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Economic Decision Criteria for Fleahopper and Bollworm Management in Cotton:

Texas Coastal Bend

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Economic Decision Criteria for Fleahopper and Bollworm Management in Cotton: Texas Coastal Bend

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Abstract

This study focused on two areas. One was a method (1) for incorporating economic decision criteria into models of plant damage from insect pests and (2) for developing an economic decision model for cotton pest management in the Texas Coastal Bend. The second was applying the economic decision model to alternative levels of fleahopper and bollworm damage and thereby comparing economic and yield decline losses for cultivars and growth stages at infestation.

Lint yield reductions caused by cotton fleahoppers were estimated for eight cotton cultivars for the growth period of the fifth true-leaf through the first week of bloom. Yield reductions were estimated for fleahopper infestation at levels of 3%, 10%, 15%, and 30%. The analysis suggests that cotton cultivars are not equally affected by infestations of fleahoppers. Although SP-37H incurred no yield reduction at the 30% level of fleahopper infestation, CAB-CS, SP-21, SP-21S, SP-37, and RDC-102 were highly sensitive to fleahoppers, and treatment was economical at levels of infestation as low as 3%.

The model lint yield reductions caused by bollworms were estimated for four cotton cultivars for the growth period of the sixth true-leaf through the first week of bloom at levels of bollworm-damage squares of 3%, 10%, 15%, 20%, 25%, and 30%. The four cotton cultivars, CAMD-E, SP-37, STV-213, and RDC-102, experienced yield reductions from bollworm injury as low as 3% damaged squares; treatment was economical at levels of damaged squares as low as 4%.

At lint prices of 50¢, 65¢, and 80¢ per pound, economic losses per acre were estimated for cotton fleahopper infestations, assuming no insecticide treatment. Economic losses per acre varied considerably between cultivars and levels of infestation as the fleahopper infestations were varied from 3% to 30%. At the same alternative lint prices, however, economic losses per acre for bollworm infestations were only moderately different between culitvars and levels of infestation. This analysis indicates that for CAMD-E cultiver, the breakeven treatment point is at the level of 23% fleahopper infestations and at 4% bollworm-damaged squares.

This modeling of various scenarios provides a general guide for producers in the region relative to the potential economic injury of cotton fleahopper and bollworm. In particular, results indicate a strong economic incentive for chemical control at very low infestation levels when numbers of insects and injury are increasing. The information emphasizes the need to continue development of integrated pest management technology. Further, these results indicate that the economic incentive differed among cultivars, the two insect pest species, and the growth stage of the plant when attacked.

Estimates of yield decline and economic impact presented herein were not considered for all the dynamics of crop production, such as weather, continuous insect infestation, and simultaneous infestations of fleahopper, bollworm, etc. A second, future infestation of an insect pest was not included in the projections. In addition, the study did not consider the potential infestation of other species of late-season insect pests, the effect of control decisions on beneficial insects, or the potential costs involved if insect pests develop resistance to insecticide.

Key words: Economic decision model, fleahopper, bollworm, yield decline, economic loss, breakeven treatment

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Introduction

The cotton fleahopper *Pseudatomoscelis seriatus* (Reuter) and the bollworm *Heliothis zea* (Boddie) are distributed throughout the Coastal Bend region of Texas. These pests appear to have become increasingly important economically because of the widespread adoption of short-season cotton varieties and accompanying changes in cultural practices. Intensive insecticide application for the cotton fleahopper and bollworm reduces population densities of the beneficial insects and spiders. For control of the cotton fleahopper and bollworm on short-season cotton, insecticides are either applied as a scheduled preventive treatment or, more commonly, when damage becomes visible and reaches or exceeds a fixed arbitrary treatment threshold.

Neither of these approaches is entirely satisfactory as a pest management practice or from an economic viewpoint because the possible outcomes for treatment of a particular insect infestation cannot be predicted economically or biologically. The pest manager cannot optimize his/her investment in pest management or reduce risk of economic losses. Insecticides applied for the cotton fleahopper, bollworm, or boll weevil can also induce the occurrence of late-season tobacco budworm, especially if harvest season is prolonged (Rummel et al. 1986). Efficient management practices for these pests, therefore, depend greatly on making biologically, ecologically, and economically correct integrated pest management (IPM) control decisions.

Short-season cotton production techniques are an integral part of the IPM program in the Texas Coastal Bend, and determinations of the economic injury level (EIL) (Benedict et al. 1989) are basic to IPM. The primary goal of IPM is the maintenance of pest damage and subsequent yield loss below a pre-established and economically defined EIL (Schneider et al. 1986). The EIL has been defined as that pest density at which economic damage results in an economic yield loss (loss of returns) equal to the cost of controlling the damage. Traditionally in the entomological literature, economic threshold level (ETL) has been defined as that pest density at which control measures are imposed to prevent an increasing pest density from reaching the EIL (Rabb et al. 1974, Smith 1971, Stern 1973, Stern et al. 1959). The general absence of accurate and statistically justifiable EIL's that clearly predict the economic need for artificial control measures, however, has been considered a major reason for the confusion over "when to treat" in IPM today (Van den Bosch et al. 1971).

As crop profit margins narrow for farmers, production systems must be fine-tuned to reduce the risk of economic loss. Thus, if scientists would integrate fundamental insect injury/plant response studies of cotton fleahopper and bollworm with economic models, farmers would have a more accurate and rational basis for decisions about cotton production.

Recently, Zummo (1984) developed bollworm EIL's for a range of control costs, three crop ages, and four cotton cultivars in South Texas. His EIL calculations were based on the regression slope of the percentage of damaged squares to the percentage of lint yield loss. In addition, Benedict and co-workers (unpublished data, 1983-86) developed fleahopper injury-yield response regression equations for four short-season dryland cultivars using the number of fleahoppers present rather than the square damage. We used these pest damage regression relationships as the foundation to develop an economic decision model for insect pest management in cotton.

The incorporation of economic decision criteria with selected regression models was designed to provide an integrated decision model that would indicate when the cost from damage of insect pests was equal to or greater than the control costs. The cost-benefit analysis was a marginal analysis that indicated expected value of the lint loss compared with change in costs of insecticide applications, harvesting, ginning, and other yield-related costs. By incorporating economic decision criteria into pest models, a more precise timing of needed insecticide applications can be established according to the dynamics of a given production region or year. The integrated decision model was programmed for a microcomputer and is being field-tested at selected farms.

The purposes of this report are, first, to present the method used to develop the decision model and, second, to demonstrate use of the model in evaluating insect management decisions considering alternative lint, pest control, and other input prices. This second purpose is the major focus of this report. Results of these analyses provide a basis for developing general recommendations of insect pest control on cotton in the Texas Coastal Bend. The model is applicable to other cotton-producing regions across the U.S.

Literature Review

McCarl (1981) developed a detailed literature review concentrating on economic aspects of insect pest management. The concept of the static economic threshold of insect pests triggering a need for insecticide spray (Stern et al. 1959) provided the stimulus to work on the cost/benefit of pest control, especially insecticides (Headley 1972). Shoemaker (1973a, b) laid the theoretical groundwork for establishing optimal insecticide use according to a dynamic-programming approach. Hall and Norgaard (1973), meanwhile, expanded on Headley's work by considering the optimal use of pesticides when both timing and dose were treated as a variable.

According to simulations, the intrinsic growth rates of pest populations in cotton have a surprising influence on the economics pest control (Talpaz and Borash 1974). At higher insect growth rates, for example, the optimal application policy was estimated to be fewer treatments but at higher pesticide doses.

Interestingly, this also resulted in higher profits than in lower insect growth rates. Regev et al. (1976) used a simplified version of the Gutierrez et al. (1976) alfalfa - Egyptian alfalfa weevil model to optimize a profit function for the alfalfa weevil and alfalfa crop. Talpaz et al. (1978) used the Curry et al. (1980) cotton and boll weevil model to maximize net revenue and employed a numerical algorithm when insecticides were applied to control the weevil. Other such simulation studies included the analysis of pesticide use and timing for *Lygus* spp. control (Gutierrez et al. 1977) and biological control of boll weevil (Murty et al. 1980 and Curry and Cate 1984).

Economic evaluations indicate considerable success owing to the implementation of pest management science. Several studies (Lacewell and Taylor 1980, Masud et al. 1981, and Shaunak et al. 1982) indicate that short-season cotton production systems generally increased yields at less cost and also decrease pesticide use and farmer risk. Masud et al. (1985) analyzed the economic value of the uniform planting date and showed great economic returns from relatively simple cultural control practices.

Study Area

The study area was near Corpus Christi in the Coastal Bend region. The climate is intermediate between that of humid, subtropical coastal area to the northeast and that of the semi-arid area to the west and southwest. Average rainfall is 28.5 inches, and average length of the growing season ranges from 335 days near the coast to 288 days in the western part of Nueces County. Soil types are mostly dark loamy and clayey Orelia and Victoria (U. S. Department of Agriculture 1965). The main agricultural products in the region are cotton, grain sorghum, and corn. In addition, pastureland for grazing cattle is also maintained.

Methods

The study to incorporate economic decision criteria into selected entomological models was designed to assess the economic impact of alternative pest levels. The economic analysis was a comparison of expected value of yield loss (less yield-related costs) to costs of treatment for a selected pest infestation level.

Insect Pest Injury - Plant Yield Loss Models

Data collected by Benedict et al. (1989) on the cotton fleahopper and bollworm at Corpus Christi were converted to a percentage of fleahopper infestations, a percentage of bollworm-damaged squares, and a percentage of yield losses. The percentages were transformed to arcsin (in radians) because of the wide range (0 to 40). This transformation helped in stabilizing the error variance and made treatments and replication effects additive. For both the cotton fleahopper and bollworm, the insect injury and plant yield response regression relationships were developed on four cotton cultivars and three stages of growth. Results of the estimates along with statistical interpretations are presented in Ring et al. (1989). These regression relationships have been developed into yield reduction equations and were used for the economic decision model for the two insect pests.

Cotton Fleahopper

Equations of insect injury/plant yield loss for the cotton fleahopper are as follows, where Y equals a percentage of yield reduction in pounds of lint per acre caused by fleahopper damage, and X equals a percentage of cotton fleahoppers calculated from numbers per 100 plants:

Growth period II, i.e., fifth true-leaf through the first week of bloom:

Cultivars

1. CAMD-E: $\arcsin \sqrt{Y} = +1.24 (\arcsin \sqrt{X}) - 0.05 (\arcsin \sqrt{X})^{2}$.
2. SP-37H: No yield loss found.
3. CAB-CS: $\arcsin \sqrt{Y} = -1.89 (\arcsin \sqrt{X}) + 0.03 (\arcsin \sqrt{X})^{2}$.
4. STV-213: $\arcsin \sqrt{Y} = +1.60 (\arcsin \sqrt{X}) - 0.05 (\arcsin \sqrt{X})^{2}$.

The following relationships for the cotton fleahopper were also calculated from published field studies or from estimates from cultivar field test comparisons:

5. SP-21: $\arcsin \sqrt{Y} = -1.46 (\arcsin \sqrt{X})$.
6. SP-21S: $\arcsin \sqrt{Y} = -1.64 (\arcsin \sqrt{X})$.
7. RDC-102: $\arcsin \sqrt{Y} = -2.15 (\arcsin \sqrt{X})$.
8. SP-37: $\arcsin \sqrt{Y} = -1.60 (\arcsin \sqrt{X})$.

There were no models for growth period I, i.e., seedling through the fourth true-leaf, and growth period III, i.e., second week of bloom through the boll maturity stage in this study. This was based on the assumption that cotton fleahoppers do not damage cotton during these growth periods; thus, insect treatment was not recommended for these two growth periods.

Bollworm

The equations for the bollworm were as follows, where Y equals a percentage of yield reduction in pounds of lint per acre owing to bollworm damage.

Growth period II, i.e., sixth true leaf through the first week of bloom where T equals a percentage of bollworm-damaged squares:

Cultivars

1. CAMD-E and SP-37: $\arcsin \sqrt{Y} = -0.83 (\arcsin \sqrt{T})$.
2. STV-213: $\arcsin \sqrt{Y} = -0.68 (\arcsin \sqrt{T})$.
3. RDC-201: $\arcsin \sqrt{Y} = -0.95 (\arcsin \sqrt{T})$.

Growth period III, i.e., second week of bloom through boll maturity where S equals a percentage of bollworm-damaged squares:

Cultivars

1. CAMD-E: arcsin $\sqrt{Y} = -0.72$ (arcsin $\sqrt{S}$).
2. SP-37: arcsin $\sqrt{Y} = -0.92$ (arcsin $\sqrt{S}$).
3. STV-213: arcsin $\sqrt{Y} = -0.87$ (arcsin $\sqrt{S}$).
4. RDC-102: arcsin $\sqrt{Y} = -0.95$ (arcsin $\sqrt{S}$).

In addition, published data from other scientists (Heilman et al. 1981) were used to determine the following relationships:

Growth period I, i.e., seedling through the fifth true-leaf where R equals a percentage of bollworm-damaged terminals.

Cultivars

1. CAMD-E and SP-37: arcsin $\sqrt{Y} = -0.65$ (arcsin $\sqrt{R}$).
2. STV-213: arcsin $\sqrt{Y} = -0.43$ (arcsin $\sqrt{R}$).
3. RDC-102: arcsin $\sqrt{Y} = -0.75$ (arcsin $\sqrt{R}$).

The bollworm equations represent a single infestation of bollworm lasting approximately 15 days.

Economic Decision Model

The economic decision model is composed of the aforementioned insect injury models and budgeting procedures combined with breakeven analysis. As in the previously discussed pest model, the economic model for both the cotton fleahopper and bollworm were built for four cotton cultivars and three stages of growth. The model is user friendly and menu-driven. It was developed to evaluate changes in yield of lint and seed caused by the level of pest infestation of fleahopper (as a percentage of infested plants) and bollworm (as a percentage of damaged squares). This was accomplished through a subroutine developed from the insect pest injury models that estimates percentage of yield decline from the regression slope of percentage of fleahopper numbers to percentage of yield loss for the fleahopper equation and the percentage of damaged squares to percentage of yield loss for the bollworm equation, by cultivar and growth period. In addition, six equations were included in the model to calculate (1) yield with bollworm or fleahopper infestation, (2) lint yield decline and associated seed yield decline, (3) value of lint and seed yield decline, (4) reduction in harvest cost because of less yield, (5) net economic loss, and (6) insect treatment benefit. A schematic diagram of the economic decision model is presented in Figure 1.

Data necessary for the economic calculations include a base lint yield (yield expected without these insect pests), prices of lint and seed as well as insecticide treatment costs, total variable production costs and those per unit costs, total variable production and those per unit costs related to yield, such as harvesting, moduling, hauling, ginning, and bags and ties. Lastly, the cost per acre for an insecticide application must be included. These estimated prices and costs used in the illustration are shown in Table 1. They represent dryland cotton production in the Coastal Bend (Texas Agricultural Extension Service 1987). These values were used to estimate the lint yield decline and the economic outcomes for various cotton production scenarios under alternative levels of percentage of fleahopper-infested cotton terminals or percentage of bollworm-damaged squares.

Table 1. Assumed yield, price, and production costs of cotton, Texas Coastal Bend region, 1987.

	Fleahopper model	Bollworm model
Lint yield without insect (lb/ac)	750	750
Lint price (cent/lb)	65[a]	65[a]
Seed price ($/ton)	110	110
Total variable costs ($/ac)	80	80
Cost per treatment for insect control, including cost of insecticide and applications ($/ac)	2	7
Stripper harvest cost ($/cwt)	15	15
Module and hauling cost ($/cwt)	5	5
Transportation cost ($/bale)	5	5
Ginning, bags, and ties cost ($/bale)	77	77

[a] *Alternately assumed 50¢/lb and 80¢/lb.*

Results

To estimate lint yield decline caused by the cotton fleahopper and bollworm infestations in the Texas Coastal Bend, we set a base yield without pests at 750 lbs of lint per acre for illustrative purposes. The base yield may differ by variety and by farm operator. Regression equations representing the insect injury/yield loss relationships were used to estimate the percentage of yield decline for given pest infestation levels. The estimated yield decline value was then used to estimate net loss per acre for alternative scenarios. Scenarios included alternative levels of percentage of fleahopper infestation and percentage of bollworm-damaged squares, prices of cotton lint, different plant growth stages, and different cultivars.

Yield Decline: Fleahopper

Lint yield reductions owing to cotton fleahopper infestations were estimated for eight cotton cultivars for the growth period of the fifth true-leaf through the first week of bloom (growth period II) and for six alternative levels of fleahopper infestation: 3%, 10%, 15%, 20%, 25%, and 30% (Table 2). There were no yield reductions for SP-37H. CAMD-E and STV-213 cultivers incurred the least amount of yield decline. For CAMD-E, yield reduction did not occur until fleahopper density increased to 20%. Of all the cultivars damaged by fleahoppers, STV-213 incurred the lowest level of yield decline (1 lb/ac) at the 30%

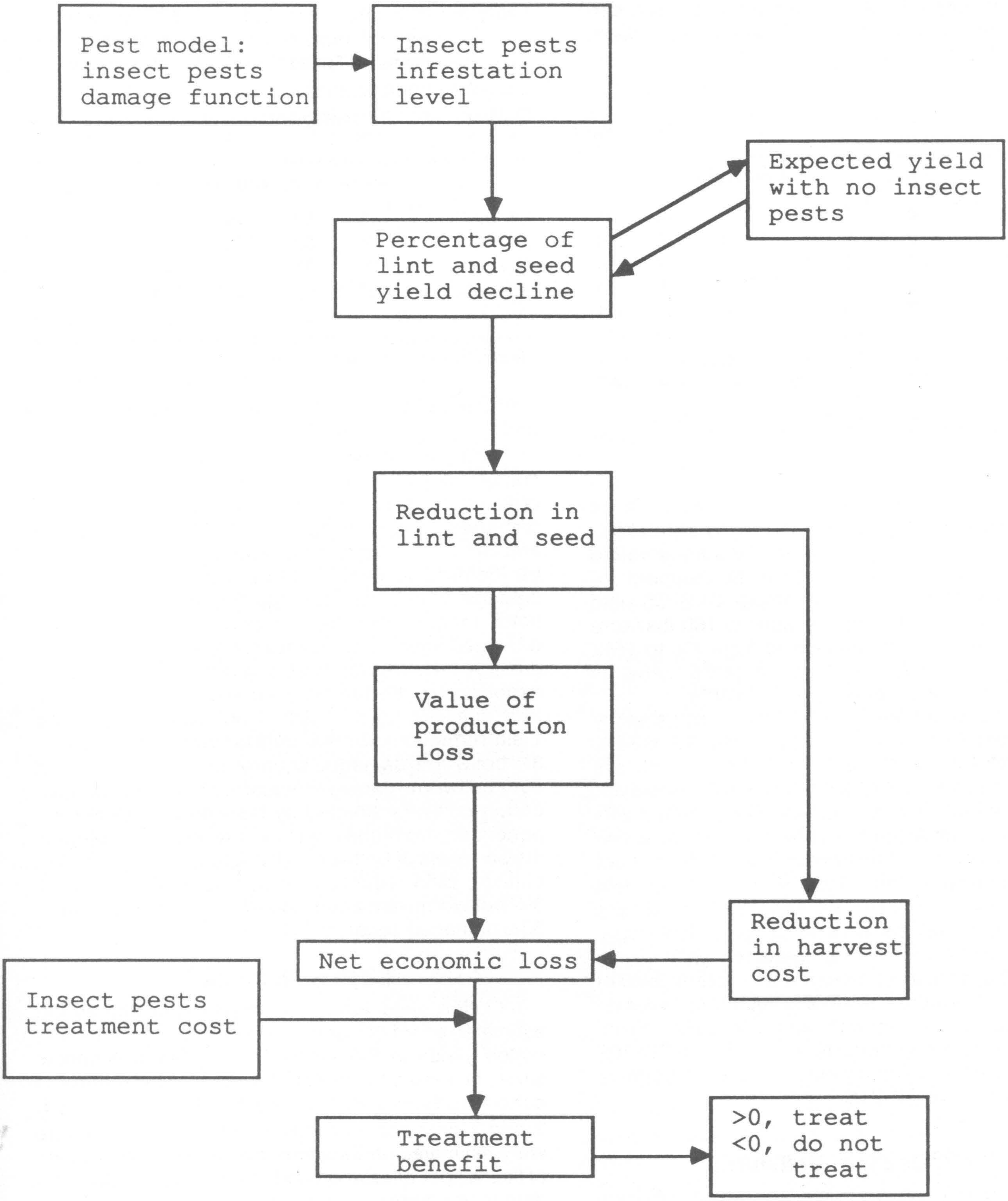

Figure 1. Schematic diagram of the economic decision model for the cotton fleahopper and bollworm.

Table 2. Estimated lint yield reduction by percentage of fleahopper infestation and cultivar, Texas Coastal Bend region.[a]

Cultivar	Percentage of plants with fleahoppers					
	3	10	15	20	25	30
	---------------- (lbs/acre) -------------					
1) CAMD-E	0	0	0	1	14	44
2) SP-37H	0	0	0	0	0	0
3) CAB-CS	56	130	160	177	184	184
4) STV-213	0	0	0	0	0	1
5) SP-21	47	154	226	294	359	421
6) SP-21S	60	190	276	356	430	497
7) RDC-102	100	305	427	529	611	674
8) SP-37	57	182	265	342	414	480

[a] Assumes the cotton plant stage of growth to be the fifth true-leaf through the first week of bloom.

fleahopper density level. This cultivar incurred no yield decline at fleahopper densities of less than 30%. For the remaining cultivars, yield reductions varied considerably as the percentage of fleahoppers increased from 3% to 30%. For example, CAB-CS yield reductions ranged from 56 lbs/acre to 160 lbs/acre as fleahopper densities increased from 3% to 15%. Yield reductions however became more stable at fleahopper infestation levels of 20% to 30%.

Lint yield reductions for SP-21 increased steadily as fleahopper infestations increased from 3% to 30%. Yield reductions of SP-21S and SP-37 cultivars followed the same pattern as that of SP-21. However, SP-21S sustained higher yield decline than did SP-21, and SP-37 sustained a slightly lower yield decline than did SP-21S as the percentage of fleahopper densities increased from 3% to 30%. The highest yield reductions were incurred by RDC-102. Yield was reduced about 100 lbs/acre of lint at a fleahopper infestation level of 3% and increased to a yield loss of about 674 lbs/acre at a fleahopper infestation level of 30%. RDC-102 is more sensitive to fleahopper infestations because it is smooth and glandless. From variety testing, entomologists know that RDC-102 sustains more damage and yield loss from fleahoppers than do CAB-CS or SP-21S.

Yield Decline: Bollworm

Lint yield reductions caused by a single bollworm infestation were estimated for four cotton cultivars for the growth period of the sixth true-leaf through the first week of bloom (growth period II) and for six alternative levels of bollworm-damaged squares, 3%, 10%, 15%, 20%, 25%, and 30% (Table 3). Similar analyses could be done to estimate lint yield reductions from bollworm infestations for growth period I, seedling through the fifth true-leaf, and for growth period III, second week of bloom through the boll maturity. In this example, however, yield reductions from bollworm were not estimated for growth period I and growth period III.

Table 3. Estimated lint yield reduction by percentage of bollworm-damaged squares and cultivar, Texas Coastal Bend region.[a]

Cultivar	Percentage of bollworm-damaged squares					
	3	10	15	20	25	30
	---------Yield reductions (lbs/acre)---------					
CAMD-E	16	52	79	106	133	161
SP-37	16	52	79	106	133	161
STV-213	10	35	54	72	91	111
RDC-102	20	68	102	136	171	205

[a] Assumes the cotton plant stage of growth to be the sixth true-leaf through the first week of bloom.

Lint yield reductions for the four cotton cultivars started at 3% bollworm-damaged squares and increased linearly as the percentage of bollworm-damaged squares progressed to 30%. For CAMD-E and SP-37 cultivars, yield reductions were found to be identical at each of the selected levels of percentage of bollworm-damaged squares. Yield reductions ranged from 16 lbs/acre at 3% bollworm-damaged squares to 161 lbs/acre at 30% bollworm-damaged squares for these cultivars. STV-213 cultivar experienced the lowest yield reduction among the four cultivars as a result of bollworm infestations. Yield reductions for this cultivar was 10 lbs/acre at 3% bollworm-damaged squares and 111 lbs/acre at 30% bollworm-damaged squares. Finally, of the four cotton cultivars affected by bollworm, RDC-102 experienced the highest lint yield reduction at each of the six levels of bollworm-damaged squares. For this cultivar, yield reduction ranged from 20 lbs/acre at 3% bollworm-damaged squares to 205 lbs/acre at 30% damaged squares (Table 3).

Economic Impact

Cotton yield loss by cultivar demonstrates the estimated effect of insect pest infestations on dryland cotton yields in the Texas Coastal Bend. A critical issue, however, is the effect on costs and returns to cotton producers. By applying the values in Tables 1, 2, and 3, net economic losses (lint and seed) per acre were estimated under alternative levels of percentage of fleahopper infestation and percentage of bollworm-damaged squares by price of cotton for each cotton cultivar and each insect treatment cost. In general, the net economic effect with no insecticide treatment for each cotton cultivar was estimated by subtracting the reduced harvest and processing costs caused by a yield decline from the value of yield decline. To calculate the value of a per acre yield decline, assumed lint prices were alternately placed at $0.50, $0.65, and $0.80 per pound. An estimate of the potential economic benefit to the farmer from insect treatment was obtained by subtracting the treatment cost (material and application) from the net economic loss expected with no treatment.

Fleahopper. Net economic losses per acre caused by fleahopper infestation, assuming no insecticide treatments, were estimated for seven cotton cultivars for the growth period of the fifth true-leaf through the first week of bloom and at fleahopper infestation levels of 3%, 10%, 15%, 20%, 25%, and 30%. Net losses were not estimated for SP-37H because no yield losses were estimated for this cultivar.

An example of output from the economic decision model is presented in Appendix 1 and summarized in Table 4. In the example, we compared per acre economic impact of fleahopper infestations with and without insect treatment for CAMD-E. Estimates of economic impact also include a 23% fleahopper infestation level to illustrate the approximate breakeven point for insect treatment. As indicated earlier, yield reduction for CAMD-E did not occur until the percentage of fleahopper infestation increased to 20%. Thereafter, yield decline continued steadily to about 44 lbs of yield/acre at 30% fleahoppers. The resulting value of yield decline assuming the lint and seed price of $0.65/lb and $110.00/ton, respectively, was $0.93/acre at the 20% infestation level and increased to $32.48/acre at the 30% fleahopper infestation level. A decline in yield from fleahopper infestation resulted in less cotton harvested. The reduction in harvest cost owing to yield decline was estimated to be $0.42/acre at the 20% fleahopper infestation level (Table 4). Reduction in harvest costs from fleahopper infestation levels of 20% to 30% were not enough to compensate for the decline in value of the yield. In the absence of any insecticide treatment, CAMD-E cotton initially incurred a small economic loss of $0.52/acre at the 20% infestation level, which then steeply increased with the increase in fleahopper densities (Table 4 and Figure 2).

Assuming a treatment cost of $2.00/acre (insecticide and applications), CAMD-E cotton was not recommended for treatment until the fleahopper infestation level increased to 23%. At this infestation level, a reduction in farmer economic benefit by not treating CAMD-E was $0.87/acre (Table 4). Examining the economic loss at 23% fleahopper-infested plants, we found the breakeven point for treatment of CAMD-E to be $2.87/acre. This is the point where the cost of yield losses from insect damage equals the cost of control, when the price of lint was set at $0.65/lb (Table 4 and Figure 2). For a lint price of $0.50/lb, this breakeven point will be at a higher level of fleahopper infestation (e.g., 24%), and conversely, for a lint price of $0.80/lb, the breakeven point will be at a lower level of fleahopper infestation (e.g., 22%).

Table 4. Estimated economic impact of a range of fleahopper infestation levels for CAMD-E cultiver, Texas Coastal Bend region.[a]

Fleahopper infestation level (%)	Yield decline, lint cotton (lb/ac)	Value of yield decline ($/ac)	Reduction in harvest cost[b] ($/ac)	Net economic loss[c] ($/ac)	Potential economic benefit[d] ($/ac)
3	0	0	0	0	-2.00
10	0	0	0	0	-2.00
15	0	0	0	0	-2.00
20	1.26	0.93	0.42	0.52	-1.48
23	6.96	5.18	2.31	2.87	0.87
25	13.81	10.27	4.58	5.69	3.69
30	43.69	32.48	14.47	18.01	16.01

[a] Assumes the cotton plant growth period to be the fifth true-leaf through the first week of bloom.

[b] Assumes a price of 65¢/lb for lint and $110/ton for associated seed.

[c] Assumes no insecticide treatment for fleahoppers.

[d] Assumes insect treatment costs (insecticide and application) at $2.00/acre.

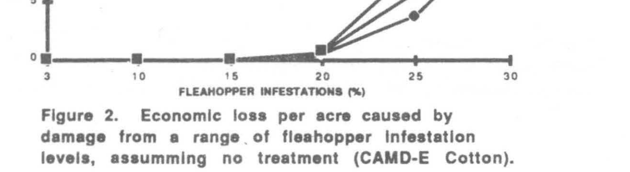

Figure 2. Economic loss per acre caused by damage from a range of fleahopper infestation levels, assumming no treatment (CAMD-E Cotton).

The estimated economic loss for the other cultivars, assuming no treatment of fleahopper infestation, is presented in Figures 3-8. Of these cultivars, STV-213 was the least sensitive to damage and incurred net economic loss per acre only at the 30% fleahopper infestation level (Figure 3). Economic loss among the remaining cultivars differed considerably as the percentage of fleahopper-infested plants varied from 3% to 30%. The net economic loss per acre for CAB-CS reached a peak at the 25% infestation level and actually began to decline at the 30% infestation level (Figure 4). The net economic loss per acre for SP-21 increased linearly as the fleahopper infestation increased (Figure 5). Although the net economic loss per acre incurred by SP-21S was higher than that for SP-21, this loss followed a pattern of increased loss similar to that of SP-21 (Figure 6). Similarly, the net losses per acre incurred by SP-37 was slightly lower than that of SP-21S, and it followed a pattern of increased loss similar to that of SP-21 and SP-37 (Figure 7). Finally, of all the cultivers, RDC-102 incurred the highest net economic loss per acre at each level of fleahopper infestation (Figure 8).

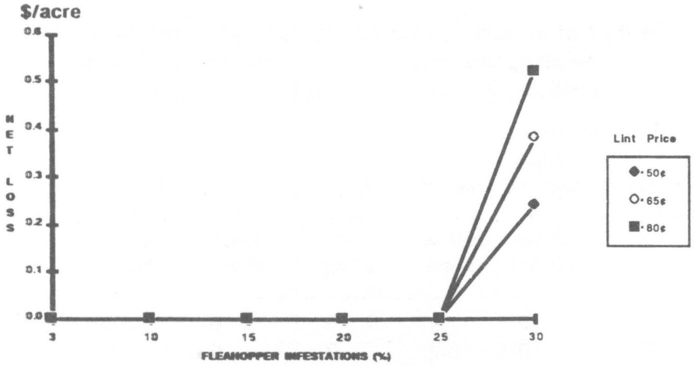

Figure 3. Economic loss per acre caused by damage from a range of fleahopper infestation levels, assuming no treatment (STV-213 Cotton).

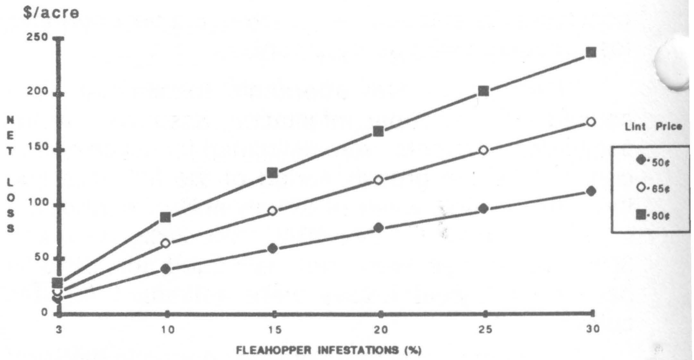

Figure 6. Economic loss per acre caused by damage from a range of fleahopper infestation levels, assuming no treatment (SP-21S Cotton).

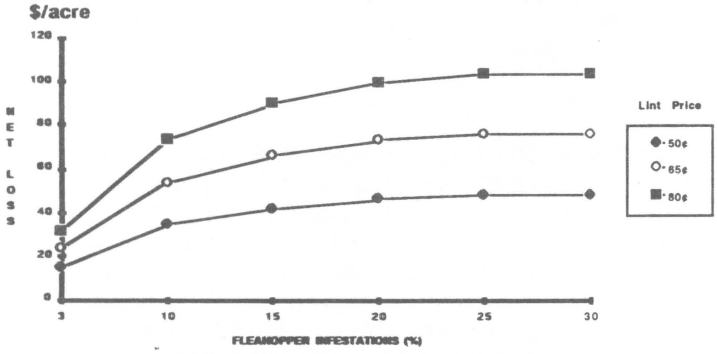

Figure 4. Economic loss per acre caused by damage from a range of fleahopper infestation levels, assuming no treatment (CAB-CS Cotton).

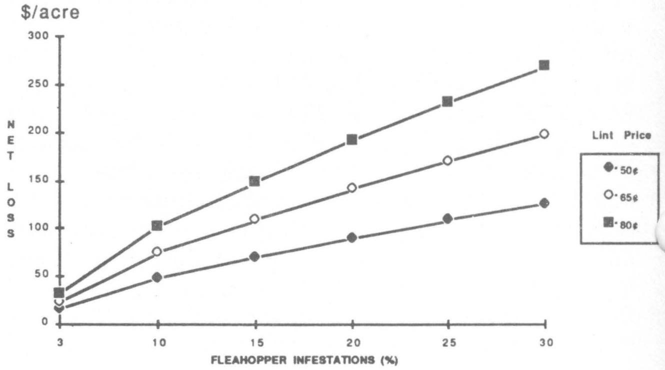

Figure 7. Economic loss per acre caused by damage from a range of fleahopper infestation levels, assuming no treatment (SP-37 Cotton).

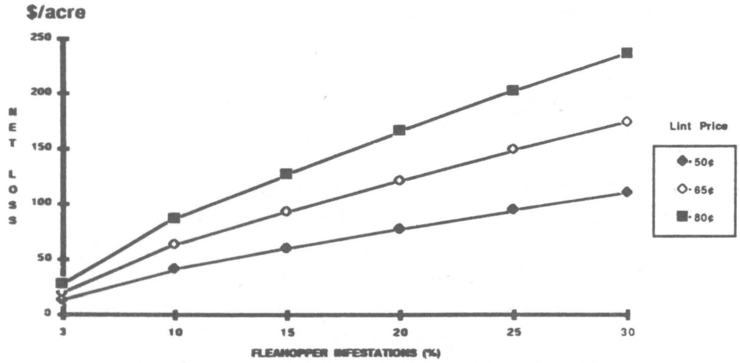

Figure 5. Economic loss per acre caused by damage from a range of fleahopper infestation levels, assuming no treatment (SP-21 Cotton).

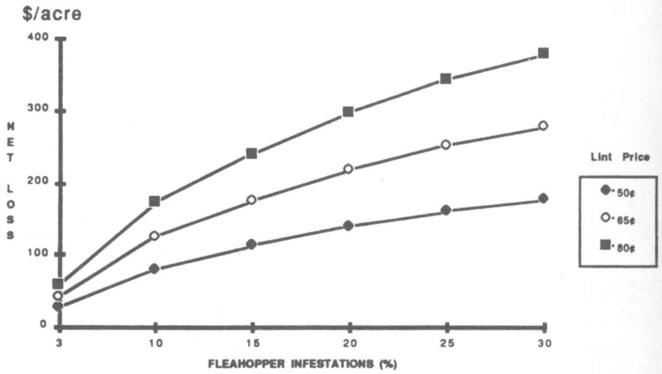

Figure 8. Economic loss per acre caused by damage from a range of fleahopper infestation levels, assuming no treatment (RDC-102 Cotton).

Bollworm. Net economic losses per acre from alternative bollworm infestations, assuming no insecticide treatment, were estimated for four cotton cultivars and for the growth period of the sixth true-leaf through the first week of bloom (growth period II). An example of output from the economic decision model is presented in Appendix 2 and summarized in Table 5. In the example, we compared the per acre economic impact of bollworm infestations without insecticide treatment and with insecticide treatment on CAMD-E and SP-37 cultivars. The economic impact was also estimated assuming 4% bollworm-damaged squares by estimating the breakeven point for treatment. Unlike the fleahopper example, yield decline for CAMD-E and SP-37 from bollworm infestations started immediately and was found to be highly sensitive to bollworms at all levels of damaged squares (Table 5). The value of yield decline, assuming lint and seed price of $0.65/lb and $110.00/ton, respectively, was $15.43/acre at 4% bollworm-damaged squares and increased to about $119.00/acre at 30% bollworm-damaged squares. The corresponding reduction in harvest cost ranged from $6.87/acre at 4% bollworm-damaged squares to $53.20/acre at 30% damaged squares.

Net loss per acre, assuming no insecticide treatment on CAMD-E and SP-37 cultivars, was estimated to be $8.56/acre at the level of 4% bollworm-damaged squares. This net loss increased linearly to $66.21/acre at 30% bollworm-damaged squares (Table 5 and Figure 9). Assuming a treatment cost of $7.00/acre (insecticide and application), CAMD-E and SP-37 cultivars were recommended for treatment at 4% bollworm-damaged squares. This is because at the level of 4% bollworm-damaged squares, the value of the expected yield reduction exceeded the cost of treatment. At this level of bollworm infestation, a reduction in farmer economic benefit by not treating CAMD-E or SP-37 cotton was $1.56/acre (Table 5).

Table 5. Estimated economic impact by percentage of bollworm-damaged squares for CAMD-E and SP-37 cultivars, Texas Coastal Bend region.[a]

Bollworm-damaged squares (%)	Yield decline, lint cotton (lb/ac)	Value of yield decline ($/ac)	Reduction in harvest cost[b] ($/ac)	Net economic loss[c] ($/ac)	Potential economic benefit[d] ($/ac)
3	16	11.56	5.15	6.41	-0.59
4	21	15.43	6.87	8.56	1.56
10	52	38.83	17.30	21.53	14.53
15	79	58.58	26.10	32.48	25.48
20	106	78.58	35.01	43.57	36.57
25	133	98.85	44.04	54.81	47.81
30	161	119.41	53.20	66.21	59.21

[a] Assumes the cotton plant growth period to be the fifth true-leaf through the first week of bloom

[b] Assumes a price of 65¢/lb for lint as well as $110/ton for associated seed.

[c] Assumes no insecticide treatment for bollworms.

[d] Assumes insect treatment costs (insecticide and application) at $7.00/acre.

On examining the economic loss at the level of 4% bollworm-damaged squares, we found the breakeven point for the treatment to be $8.56/acre. This is the point where economic losses from insect damage were equal to the cost of treatment, when the price of lint was set at $0.65/lb (Table 5 and Figure 9). The price of $0.80/lb of lint increased the yield loss value at each infestation level (e.g., 3%); thus we recommend treatment at a lower infestation level than that were the price at $0.50/lb of lint (e.g., 6%).

The estimated economic losses from bollworm infestations assuming no treatment for the remaining two cotton cultivars are presented in Figures 10 and 11. Net loss per acre among the cultivars (including CAMD-E and SP-37 cultivars) from bollworm infestations differed moderately. STV-213 incurred the least net loss per acre at each level of percentage of bollworm-damaged squares (Figure 10). Finally, RDC-102 incurred the greatest net loss per acre at all levels of bollworm infestation (Figure 11).

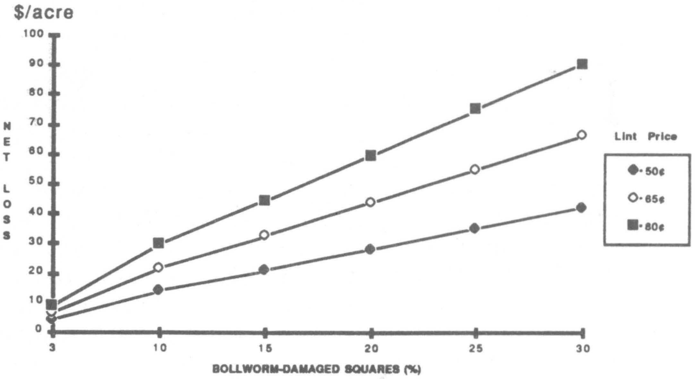

Figure 9. Economic loss per acre from bollworm-damaged squares, assuming no treatment (CAMD-E and SP-37 Cotton).

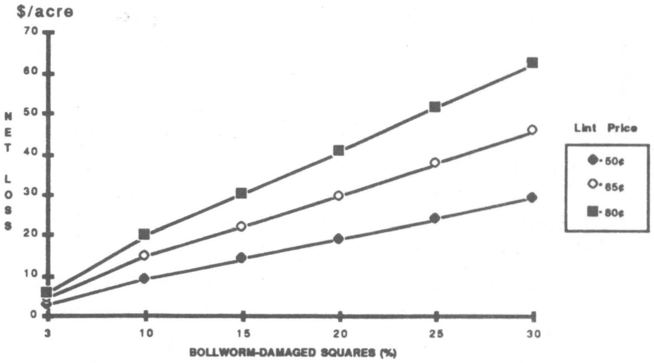

Figure 10. Economic loss per acre from bollworm-damaged squares, assuming no treatment (STV-213 Cotton).

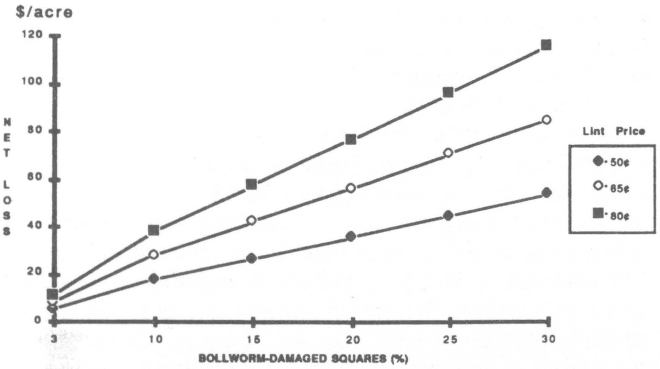

Figure 11. Economic loss per acre from bollworm-damaged squares, assuming no treatment (RDC-102 Cotton).

Summary and Conclusions

This paper is concerned with reports on the development of an economic decision model and with comparisons of the economic impact of various insect management scenarios using the model for cotton pest management in the Texas Coastal Bend. The economic decision model was used to assist in evaluating whether or not to treat simulated fleahopper or bollworm infestations as indicated by the cost of control versus the cost of insect-related damage.

The model was applied to alternative levels of percentage of fleahopper infestation and percentage of bollworm-damaged squares to determine yield decline by cultivars and growth stage at infestation and to determine economic loss assuming no insecticide treatment. When the net economic loss from insect pest injury is approximately the cost of treatment or greater, there is economic incentive to treat. This study does not include an analysis of secondary pest outbreaks or of development of pesticide resistance by insect pests.

Lint yield reductions caused by cotton fleahopper were estimated for eight cultivars for the growth period of the fifth true-leaf through the first week of bloom and for fleahopper infestation at levels of 3%, 10%, 15%, 20%, 25%, and 30%. The analysis indicates that the cultivars are not equally affected by fleahoppers. The SP-37H cultivar incurred no yield reduction even at the 30% fleahopper infestation level. In addition, STV-213 was not affected by fleahoppers until the 30% infestation level was reached, and CAMD-E experienced no yield reductions until fleahopper numbers reached 20%. The remaining cultivars, such as CAB-CS, SP-21, and RDC-102, were highly sensitive to fleahoppers, and treatment was economical at levels of infestation as low as 3%.

Lint yield reduction caused by bollworms were estimated for four cotton cultivars for the growth period of the sixth true-leaf through the first week of bloom at bollworm-damaged squares of 3%, 10%, 15%, 20%, 25%, and 30%. The four cotton cultivars CAMD-E, SP-37, STV-213, and RDC-102 were highly sensitive to bollworm infestations; yield reductions occurred at levels as low as 3% damaged squares, and treatment was economical at levels of infestations as low as 4%.

At lint prices of 50¢, 65¢, and 80¢ per pound, economic loss per acre from cotton fleahopper infestations among the eight cultivars varied considerably as the fleahopper infestations were varied from 3% to 30%. Economic loss per acre was estimated for no insecticide treatment. At the same alternative lint prices, the economic loss per acre from bollworm infestations among the four cultivars were moderately different. This analysis indicates that for CAMD-E cotton, the breakeven treatment point is at the level of 23% fleahopper numbers and 4% bollworm-damaged squares.

These various scenarios provide a general guide for producers in the Coastal Bend region relative to economic implications of alternative levels of cotton fleahopper and bollworm. In particular, this study indicates economic incentive for chemical control at a very low level of infestation for some cultivars but not for others. Economic incentive for chemical control also depended upon insect pest species and growth stage of the cotton plant when attacked with both fleahopper and bollworm. We observed changes in the average number of days to crop harvest (mean maturity date) depending upon level of insect infestation, cultivar, and plant growth stage at infestation. Our data, however, are not complete for all cultivars and insects and, thus, could not be presented here.

Limitations of the Study

All the dynamics of crop production, such as weather, continuous insect infestation, simultaneous infestations of bollworm and fleahopper, or multiple infestations of insect pests, were not considered in the estimates of yield decline and economic impact presented herein. In addition, we did not consider potential infestations of other late-season insect pest species, the effect on beneficial insects, the potential costs involved if these insects develop resistance to insecticides, or the economic costs associated with changes in mean crop maturity dates following insect damage. Another limitation of this analysis is that future insect population size with or without control is not projected. Treatment of these pests at or below the breakeven infestation level is justified only when infestations are predicted to be increasing in damage potential.

A further limitation of this analysis is the thoroughness of the insect injury/crop damage equations. Most of these regression equations were developed from sound replicated experiments; however, some were from data taken in only one study in one year rather than averaged from data collected over several years and from several studies. One was also estimated from variety test results.

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Sincere appreciation is extended to Jim Mjelde and Tom Knight, Department of Agricultural Economics, and Ray Frisbie, Department of Entomology, all of Texas A&M University, for their review and suggestions related to this bulletin. Our appreciation is also extended to Marian Schneider, Rachel Carrier, and Adrienne Morgan for their patience and competent work in typing several drafts of this manuscript.

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Appendix 1

Economic Implications of Fleahoppers on CAMD-E Cotton

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        FLEAHOPPER DECISION MODEL BY S. MASUD, R. LACEWELL, AND J. BENEDICT
        -------------------------------------------------------------------

EXPECTED COTTON YIELD WITHOUT FLEAHOPPERS PRESENT (LBS/ACRE)= 750

EXPECTED PRICE FOR LINT (CENTS/LB)= 65

EXPECTED PRICE FOR SEED ($/TON)= 110

EXPECTED TOTAL VARIABLE COST, EXCLUDING FLEAHOPPER CONTROL AND HARVESTING COST
($/ACRE)= 80

COST PER TREATMENT FOR FLEAHOPPER CONTROL INCLUDING COST OF INSECTICIDE AND
APPLICATION ($/ACRE)= 2

COTTON VARIETY =CAMD-E

COTTON PLANT GROWTH PERIOD =5th True-leaf Through 1st Week of Bloom

METHOD OF HARVEST=Stripper

COST FOR STRIPPER HARVEST ($/CWT OF LINT COTTON)= 15

MODULE AND HAULING COST ($/BALE)= 5

TRANSPORTATION COST ($/BALE)= 5

GINNING, BAG & TIES COST ($/BALE)= 77


--------------------------------------------------------------------
Pct Fleahopper      Yld W/Fleahopper    Yld Decline     Yld Decline val
     (%)                (lbs/ac)         (lbs/ac)           ($/ac)
---------------     ----------------    -----------     ---------------
    23.00              743.04              6.96               5.18
    10.00              750.00              0.00               0.00
    15.00              750.00              0.00               0.00
    20.00              748.75              1.26               0.93
    25.00              736.19             13.81              10.27
    30.00              706.31             43.69              32.48
--------------------------------------------------------------------
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1.4 M – 2-90