American-Eurasian J. Agric. & Environ. Sci., 1 (2): 70-82, 2006
ISSN 1818-6769

Boll Weevil (Coleoptera: Curculionidae) and Pink Bollworm (Lepidoptera: Gelechiidae) Incidence in Early, Middle and Late Maturing Cotton with Cattle Grazing Effects in Cotton Residues

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Abstract: Two field experiments were conducted during 1999 and 2000 to assess the effects of different maturing cultivars and grazing effects in the incidence of boll weevil (*Anthonomous grandis* Boheman) and pink bollworm (*Pectinophora gossypiella* Saunders) in a cotton (*Gossypium hirsutum*) crop. A 2x3 complete factorial resulted in six treatments that were tested in a Complete Randomized Block Design with four replications. Factor A consisted of three different cotton cultivars: a early maturing cultivar (Sure-grow 125); a middle maturing cultivar (Deltapine 5415) and a late maturing cultivar (Deltapine 90). Factor B consisted of grazing effects and no grazing effects. The soil from the experiment 1999 was a sandy loam with a pH of 6.7 while the soil from the experiment 2000 was a silty loam with a pH of 7.3. None of the soil presented salt or sodium problems. Adults of both boll weevils and pink bollworms were evaluated through weekly captures using specific sexual pheromone traps located in the cotton fields. Boll weevil infestation under the treatments was evaluated through weekly sampling of eggs and larvae in 120 squares and 120 bolls while pink bollworm larval populations in each treatment were evaluated with a weekly survey in 120 flowers and 120 immature bolls. Cotton´s vegetal development was determined from 12 randomly selected plants in each treatment where the following information was measured: plant height, blossom appearance at 3-day intervals; percentage damage in open bolls due to boll weevil and pink bollworm; number of nodes in the first fruiting branch; square appearance as well as square disappearance; flower appearance; boll appearance; number of fruiting branches and number of open bolls per plant. Yield was estimated in a 20 m^2 plot in each treatment calculated as kg of cottonseed ha^{-1}. Twenty open bolls were randomly selected to estimate fiber percentage, seed index and average weight. In addition, a random sample of mature bolls was obtained to determine fiber quality; length, strength and micronaire. Following estimation of yield, a stalk destruction on the field was performed and after that, grazing was allowed in the design areas. Adults of boll weevil´s maximum peak was noted in october for both years with 65.9 average per trapped per day (ATD) for trial 1999 and 25.5 ATD for trial 2000. The most severe boll weevil infestations in 1999 were found in the middle maturing and late maturing cultivars during August and September in both squares and bolls. The same pattern was noted for boll weevil infestation in 2000. Pink bollworm moths reached a maximum peak in October 1999 with 85.8 ATD while in experiment 2000 it was found a maximum peak of 48.2 ATD during October. Infestation of pink bollworm during 1999 varied from 5.0% in the early cultivar to 3.8% and 4.5% in the middle and late cultivars while infestation levels in 2000 ranged from 0.0 to 8.6% observed in the late maturing cultivar. No differences were noted in fiber quality of the evaluated cultivars. The effect of grazing indeed reduced the amount of adults of both boll weevil and pink bollworm.

Key words: Boll weevil · pink bollworm · cotton pests · cotton cultivars · grazing effect · cotton residues

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INTRODUCTION

The statistics show that worldwide about 34 million hectares are cultivated with cotton (*Gossypium* spp), representing eight production systems [1]. Cotton crops supply 20 million metric tons of fiber [2] with the most important cotton producers being China, United States, India, Pakistan, Uzbekistan, Turkey and Australia [3]. Insect pests are a major concern in this agricultural crop where two of the most important pests are the boll weevil (*Anthonomous grandis* Boheman; Coleoptera, Curculionidae,) and the pink bollworm (*Pectinophora gossypiella* Saunders; Lepidoptera, Gelechiidae). The boll weevil is considered to have originated in Mexico and Central America [4] and has been responsible for causing serious damage to cotton crops in Brazil [5] and Mexico [6]. In the United States, boll weevil was responsible for losses of billions of dollars in its economy and as a consequence in 1978 the US Department of Agriculture began an intensive eradication program where presently, the boll weevil has disappeared in the southeastern cottonbelt [7].

Five species currently constitute the genus *Anthonomous* [8]. The adult spends the winter in hibernation sheltered under cotton residues left in fields after harvesting as well as in other environments close to fields and emerges early in the following year. The genus *Pectinophora* contains two species, which are considered as pests; *P. gossypiella* (Sanders) with the common name of pink bollworm and *P. scutigera* (Holdaway) known as pink-spotted or pink bollworm. Pink bollworm is believed to be indigenous to India, introduced to Mexico in 1911 and thence introduced to the United States in 1918 where it was recorded for the first time [9]. This pest overwinters in crop residues, causing a damage of 20-50% to the next crop depending on the amount of infested area while reaching a 9% yield loss even in controlled fields [10] and is considered as one of the most important pests worldwide [2]. The pink bollworm has been controlled recently using breeding resistant transgenic Bt cotton cultivars, commercially available since 1996 [11]; however, Mexican farmers still fear this technology in contrast with farmers in the United States where 84% of growers were satisfied with Bt cotton cultivars [12].

Different methods to control insect pests in cotton were the focus of several studies, where pesticides remain as the most important control of pests overseas [13] as well as in Mexico [14]. Unfortunately insect pests have developed resistance to many chemical products [2, 15, 16]; so that, in some areas like India cotton growing costs for insecticide usage is as high as 44% [17] making it necessary to suggest to farmers other alternatives like biological control [18] or cultural control [19] or a combination of those strategies with chemical control. In Brazil cultural practices are broadly used in cotton crops, such as the use of early maturing varieties to prevent pest damage [20]. In the United States it is necessary to destroy pests´ natural niche [21], a technique that is very effective in pink bollworm control [22]. In some cases, cotton residues are utilized by farmers as feedstuff for cattle grazing directly in the fields with acceptable weight gains [23]. This livestock grazing provokes a reduction of some insect pests [20, 24], where in some specific cases destruction may reach of 90% of pink bollworm larval populations [25].

In Mexico cotton farming produces important raw materials for the textile, oil and cattle feeding industries with many social and economic benefits for local communities. In 2001, farmers in Chihuahua planted 31,966 hectares of cotton and produced an estimated 125,000 bales [26]. However, the presence of insect pests is a chronic problem in all farms where the costs of controlling boll weevils and pink bollworms are high and increasing frequently. An average of 11 insecticide applications per year were required in cotton fields in Chihuahua to control these two pests [27]. Technically, once the fields have been harvested, the farmers should plough to destroy the maximum number of pests in soils and to bury all crop residues, but it is expensive for Mexican farmers in production systems that already require high labor, energy and other farming inputs; therefore, livestock grazing or any other kind of management that will reduce insecticide applications will allow farmers to increase net profitability as well as other indirect benefits to farmers and their communities.

The objective of this study was to determine if differences in insect pest infestations exist when planting different maturing cotton cultivars. A second objective was to determine if grazing with cattle in fields containing cotton residues reduces the number of boll weevils and pink bollworms in soils. This research may lead to a better understanding of the advantages of using cotton cultivars that hasten the development of cotton plants and set a crop before insect pests become abundant and as a consequence to reduce insecticide applications and to analyze the advantages of grazing cotton residues in terms of pest infestations.

MATERIALS AND METHODS

Two field experiments were conducted in two growing seasons in an area located close to the Experimental Station of Ciudad Delicias, which is placed in the central part of the State of Chihuahua, Mexico. The first experiment was conducted during 1999 in a field owned by the producer José Guadalupe Almanza while the second experiment was conducted during 2000 in a field owned by the producer Enrique Mendoza Orrantia. In both fields soil was collected from 0-15 and 15-30 cm depth and analyzed in the soil testing lab at the Autonomus University of Chihuahua to determine their: texture; pH (saturation paste); electrical conductivity (dSm^{-1}); organic matter content (%); nitrogen (NO_3-N by soil water extract); phosphorous ($NaHCO_3$ extracted); potassium (1:5 soil water extract) and iron (DTPA extraction).

A 3x2 factorial arrangement of treatments was designed to have a total of six treatments. Factor A was the cotton cultivars representing three different maturing levels: an early maturing cultivar represented by the sure-grow 125; a middle maturing cultivar using the Deltapine 5415 and a late maturing cultivar using Deltapine 90. Factor B was the effect of grazing cotton plant residues under two levels: grazing and no grazing. Therefore, treatments were the following: 1) early cultivar with grazing; 2) early cultivar without grazing; 3) middle cultivar with grazing; 4) middle cultivar without grazing; 5) late cultivar with grazing and 6) late cultivar without grazing. Grazing effects were evaluated with cattle (*Bos Taurus*) feeding on cotton residues and supplemented with trace elements and offering the animals sufficient drinking water.

The experimental design was a Completely Randomized Block Design with 4 replications. Plots contained 20 furrows that were 96 cm wide and 20 m long; therefore, each plot was 384 m^2 and were bordered on each side by two blank rows and on each end by a 1 m alley. During April the three cultivars were mechanically planted at a seeding rate of 100,000 seed ha^{-1} and thinned when plants had the second pair of true leaves, leaving a final plant population density of 80,000 ha^{-1} accordingly to the recommendation of the experimental station. The other agronomic practices including weed control, fertilization and irrigation were applied to the field in an uniform level in accordance with the experimental station guidelines.

Boll weevil adults in experimental plots were counted using two traps with specific sexual pheromone (grandlure) on a weekly basis from May 1 to November 11 in 1999 and from May 1 to November 10 in 2000. The pheromone was replaced in 30-day periods. Percentage of boll weevil infestation in the cotton crop was calculated with weekly egg and larvae counts made in 120 squares and in 120 bolls during timing of squares and bolls. First sampling of squares in 1999 was performed June 18 and ended when the last squares appeared while first sampling of bolls initiated in July 13 and ended with the appearance of last bolls in each variety. In 2000, first survey for squares was performed June 16 while boll sampling began June 30. Pink bollworm moth populations were counted in the experimental fields with two Huber oil traps impregnated with the specific sexual pheromone gossyplure (4 mg gossyplure per septum). Moths were counted weekly from May to November every year and the substitution of the pheromone was realized at 21-day intervals. Pink bollworm larval population in the field expressed as percentage was determined with weekly samples in 120 blossoms and in 120 selected immature bolls (14-days to 21-days old) during both years.

Vegetal developments of cotton plants were measured in 12 randomly selected plants in each plot which were identified and labeled obtaining the following variables: plant height; flower appearance at 3-day intervals, percentage of damage of boll weevil and pink bollworm in identified and labeled bolls; number of nodes to the first fruiting branch; days from first to last squares; flowers and open boll stage; number of fruiting branches and total number of open bolls per plant. Cotton yield was estimated by hand-harvesting 20 m^2 in each plot and then transforming the data to production in kilograms per hectare. In addition a random sample of 20 mature bolls was obtained to estimate lint percentage, seed index and average weight of open bolls. A second sample was obtained to determine fiber quality; length, strength and micronaire index. After harvesting the field, a stalk destruction was performed and the following were determined: number of adult boll weevils and larvae of pink bollworm in 1 m^2 of cotton residues per plot before and after allowing grazing. The grazing period was 14 days. An analysis of variance was conducted for each variable at the 0.05 level of significance. When the F was significant a mean comparison was done using Tukey's test at 0.05 level of significance [28].

RESULTS AND DISCUSSION

1999: The soil was a fine-loamy, mixed, mesic, Aridic Paleustoll with a pH of 6.2; electrical conductivity was

Table 1: Percentage of boll weevil eggs and larvae in early, middle and late maturing cotton cultivars in 1999 and 2000

1999

Maturity	Location	Jul 2	Jul 13	Jul 21	Jul 28	Aug 4	Aug 11	Aug 19	Aug 25	Sep 4	Sep 9	Sep 17
Early	Squares	2.3	6.7	7.6	11.0	12.7						
	Bolls		0.0	0.0	3.3	4.8	9.5	11.1	15.0	19.0	20.0	
Bolls	Middle	0.0	2.2	4.9	7.7	18.9	46.2					
	Squares		0.0	0.0	3.2	0.0	4.7	3.8	10.0	10.0	10.0	22.2
Late	Squares	0.0	2.9	4.0	4.1	4.5	20.8	58.8				
	Bolls		0.0	0.0	2.3	5.0	20.0	18.2	20.0	20.0	22.7	25.0

2000

Maturity	Location	Jun 23	Jun 30	Jul 7	Jul 14	Jul 21	Jul 28	Aug 4	Aug 11	Aug 18	Aug 25	Sep 1	Sep 8	Sep 15
Early	Squares	0.0	1.2	3.6	4.2	5.4	6.3							
	Bolls		0.0	0.0	0.0	0.6	0.9	1.2	2.4	3.3	5.4	5.9		
Middle	Squares	0.0	0.9	2.4	3.7	7.1	7.7	8.4	8.7					
	Bolls		0.0	0.0	0.0	1.2	1.5	2.1	2.1	3.9	5.1	7.8	8.8	9.1
Late	Squares	0.0	0.9	2.7	4.8	7.5	7.8	8.4	9.8	10.4				
	Bolls		0.0	0.0	0.0	1.8	2.1	2.7	2.7	5.4	8.7	9.3	9.3	10.2

0.70 dSm^{-1}; organic matter content was 0.88%; NO_3-N was 7.3 ppm; P was 22.9 ppm; K was 53 ppm and Fe was 9 ppm.

Population of adult boll weevils from May to November is shown in Fig. 1. Average number per trap per day (ATD) ranged from 0.0 to 3.5 in the period from May to late August, where it was observed that after August, a significant increment of captured pests was evident. On October 6, boll weevils counts reached peak catches with an average of 65.9 ATD and after that survey, adult numbers captured in traps began to decline. These results agree with other findings that showed a similar trend in cotton fields in the Chihuahua State [26]. Square sampling to detect boll weevil eggs and larvae began June 18. Table 1 shows percentage of boll weevil eggs and larvae in both squares and bolls in the three cultivars tested. In the early maturing cultivar, infestation in squares was detected on July 2 with 2.3% and then the maxium increment of 12.7% was noted in the August 4 survey, when the last squares appeared in this cultivar. Maximum percentage of eggs and larvae in bolls for this cultivar was noted in September 9 samples. For the middle maturing cultivar, the maximum percentage of boll weevil eggs and larvae was 46.2 for squares and 22.2 for bolls in August 11 and September 17 surveys, respectively. For the late cultivar, infestation started July 13 in squares with a 2.9% and then this percentage was incremented until 58.8% in the August 19 survey that coincided when appearance of the last squares. For this cultivar boll infestation started July 28 with 2.3% and the maximum peak was on September 17 with 25.0%.

Moth populations of pink bollworm ranged from 0.5 to 16.3 ATD from May to August and it was evident from Fig. 2 that maximum peak of pink bollworm moths was observed in the October 6 survey, with 85.8 ATD. These results agree with previous studies [26, 29]. It can be noted that during September and the beginning of October, the ATP was higher than 30%. On July 16, 4.0 ATD were found and on August 25, 16.0 ATD were observed. Boll sampling to detect pink bollworm larvae were initiated July 28 and ended September 17. Infestation levels were irregular with sporadic counts. In the early maturing cultivar, infestation was 5% on August 25, while in the middle maturing cultivar, 3.8% was found on August 19. In the late maturing cultivar, 4.5% was found on September 9.

Plant height evaluation began 66 days after planting and 2 days after appearance of the first flowers. Its generally recognized that most cultivars began flowering in the range from 57 to 64 days after planting [30]. During all vegetal growth periods, the late cultivar was taller than the other cultivars. Hence, significant differences were found in plant heights where mean final heights were 73.0 cm for the early cultivar, 82.0 cm for the middle cultivar and 90.7 cm for the late cultivar. Table 2 shows total production of squares, flowers and open bolls in the three cultivars for 1999 and 2000. First squares appeared at 45 days after planting in the early cultivar and at 47 and 49 days after seeding in the middle and late cultivars while last square appearances were observed at 102, 112 and 119 days (Table 2). First flowers were noted 63 days after planting in the early cultivar while first flowers were noted

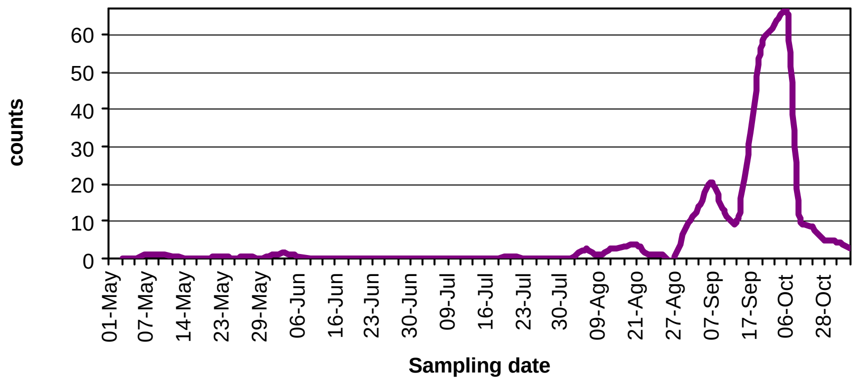

Figure 1: Average adult boll weevils per trap per day in a cotton field during 1999

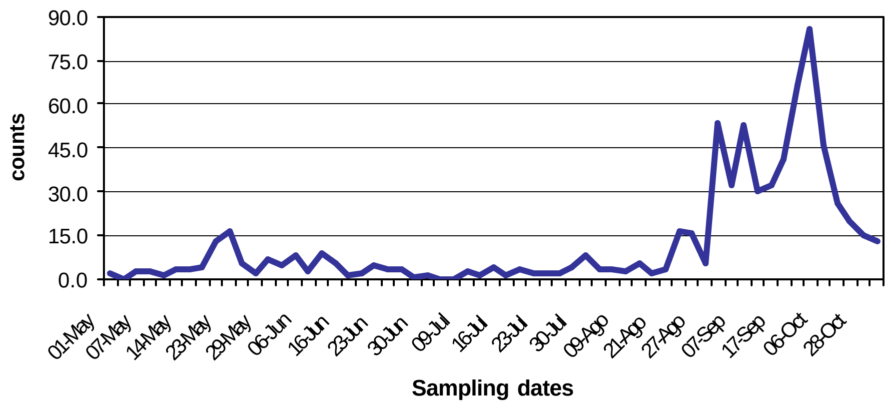

Figure 2: Average pink bollworm moths per trap per day in a cotton field during 1999

Table 2: Total production of squares, flowers and bolls in early, middle and late maturity cotton cultivars during 1999 and 2000

	Days after seeding							
	Beginning		Production time		Latest appearance		Period (days)	
	1999	2000	1999	2000	1999	2000	1999	2000
Early variety								
Squares	45	45	45-102	45-103	102	103	57	58
Flowers	63	62	63-112	62-113	112	113	49	51
Bolls	119	119	119-161	119-161	161	161	42	42
Middle variety								
Squares	47	47	47-112	47-112	112	112	65	65
Flowers	64	64	64-120	64-121	120	121	56	57
Bolls	123	122	123-167	122-168	167	168	44	46
Late variety								
Squares	49	49	49-119	49-122	119	122	70	73
Flowers	64	65	64-127	65-128	127	128	63	63
Bolls	123	124	123-174	124-176	174	176	51	52

at 64 days after planting in the middle and late mature cultivars. The last flowers appeared at 112, 120 and 127 days after planting for each cultivar tested (Table 2). Boll production started at 119 days after seeding and stopped at 161 days in the early cultivar while in the middle and late cultivars boll appearance was at 123 days after seeding and stopped boll production at 167 and 174 days for middle and late cultivar (Table 2).

Table 2 additionally shows the period in days of square production (45-102; 47-112 and 49-119 days) flower production (63-112; 64-120 and 64-127 days) and boll production (119-161; 123-167 and 123-174 days) for every cultivar tested, that resulted in a period of square production of 57, 65 and 70 days for the early, middle and late cultivar. Total days of flower production (49, 56 and 63 days) and total days of boll production (42, 44 and 51 days) are shown in Table 2. Blossom dynamics for the three cultivars are presented in Fig. 3. The early maturing cultivar produced 95% total flowers in a 6-week period in comparison with the late maturing cultivar that needed 8 weeks to reach the same flower percentage. The results showed in Table 2 and Fig. 3 confirmed that the early maturing cultivar avoided the worst densities of boll weevils throughout presenting 57 days to square production, a shorter flowering period of 49 days and an earlier boll maturation of 42 days. The early maturity cultivar production characteristics made it possible to produce the cotton crop before the insect pests could build up high densities. These results agree with the findings of Chu *et al.* [31], who found that seeding early maturing cultivars is very effective in reducing pest densities and crop yield.

Table 3 shows the agronomic features of the three cultivars tested as well as data concerning yield, damage in yield and attributes of fiber quality for both years. In the early maturing cultivar, the first fruiting branch originated in the fifth node; it produced 12 fruiting branches, 12.6 open bolls per plant and an average of 5.6 g of open boll. In the middle maturing cultivar, the first fruiting branch originated in the sixth node; it produced 13 fruiting branches, 9.4 open bolls per plant and 4.9 g of open boll. In the late cultivar the first fruiting branch originated in the seventh node and produced 16 fruiting branches, 19 open bolls per plant and 6.0 g of open bolls.

Moreover, the Table 3 shows the number of protectional fruiting (69, 77 and 86 branches); the number of insecticide applications (7, 9 and 9) and damage in yield as percentage (5.3, 7.6 and 8.4%) for early, middle and late maturing cultivars. Precocity percentage was different for the cultivars tested where it was found a 60.1% for early cultivar, 40.5% for the middle cultivar and 38.6% for the late cultivars. First harvest was estimated at 139 days after seeding in the early maturing cultivar and at 143 days after seeding for the other two cultivars; In other words, cotton yield was estimated 20 days after appearance of the first open boll. Significant differences were found in yield where the early maturing cultivar reached the highest production with 3,018 kg of cotton in comparison with 2,357 kg of cotton for the middle cultivar and 1,966 kg for the late maturing cultivar.

Fiber percentage that was obtained from cotton was slightly higher for the early cultivar with 42.0% in

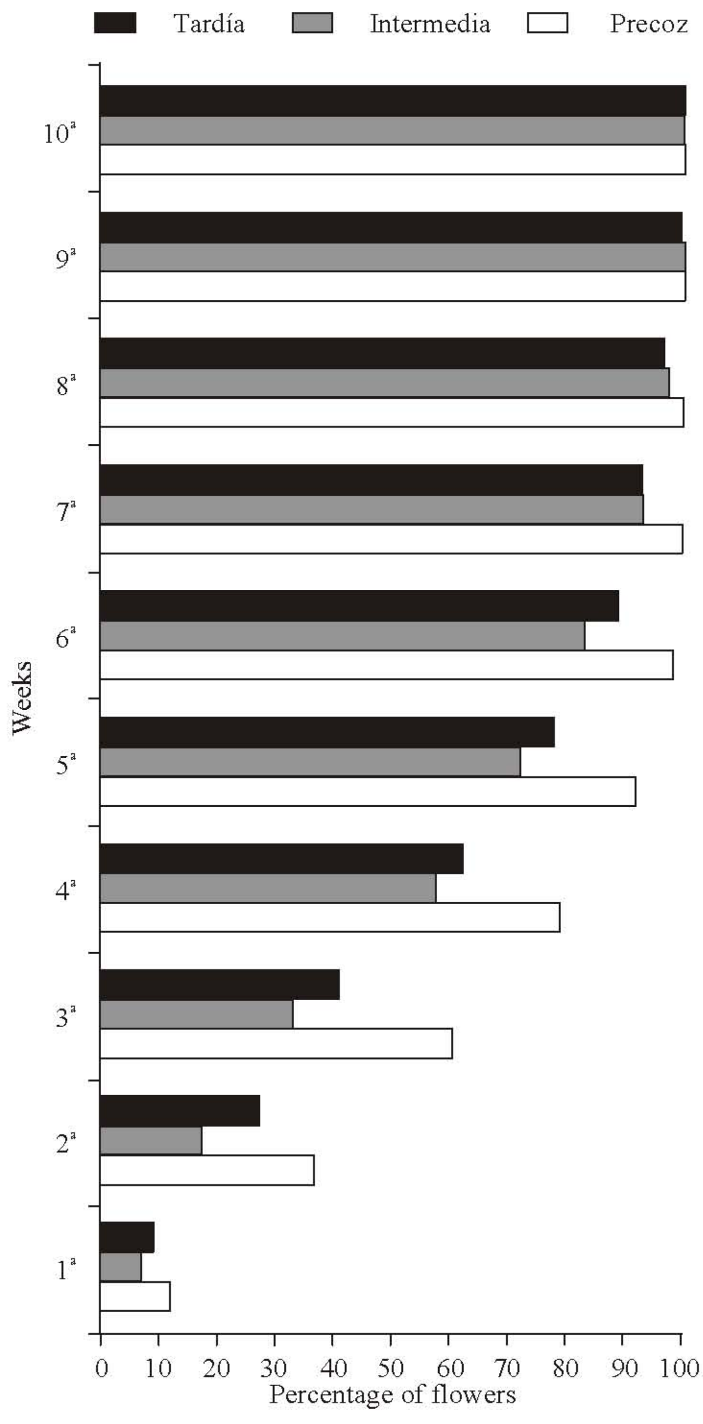

Fig. 3: Blossom dynamics for early, middle and late maturing cotton cultivars during 1999

comparison with 40.5% and 40.3% for the middle and late maturing cultivars, respectively. Seed index expressed as weight in grams of 100 seeds was 10.3 for the early maturing cultivar while an index of 10.2 for the late cultivar and 9.1 for the middle cultivar were observed.

No differences in fiber length of the cultivars were noted. The four upland staple classes generally recognized are: short (<21 mm), medium (22-25 mm), medium long (26-28 mm) and long (29-34 mm). Hence, the three cultivars could be classified as medium long

Table 3: Agronomic attributes, yield, damage and characteristics of fiber in early, middle and late maturing cotton cultivars during 1999 and 2000

	Days after seeding					
	Early cultivar		Middle cultivar		Late cultivar	
Characteristics	1999	2000	1999	2000	1999	2000
First fruiting branch	5° node	5° node	6° node	6° node	7° node	7° node
Fruiting branches	12.0	15.0	13.0	16.0	13.0	16.0
Open bolls per plant	12.6	21.0	9.4	22.0	8.5	19.0
Open boll weight (g)	5.6	6.3	4.9	5.9	5.2	6.0
Protectional fruiting	69.0	69.0	77.0	78.0	86.0	86.0
Insecticide applications	7.0	5.0	9.0	7.0	9.0	7.0
Damage in yield (%)	5.3	3.7	7.6	4.2	8.4	6.8
First harvest (das)	139.0	138.0	143.0	143.0	143.0	149.0
Precocity (%)	60.1	55.0	40.5	39.5	38.6	34.8
Yield (kg ha^{-1} cotton)	3,018.0	5,187.0	2,357.0	5,218.0	1,966.0	4,749.0
Fiber percentage	42.0	41.6	40.5	39.4	40.3	39.9
Seed Index	10.3	10.3	9.1	9.7	10.2	9.8
Fiber length (mm)	27.7	27.7	28.4	28.2	28.5	27.9
Strength (psi)	81,200.0	80,900.0	81,800.0	88,300.0	84,800.0	85,300.0
Micronaire (im)	5.1	5.0	4.7	4.8	4.8	4.3

das = Days after seeding, psi = Pounds per square inch, im = Index of micronaire

because of the results showed a fiber lengths of 27.7 mm, 28.4 mm and 28.5 mm for the early, middle and late cultivars, respectively (Table 3). The fiber length results are similar to the results reported for the cultivars released in 1980 that presented less than 30.48 mm [32]. No significant differences were noted in fiber strength of the cultivars tested. Early cultivar obtained 81,200 lbs $inch^{-2}$ while middle and late cultivars gave strength values of 81,800 and 84,800 lbs $inch^{-2}$, respectively. This small difference in fiber strength must be do to genetic differences which is recognized as the major factor in the strength parameter [33].

No significant differences in micronaire index was noted. Table 3 is showing results of this parameter and according to Bradow and Davidonis [34] who mentioned that the range of micronaire index to consider a good cotton fiber was from 3.5 to 4.9; therefore, the early maturing variety with a micronaire index of 5.1 was out of this range. In either case the three cultivars could be considered good for industrial purposes [35].

Table 4 shows the average number of boll weevils adults as well as pink bollworm larvae found in soil samples after harvesting. Livestock grazing effectively reduced the number of adults of the two insect species evaluated in this experiment (Table 4); therefore, results of this research suggest that grazing cotton residues may allow the farmers an additional profit from the grazing and a reduction in pest infestations for the crop in the following year. Total cotton residues were about 1,900 kg of dry matter per hectare, which agrees with the results reported by Rubio *et al.* [23] who estimated cotton residues in a similar cotton production system.

2000: Lab results showed that soil is a fine-loamy, mesic, Aridic Paleustoll with a pH of 6.5; electrical conductivity was 0.81 dSm^{-1}; organic matter content was 0.90%; NO_3-N was 7.5 ppm; P was 22.5 ppm; K was 45 ppm and Fe was 5.0 ppm.

Population dynamics of adults of boll weevil from May to November is shown in Fig. 4. Average number of counts ranged from 0.0 to 0.3 ATD from May to August when a significant increment was noted at the beginning of September. Maximum peak of adults was observed on October 21 with 25.5 ATD. A comparison of the occurrences of adult boll weevils for 1999 and 2000 showed that, undoubtedly, insect pest counts were higher during 1999 than 2000 (Figs. 1 & 4). These results disagree with other findings [36] that did not find differences in the number of adult weevils between years. Surveys to detect eggs as well as larvae of boll weevils began June 16 and ended with the last square appearance (Table 1). The infestation was detected on June 30 in the early maturing cultivar with 1.2%, which later reached 6.3% in the July 28 survey. Maximum percentage of boll weevil eggs and larvae in squares was 8.7% for the middle cultivar in August sampling and

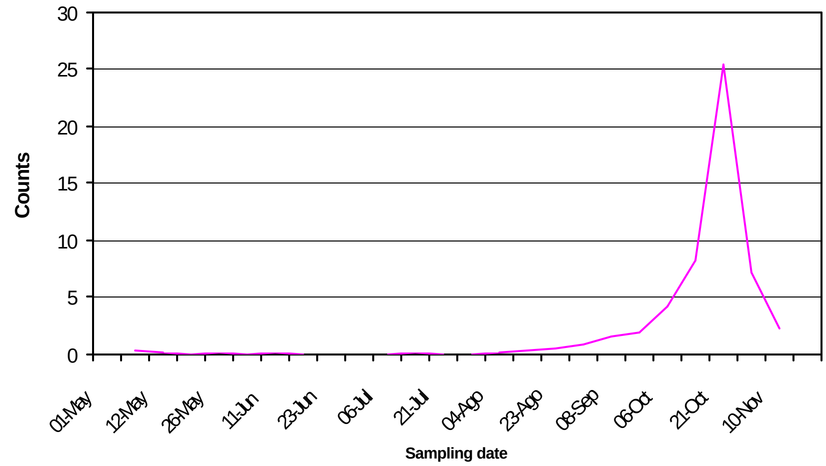

Figure 4: Average adult boll weevils per trap per day in a cotton field during year 2000

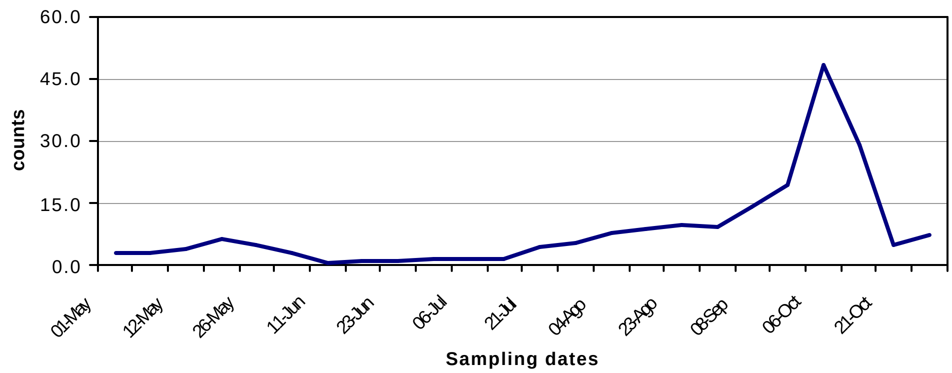

Figure 5: Average pink bollworm moths per trap per day in a cotton field during 2000

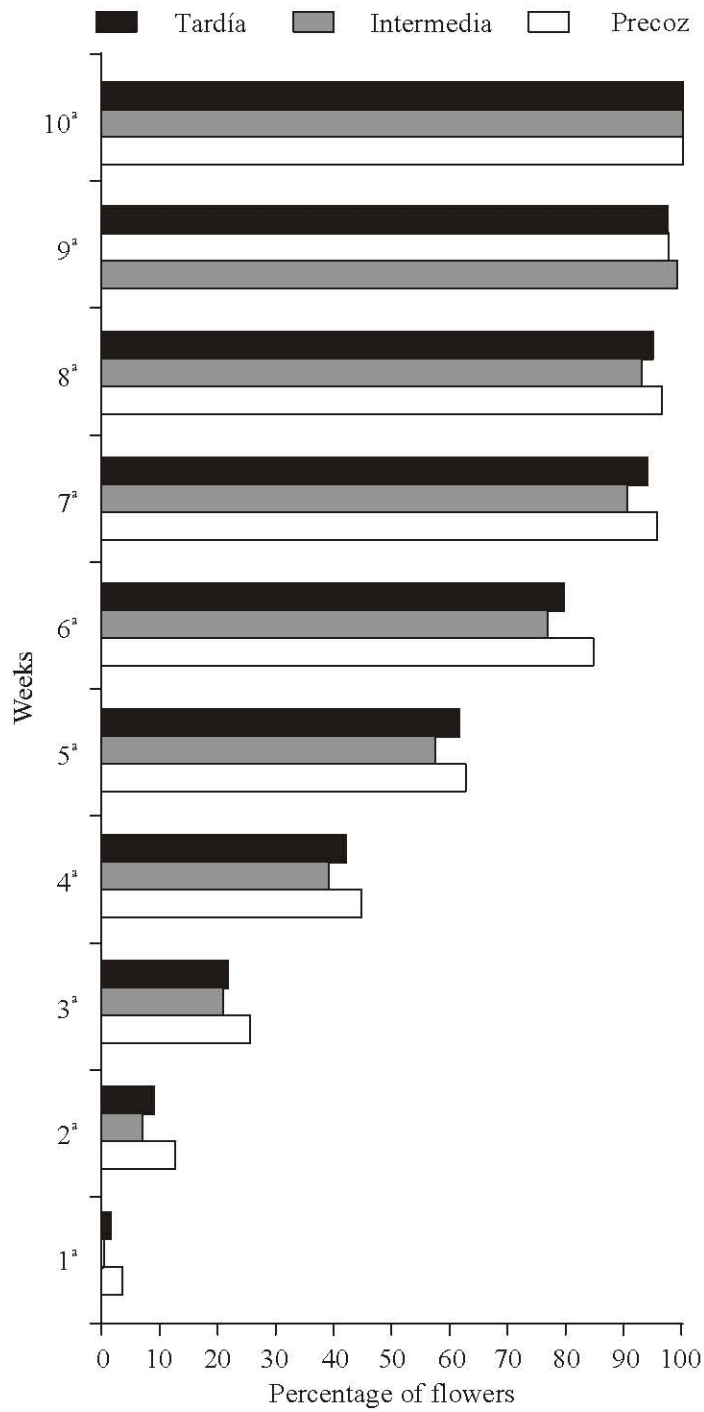

Fig. 6: Blossom dynamics for three cotton cultivars during 2000

10.4% for the late cultivar also in August sampling. In bolls, the maximum peak was observed with 5.9, 9.1 and 10.2% in the early, middle and late cultivars during surveys of September 1, September 15 and September 15, respectively. A comparison of results of sampling squares and bolls during both years showed that a higher incidence of eggs and larvae of boll weevil was observed during the 1999 experiment (Table 1).

Population of pink bollworm flies ranged from 0.7 to 9.7 ATD in the period from May to August. The

Table 4: Number of adults of boll weevil and pink bollworm in a cotton filed under six treatments, before and after grazing during 1999 and 2000

	1999		2000	
Tratamiento	After harvesting	After grazing	After harvesting	After grazing*
Boll weevil				
Early cultivar with grazing	60,000	1,667	7,500	0
Early cultivar without grazing	61,667	58,333	5,000	0
Middle cultivar with grazing	73,333	5,000	7,500	0
Middle cultivar without grazing	66,667	63,333	12,500	0
Late cultivar with grazing	81,667	3,333	12,500	0
Late cultivar without grazing	86,667	81,667	15,000	0
Pink bollworm				
Early cultivar with grazing	91,667	3,333	22,500	0
Early cultivar without grazing	90,000	86,667	20,000	0
Middle cultivar with grazing	118,333	8,333	17,500	0
Middle cultivar without grazing	108,333	106,667	17,500	0
Late cultivar with grazing	120,000	6,687	25,000	0
Late cultivar without grazing	110,000	101,657	22,500	0

*no adults were detected in this sampling

highest counts were observed in September, October and November with October having the maximum peak of 48.2 ATD (Fig. 5). An analysis of both years concerning pink bollworm dynamics, clearly showed that year 1999 was highly infected than year 2000. Boll sampling to detect pink bollworm larvae were initiated July 7 and ended September 15. Infestation levels were irregular among the sample dates as well as in cultivars. In the early maturing cultivar, infestation in flowers was 0.6% in July 14, 0.9% in July 21, 1.5% in July 28 and 1.2% in August 4. In the middle and late cultivars the maximum peak of pink bollworm was detected in squares with 7.4% in September and 8.6% also in September.

Plant height evaluation began 53 days after planting. No significant differences were noted in plant height where the three cultivars grow in the range of 1.14 m to 1.20 m.. First square appearance was at 45 days after planting in the early cultivars while in the middle and the late cultivars first squares were noted at 47 and 49 days after seeding (Table 2). Last squares were observed at 103, 112 and 122 days after seeding. First flowers were detected 62, 64 and 65 days after planting in the three cultivars tested (Table 2). It can be noted that the first bolls were observed in the early cultivar at 119 days after seeding and at 122 and 124 in the middle and late cultivars. Blossom dynamics for the three cultivars is presented in Fig. 6. It can be noted that early maturing cultivar produced in seven weeks 96% of flowers in comparison with the late cultivar that needed nine weeks to reach the same flowering percentage.

The agronomic characteristics as well as data concerning yield, damage in yield and attributes of fiber quality is presented in Table 3. In the early maturing cultivar the first fruiting branch originated in the fifth node being similar to the 1999 finding. This pattern was similar in the other two cultivars. In general, cultivars presented more fruiting branches, more open bolls per plant, more open boll weight and more protectional fruiting branches during experiment performed in 2000 than the experiment conducted in 1999 (Table 3). Number of insecticide applications in each cultivar were 5 for the early maturing cultivar and 7 applications for the other two cultivars. Damage in yield was 3.7, 4.2 and 6.8% for the cultivars evaluated (Table 3) and it is notorious that lesser percentages of damage were observed in experiment 2000 in comparison with percentages of damage of yield in experiment 1999.

First harvest was estimated at 138 days after planting in the early maturing cultivar obtaining a yield of 5,187 kg ha^{-1} (Table 3) that was significantly higher than yield of 1999. The middle maturing cultivar produced 5,218 kg ha^{-1} while the late cultivars yielded 4,749 kg ha^{-1}. As well as in the first cultivar, these two cultivar produced higher yields in experiment 2000 in comparison with results of experiment 1999. Results concerning fiber quality such as length, strength and micronaire were similar in experiment 2000 and experiment 1999 and are considered well for industrial purposes (Table 3).

Determination of populations of both boll weevil and pink bollworm in soil after harvest evaluation and after grazing the cotton residues are presented in Table 4. Livestock grazing effectively reduced the number of adults of the two insect species evaluated in this experiment. It can be observed similar pattern in both experiments regarding grazing evaluation.

ACKNOWLEDGEMENTS

We are deeply grateful with the CONACYT (National Council for Science and Technology) of Mexico which provided a grant to the National Institute for Research in Forestry, Agriculture and Pastures (INIFAP) for the results reported here.

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