2002 BELTWIDE COTTON CONFERENCES, ATLANTA, GA – JANUARY 8-12

INTERPLANTING OF ALTERNATIVE HOST PLANTS FOR ENHANCING LEPIDOPTERA IN COTTON

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Abstract

Velvetleaf (*Abutilon theophrasti* Medikus) and/or garbanzo beans (*Cicer arietinum* L.) plants were interplanted into cotton with the aim of attracting more lepidopterous pests into research plots. The use of velvetleaf proved to be effective in obtaining more *Heliothis virescens* (F.) and *Trichoplusia ni* (Hübner) pressure on cotton plants but since pests such as whiteflies and bugs were more abundant on these plants, there is a potential detrimental effect of attracting undesirable insects to experimental trials. Garbanzo beans attracted high numbers of *Heliothis virescens* and *Spodoptera exigua* (Hübner) and low numbers of *Trichoplusia ni*. Experimental cotton plots interplanted with velvetleaf and garbanzo beans attracted the whole worm spectrum described before, while not lowering yields when compared to cotton alone, but still had the potential of creating a good environment for undesirable insect species. Cotton interplanted with garbanzo beans appears to be the best of these methods for increasing larval pressure in research plots because attracts high numbers and diverse species of Lepidoptera, but it does not lower seed cotton production.

Introduction

Experimental trials to test the effectiveness of insecticides against particular pests on cotton are difficult to conduct due to the uncertainties of the insect pest pressure, particularly from those that are sporadic (e.g. armyworms). To perform those tests under reliable pest pressure, we must create experimental conditions suitable for the development of high natural pest populations but at the same time, those practices must reflect common agronomic conditions in order to obtain meaningful results. Natural and abundant pest incidence assures us opportunities to test our treatments under natural conditions, which most directly reflect the performance of insecticides under typical field situations.

Velvetleaf (*Abutilon theophrasti* Medikus), a plant considered a weed in cotton fields, is well known for its susceptibility to *Heliothis* and *Helicoverpa* attack (Hendricks 1992, Schneider et al. 1989, Navasero and Ramaswamy 1991). It has also been observed that whiteflies (Headrick et al. 1997) and a scentless plant bug (Patterson et al. 1987, Spencer 1988) are attracted to this plant. On the other hand, garbanzo beans (also known as chickpeas, *Cicer arietinum* L.), an important agronomic crop in several parts of the world, is believed to have few insects that feed on it, being the most important *Heliothis* spp. (Shaver and Lopez 1996, Reed et al. 1980) and *Helicoverpa armigera* (Hübner) (Ramnath et al. 1992). This plant is often highly defoliated by armyworms (primarily *Spodoptera exigua* (Hübner)) in Mexico and the US (Blanco, personal observation).

We interplanted velvetleaf and garbanzo beans with cotton to find out if their presence could enhance moth oviposition and therefore create higher insect pressure on cotton for conducting insecticide efficacy experiments.

Materials and Methods

Cotton (*Gossypium hirsutum* L) variety DP436RR (glyphosate-resistant) grown on sandy loam soil in a research farm in Waller, Texas was maintained under normal local agronomic conditions to conduct Tests 1-3. In both years (2000 and 2001), study fields consisting of 60 rows (40 inches row centers) by 132 feet in length, with a 20 foot space between replications 2 and 3, and actual plots of 25 feet long replicated four times, received a split application of fertilizer (4-11-11 ground incorporated at planting on both years) and a foliar application (32-0-0) 40 d later in 2000 only. Aldicarb at 1.19 lb ai/A was incorporated at planting both years.

Test 1

In 2000, two cotton fields separated by 66 feet were used to compare the influence of velvetleaf interplanted with cotton on tobacco budworm (TBW), *Heliothis virescens* (F.), incidence. The interplanted field was seeded with velvetleaf the same day of cotton planting (131 day of year [DOY]), obtaining an average stand of 0.15 plants per row-foot, while the cotton plant density in both fields was 2.25 plants/ft. Velvetleaf seed was obtained from a commercial distributor. The rest of the plants not involved in this study (weeds) in the interplanted field were removed by hand, except carpetweed (*Mollugo verticillata* L.) due to the difficulty of controlling it by this method. In the field with cotton only, weed control was achieved with one

application of glyphosate at 0.75 lb ai/A. Evaluations were made by removing and inspecting 50 randomly selected cotton plants per field at different dates to determine TBW population levels in both treatments, recording also the number of fruiting structures per plant and the weight of the lowest boll before opening (DOY 216). A paired t-test was used to analyze for the differences.

Test 2

A field in 2001, planted on DOY 113, was interplanted with velvetleaf and garbanzo beans at a density of 1.27 and 1.39 plants per row-foot, respectively, with a cotton plant density of 2.25 plants/ft. On DOY 159, when the cotton plants had achieved 5th-true leaf stage, glyphosate herbicide (0.75 lb ai/A) was broadcasted to control all the plants in one of every 3 rows, leaving a pure stand of cotton. Garbanzo bean seed was obtained from a commercial source. On DOY 171 (pre-blooming, 12th internode), one of every two of the untreated interplanted rows was treated with glyphosate (post-directed application) again in order to kill the established plants, except cotton. Velvetleaf was hand weeded due to its height, and pulled plants were left within the rows. What remained was a row of cotton and dying plants that later will be called "late weed control" in the text. The rows maintained as a pure cotton stand are referred to as "monoculture" and the rows without weed control are called "interplanted" in this study. The plants on the rows treated on DOY 171 were killed in order to "force" the insect population established on velvetleaf and garbanzo beans to disperse into the cotton plants. The interplanted rows contained an infestation of carpetweed plants at the time that the evaluations were made, but no pests of interest were found on these. Ten randomly selected cotton plants per replication on each of the three treatments were removed and inspected (data not included), as well as sweeping with a net (15.3" diameter) 100 times for each sample on different rows per treatment per replication. Data were analyzed by analysis of variance (ANOVA) and when F-values were significant ($P<0.05$), means were separated using Tukey test with $\alpha= 0.05$.

Test 3

A field in 2001 was planted and interplanted with velvetleaf and garbanzo beans on DOY 113, obtaining a final density of 1.27 and 1.39 plants per row-foot, respectively, and a cotton density of 2.25 plants/ft. The field was divided into 6 plots of 6 rows each 25 feet long and replicated 4 times. Treatments described on Table 3 were arranged in a randomized complete block design. In order to achieve the plant diversity necessary for this test, plots were hand-weeded on DOY 141, 148 and 159. All the plots had an infestation of carpetweed not controlled by hand weeding. Evaluations in this test were made by removing 10 cotton plants per plot and inspecting them for insect presence and damage. Cotton yields were obtained by hand harvesting rows 3 and 4 per plot on DOY 261. Data were analyzed by analysis of variance (ANOVA) and when F-values were significant ($P<0.05$), means were separated using Tukey test ($\alpha= 0.05$).

Test 4

In 2001 in another research area, located on the Texas A&M University farm close to College Station, Texas, 40 rows of cotton (variety DP436RR, 40" centers and 750 feet in length) were planted on 3 different dates and seeded with garbanzo beans at planting, with the same undetermined variety of Tests 2 and 3, on rows 13, 14, 27 and 28, achieving a final cotton plant density of 1.29, 2.25, and 2.21 plants per row-foot for the early (seeded on DOY 106), intermediate (DOY 134), and late planting (DOY 149), respectively. The terms "early", "intermediate" and "late" will be used to refer to these plantings later in the text. The garbanzo bean plant density when the evaluations started (DOY 194), coinciding with high tobacco budworm oviposition, was 0.3, 1.38, and 0.78 plants per row-foot for early, intermediate and late planting, respectively.

Evaluations to asses "the garbanzo and cotton developmental effect" in this test were made by removing 10 cotton plants on each of the rows 13, 14, 27, and 28 (interplanted with garbanzo) and 10 plants on each of the rows 6, 7, 34, and 35 (pure stand cotton) for each planting. Plants were inspected for insect presence and damage as well as phenological stage. Yields of the rows described above were obtained by hand harvesting. Data were analyzed by analysis of variance and when F-values were significant ($P<0.05$), means were separated performing a Tukey test ($\alpha=0.05$).

Results and Discussion

Test 1

In this test, a significantly higher number of tobacco budworm larvae on cotton interplanted with velvetleaf than on cotton grown as monoculture was observed on only one date (Table 1). On DOY 193, interplanted cotton had numbers of larvae per plant above the economic threshold recommended in Texas ($\geq$ 5,000 larvae per acre). The higher number of budworms in interplanted cotton might be also reflected in the higher number of damaged squares, terminals and bolls found on the different evaluation dates.

Test 2

Results of this test, planned to find a way to "force" the larvae feeding on velvetleaf or garbanzo beans to feed on cotton plants, can be divided into 2 major parts: The first part relates to insect numbers before they were "forced" to move into

cotton. Data shown on evaluation DOY 169 (Table 2) compare one row of cotton grown as monoculture with 2 rows interplanted with the above mentioned plants (late weed control and interplanted). Although not all the densities of insect species were significantly different among these 2 plant diversity scenarios, greater numbers of budworms and beet armyworms (*Spodoptera exigua* Hübner) were present on interplanted cotton rows. Since this evaluation was made with a sweep net, only those larvae from the monoculture rows can be said to have come from cotton plants alone. It is well known that velvetleaf attracts tobacco budworms, but we were not able to find beet armyworms feeding on this plant neither in this study nor in study Test 3. Therefore, beet armyworms must have come only from cotton, since garbanzo beans were not swept due to their low height. The second part relates to insect numbers after they were "forced" to move to cotton. Although the population of some species was high when we initiated this test, numbers greatly diminished throughout the test. The beet armyworm population crashed making it impossible to find out if these insects were susceptible to switch from garbanzo beans to cotton. The saltmarsh caterpillars, *Estigmene acrea* Drury, although also declining in numbers, did not show any indication of increasing their numbers on cotton. This might be due in part to the fact that these insects were found already on cotton plants and very few on the other 2 plant species. Cabbage loopers, *Trichoplusia ni* Hübner, demonstrated a "switch" from velvetleaf and garbanzo beans to cotton. These insects were found mostly on velvetleaf on previous evaluations, and after this plant was pulled from interplanted rows (late weed control), some of those insects were swept from cotton plants on DOY 177. Higher numbers of cabbage loopers were obtained from the interplanted rows because these plants were swept together with cotton. The switch of tobacco budworm from velvetleaf and garbanzo beans to cotton is more difficult to document and explain. At the moment of the initiation of the test, large numbers of this insect were found, but they were at an advanced larval stage ($\geq$ third instar). If they really made the change from the preferred plants to cotton, they must have moved to feed on large cotton squares and bolls due to their feeding habits. Since these fruiting structures were lower in the cotton canopy at the time of the evaluation, sweeps with the net might have missed them; therefore, capturing low numbers of budworms and not offering a clear picture of their behavior. In addition, since these insects feed on flowers and seeds of velvetleaf and these plants were swept while evaluating the interplanted rows, many tobacco budworms were captured by this method. We believe the majority of them came from velvetleaf. In this test, we were able to see only a clear "switch" of the cabbage looper from alternative plants into cotton.

Test 3

Determining the effect of interplanting velvetleaf and/or garbanzo beans on insect numbers on cotton plants was the main objective of this test. Results shown on Table 3 describe the numbers of larvae present on cotton plants at the time of the evaluations, and these data can be divided by insect species: **a)** Tobacco budworms had the tendency for higher numbers on cotton plants mixed with garbanzo beans, although not significantly different on all the evaluation dates. Cotton with velvetleaf did not show this pattern. This suggests that garbanzo plants have a greater potential to bring tobacco budworms into research plots than velvetleaf. **b)** Beet armyworms also showed a higher preference for plots interplanted with garbanzo beans. These armyworms, although not found on velvetleaf while making individual plant inspections, induced heavy defoliation on garbanzo beans in this study, supporting the finding that cotton interplanted with garbanzo could be more "attractive" to the beet armyworm. **c)** Cabbage loopers were higher on cotton plants interplanted with velvetleaf than those cotton plants grown alone or with garbanzo beans. This insect was observed feeding on velvetleaf while doing individual plant inspections. **d)** The saltmarsh caterpillar did not show any preference for the addition of any alternative plant to the research plots, except on one evaluation date (DOY 191) when in one replication a recently hatched egg mass was found on one cotton plant, making those numbers higher than what they were observed throughout the field.

The major findings of this test were the preference of the tobacco budworm and the beet armyworm for those cotton plants grown together with garbanzo beans and the cabbage looper preference for those cotton plants interplanted with velvetleaf. In addition, by analyzing the yield results, it can be observed that the presence of garbanzo beans in the plots did not significantly affect yield as compared to velvetleaf. The number of squares and bolls in all the treatments were not significantly different (data not included), therefore, the significant difference in yield between interplanting garbanzo beans or velvetleaf with cotton might be explained by the plant competition between velvetleaf and cotton or the added nitrogen fixed by garbanzo beans. This last consideration is also important in selecting one of these plants to interplant with cotton.

Test 4

Determining the effect of garbanzo beans interplanted with cotton for enhancing lepidopterous pests on cotton research plots was the main objective of this test. On the 3 different developmental stages of cotton, tobacco budworm presence on garbanzo plants was very high (data not included). No differences were found on insect oviposition or presence of larvae on cotton plants (Table 4). Some differences were found between planting dates but not between interplanted and monoculture. A partial explanation of this can be that the density of garbanzo bean plants of some of the planting dates (early and late) was lower than the density of Tests 2 and 3; therefore, attraction of the tobacco budworm could be directly related to the density of garbanzo bean plants in the field.

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Table 1. Mean plant damage and tobacco budworm (*Heliothis virescens*) incidence per 50 cotton plants grown as monoculture and interplanted with velvetleaf.

	Cotton	Cotton + Velvetleaf
Day of year 158		
Eggs	13	18
Larvae	4	7
Damaged squares	9	13
Damaged terminals	6	8
DOY 172		
Eggs	3	7
Larvae	1	4
Damaged squares	11	21
Damaged terminals	12	14
DOY 193		
Eggs	0	1
Larvae	2*	16*
Damaged squares	18*	68*
Damaged terminals	2	7
Damaged bolls	11*	25*
DOY 205		
Larvae	0	1
Damaged squares	6	5
Damaged terminals	8	14
Damaged bolls	1*	8*
Weight of 50 bolls (grams)	745	779

*Significantly different at α=0.05 by T-test.

Table 2. Mean number of larvae per 100 sweeps on cotton plants grown under different plant diversity.

	TBW[a]	SMC[a]	CL[a]	BAW[a]
Larvae on day of year 169				
Monoculture	1.0 b	9	0.0 b	22
Late weed control	14.3 a	11	1.0 b	83
Intercropping	13.5 a	9	3.0 a	85.3
Larvae on DOY 177				
Monoculture	0.3	2	0.0 b	0
Late weed control	5.3	10	12.0 a	0
Intercropping	7.3	12	13.0 a	0
Larvae on DOY 186				
Monoculture	0.5	0	1.0 b	0
Late weed control	0.0	3	0.0 b	0
Intercropping	1.8	2	6.0 a	0

[a] TBW= tobacco budworm, SMC= saltmarsh caterpillar, CL= cabbage looper, BAW= beet armyworm. Means by column in each DOY followed by a different letter are significantly different at α=0.05.

Table 3. Mean number of larvae per cotton plant grown under different plant diversity and seed cotton yield.

	TBW[a]	BAW[a]	CL[a]	SMC[a]
Larvae per plant on day of the year 156				
Cotton	0.13	0.87 c	0.00 b	0.00
Cotton + Velvetleaf	0.00	0.65 c	0.00 b	0.00
Cotton + Garbanzo	0.68	10.37 a	0.30 a	0.00
Cotton + Velvetleaf + Garbanzo	0.50	6.92 b	0.15 ab	0.00
Larvae on DOY 165				
Cotton	0.00 c	0.00 b	0.00	0.40
Cotton + Velvetleaf	0.33 bc	0.00 b	0.00	0.50
Cotton + Garbanzo	0.60 ab	0.87 a	0.00	0.42
Cotton + Velvetleaf + Garbanzo	0.75 a	0.95 a	0.15	0.15
Larvae on DOY 169				
Cotton	0.00	0.3	0.00	0.10
Cotton + Velvetleaf	0.00	0.0	0.30	0.10
Cotton + Garbanzo	0.03	0.3	0.07	0.20
Cotton + Velvetleaf + Garbanzo	0.00	0.0	0.32	0.10
Larvae on DOY 191				
Cotton	0.00	0.00	0.00	0.00 b
Cotton + Velvetleaf	0.25	0.00	0.12	0.05 b
Cotton + Garbanzo	0.10	0.00	0.00	0.05 b
Cotton + Velvetleaf + Garbanzo	0.18	0.02	0.07	5.00 a
		Seed cotton (pounds per acre) on DOY 261		
Cotton	-	728.0 ab		
Cotton + Velvetleaf	-	413.1 b		
Cotton + Garbanzo	-	947.9 a		
Cotton + Velvetleaf + Garbanzo	-	673.9 ab		

[a] TBW= tobacco budworm, BAW= beet armyworm, SMC= saltmarsh caterpillar, CL= cabbage looper.
Means in columns in each DOY followed by different letters are significantly different at α=0.05.

Table 4. Average number of tobacco budworm (*Heliothis virescens*) and damage per cotton plant planted at three different dates with and without garbanzo plants.

	DAMAGED		
	Eggs	**squares**	**larvae**
Evaluation on day of year 194			
Late cotton	0.53 ab	1.22 b	0.00
Late cotton + garbanzo	0.48 ab	4.37 a	0.13
Intermediate cotton	0.58 a	3.46 ab	0.05
Intermediate cotton + garbanzo	0.18 ab	4.82 a	0.18
Early cotton	0.08 b	3.14 ab	0.10
Early cotton + garbanzo	0.23 ab	2.50 ab	0.05
Evaluation on DOY 208			
Late cotton	1.03	NA	0.25
Late cotton + garbanzo	1.30	NA	0.18
Intermediate cotton	0.88	NA	0.20
Intermediate cotton + garbanzo	1.00	NA	0.50
Early cotton	0.63	NA	0.30
Early cotton + garbanzo	0.98	NA	0.20
	Pounds of seed cotton per acre		
Late cotton	1,505 bc		
Late cotton + garbanzo	1,468 bc		
Intermediate cotton	1,341 c		
Intermediate cotton + garbanzo	1,649 b		
Early cotton	2,040 a		
Early cotton + garbanzo	1,947 a		

Means in columns in each DOY followed by different letters are significantly different at α=0.05.