costs (National Agricultural Statistics Service 1997). Interest costs were calculated at 9.5 percent. Irrigation costs were calculated to be $6.03/ acre-inch of water for the furrow irrigation system used. Costs of each chemical product used in the test were obtained from local retailers, and aerial application costs were based on a charge of $3.00/acre. Fixed costs were based on a 1000 acre farm with a machinery investment at market value of $288,500. Depreciation and repairs were calculated based on this equipment investment. Cash rent cost of $45.00/acre was added. In addition, it was assumed that the operation must contribute $15,000 per year for the farm's withdrawals (family living and farm overhead expenses); this cost equaled $15.00/acre. Total fixed costs were allocated at 10 percent.

Data for boll weevil damage and square and boll counts were averaged over all sampling weeks for analysis. These averages and the values for yield and net income were analyzed by an analysis of variance for a split-plot experiment arranged as randomized complete blocks with three replications. Mean squares and F-ratios were calculated as defined by McIntosh (1983) for experiments combined over years. Analyses (MSTAT Development Team 1988) were performed using the FACTOR and RANGE programs of MSTAT-C. Means were separated using protected least significant difference (LSD, $\alpha = 0.05$ or 0.10).

Results and Discussion

Boll weevils were the primary target of insect control in this study (Table 1). Of the 29 total insecticide applications, 79% were for boll weevils, which included 5 applications for overwintered weevils, 16 for weevils after 1/3-grown squares appeared, and 2 for a combination of weevils and bollworms. Insecticides were required for boll weevil management throughout the growing season, with applications from 25 June to 19 August, 1993; from 21 June to 9 August, 1994; and from 27 June to 5 September, 1995.

Square numbers were significantly higher in the narrow, 30" rows than in the standard, 40" rows (Table 2). Percentage of boll weevil punctured squares was numerically higher in the 30" rows than in the 40" rows, but differences were not statistically significant. Seasonal average numbers of 1/3-grown squares and percentage boll weevil damage did not differ among varieties. Numbers of squares were significantly higher in treated plots than in untreated plots, while percentage punctured squares was significantly lower in treated plots than in untreated plots (Table 2).

In the 30" row spacing, boll weevil damage to squares plus soft bolls was significantly higher in HQ95 and Quickie compared to damage in HS-26. However, in 40" row spacings, damage was significantly lower in Quickie compared to damage levels in HS-26 and HQ95. This result indicates that cultivar performance should be evaluated in several row spacings, and recommendations regarding row spacings should be based on individual cultivar performance.

In 30" row spacings, highest yields were obtained in treated plots of HQ95 and HS-26, and lowest yields were obtained in untreated plots of these two cultivars. Yields in treated and untreated Quickie were equivalent. In the 30" spacing, the highest net return ($65.22/acre) was obtained in untreated Quickie, which was significantly greater than the net return ($-8.36/acre) obtained in treated Quickie. Net returns were statistically equivalent in treated and untreated plots of HQ95 and HS-26, but numerically, returns were lower in all treated plots, compared to untreated plots, in the 30" row spacing.

In the 40" row spacing, highest yield (742 lb/acre) and net return ($70.63/acre) were obtained in treated plots of HS-26 (Table 5). The lowest yields were obtained in Quickie, and both treated ($-59.82/acre) and untreated ($-23.24/acre) plots of this cultivar produced a negative income response. While treated and untreated plots of HQ95 produced statistically equivalent yields, the treated plots ($-46.91/acre) gave a significantly lower net income than untreated plots ($67.71/acre) due to cost differences.

Summary

Insecticide usage for boll weevil control can be optimized by judicious pairing of cultivars with row spacing. Management recommendations for row spacing and boll weevil control need to be tailored to each cultivar. For example, the only positive net returns for Quickie occurred when it was planted in a 30" row spacing. A full-season boll weevil control program may have been cost effective in 30" row spacings, but not in the 40" row spacings, for HQ95. Positive net returns were obtained for HS-26 in both row spacings and insecticide treatments, but the data indicate that HS-26 performed best under a full-season boll weevil control program in the 40" row spacing. Matching the performance of cotton varieties with appropriate row spacings can optimize the value of insecticidal use for boll weevil management.

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Table 1. Total number of insecticide applications, Munday, TX. 1993-95.

Pest	Number of Applications	Percentage of Total
Thrips	1	3.4
Cotton Fleahopper	0	0
Boll Weevil	21	72.4
Bollworm	2	6.9
Cotton Aphid	5	17.2
Total	29	100

Table 2. Influence of row spacing, cultivar, and insecticides on numbers of squares and boll weevil damage, Munday, TX. 1993-95.

Treatment	Squares/Acre	% Weevil Punctures
Row Spacing		
30"	98.1 a	27.1 a
40"	85.3 b	26.2 a
Cultivar		
HS-26	90.8 a	31.1 a
HQ95	92.9 a	34.1 a
Quickie	91.4 a	32.6 a
Insecticide		
Untreated	88.3 b	28.5 a
Treated	95.1 a	24.9 b

Values are compared within row spacing, cultivar, and insecticide treatment; values with a common letter are not significantly different (P>0.05).

Table 3. Influence of row spacing by cultivar interaction on average amount of boll weevil damage, Munday, TX. 1993-95.

	Damaged Squares + Bolls (1000's)	
Cultivar	30" Spacing	40" Spacing
HS-26	31.4 b	33.5 a
HQ95	36.6 a	32.9 a
Quickie	38.1 a	27.3 b

Cultivars are compared within row spacing, and values with a common letter are not significantly different (P>0.05).

Table 4. Influence of cultivar and insecticide treatment on yield and net income in 30" row spacings, Munday, TX. 1993-95.

Treatment	lb. lint per acre	$ per acre
Quickie		
Untreated	599 ab	65.22 a
Treated	604 ab	-8.36 b
HQ95		
Untreated	547 b	36.17 ab
Treated	663 a	20.20 ab
HS-26		
Untreated	530 b	19.87 ab
Treated	667 a	10.19 ab

Insecticide treatments are compared within cultivars, and values with a common letter are not significantly different (P>0.05).

Table 5. Influence of cultivar and insecticide treatment on yield and net income in 40" row spacings, Munday, TX. 1993-95.

Treatment	lb. lint per acre	$ per acre
Quickie		
Untreated	422 c	-23.24 bc
Treated	499 bc	-59.82 c
HQ95		
Untreated	600 b	67.71 a
Treated	532 bc	-46.91 c
HS-26		
Untreated	526 bc	15.76 ab
Treated	742 a	70.63 a

Insecticide treatments are compared within cultivars, and values with a common letter are not significantly different (P>0.05).