Influence of Plant Population on *Spodoptera frugiperda* (J. E. Smith) Infestation and Damage to Sorghum[1]

Carlos R. Trabanino[2]
Henry N. Pitre[2]
Dan H. Meckenstock[3]
Keith L. Andrews[4]

ABSTRACT

Four tests were conducted using different sorghum planting densities to investigate the effects of host plant spatial patterns on fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), infestation and damage to sorghum plants. Although total numbers of FAW per unit area were greater in higher plant populations, observed plant damage was lowest in the more dense plantings

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2/ Graduate research assistant and entomologist, respectively, Department of Entomology, Mississippi Agricultural and Forestry Experiment Station, Mississippi State, MS 39762.

3/ Visiting Assistant Professor, Department of Soil and Crop Science, Texas A&M University, located at the Panamerican Agricultural School, Apdo. Postal 93, Tegucigalpa, Honduras.

4/ Head, Department of Plant Protection, Escuela Agrícola Panamericana, Apartado Postal 93, Tegucigalpa, Honduras and Associate Professor, Department of Entomology and Nematology, University of Florida, Gainesville, FL 32611.

because the large number of larvae was spread over an even greater number of plants (density of larvae per plant was low). The higher number of insects developing in the high plant population will influence FAW dynamics; FAW population size may be increased dramatically and crop damage could be serious later in the growing season or on crops planted late.

The fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), is a polyphagous, mobile pest that annually attacks maize, *Zea mays* L., and other crops, (especially gramineous species) throughout the tropical and subtropical areas of the western hemisphere. In sorghum, *Sorghum bicolor* (L.) Moench, this insect causes damage by cutting seedlings at the base, feeding on leaves developing in the whorl, gouging out areas of the stem, and eating the developing caryopsis.

Sorghum ranks third to maize and beans (*Phaseolus vulgaris* L.) in basic grain production in Honduras (SRN, 1980). Even though sorghum produced in Honduras generally is used for animal feed, it substitutes for maize as food for human consumption in areas where maize yields are low. More than 40% of the sorghum harvest in southern Honduras is destined for human consumption (SRN, 1980; DeWalt and DeWalt, 1982; McCulloch and Futrell, 1983). Subsistence farmers in Honduras intercrop maize and sorghum at apparent suboptimal plant populations because of low soil fertility and high drought potential (Hawkins, 1984). Intercropping maize and sorghum minimizes production risks because sorghum is more drought tolerant and can survive adverse environments better than maize (Cutie, 1975; Mateo et al., 1981). Thus, sorghum is an insurance crop during dry years when the maize crop fails, which occurs in 3 of every 5 years. Hawkins (1984) points out that maize-sorghum intercropping systems provide greater net returns, on average, than monocropped maize or sorghum or some combination of the two crops. However, this planting practice could create lower yields than when the crops are planted at higher densities.

There is abundant evidence that plant density affects insect populations. Some insects find host plants more efficiently when plants are closely spaced than when they are farther apart and stay for longer periods of time in areas with high plant populations (Bach, 1980). However, herbivore reproduction and damage are less on plants in high population densities compared to plants in low population densities, presumably because plant density strongly influences the quality and quantity of the host plant.

The purpose of this study was to determine the effect of plant population on FAW infestations and observed plant damage on sorghum. This plant density-insect relationship is one important factor in understanding the potential for damage to sorghum by this pest species.

MATERIALS AND METHODS

Four tests were conducted in Oktibbeha County in northeastern Mississippi from 1982 to 1985. Dekalb sorghum (DK-42y) seed was planted at different densities in small plots each year. Treatment plot size varied every year and tests were designed as a randomized complete block. Conventional agricultural practices for sorghum production in this area were employed during the growing season. Fall armyworm larval infestation and/or plant damage was recorded each year. Percent infestations were determined using a destructive sampling method, which entailed dissecting the plant to observe presence or absence of FAW larvae (Castro et al., submitted). Plant damage was recorded on a scale of 0-9, where 0 represented no observed leaf damage and 9 represented a dead plant (Wiseman et al., 1966; Wiseman and Davis, 1979). Data were analyzed by analysis of variance and means were separated by Duncan's multiple range test (Duncan, 1955).

TEST 1

Sorghum was planted on 9 July 1982 to achieve stand densities of 7, 13 and 20 plants per meter of row. Treatment plots were four rows, 0.97 m wide and 6.1 m long, arranged in a randomized complete block with three replications per treatment. Plant damage by FAW larvae was recorded on days 42 (August 20) and 53 (August 31) after planting. Fall armyworm leaf feeding damage was recorded on eight whorl stage plants selected at random from each plot on each date. This was the only lepidopterous pest feeding on the foliage.

TEST 2

Sorghum was planted on 14 June 1983 at average densities of 1.7, 3.3, 6.6 and 13.2 plants per meter of row to investigate effects of stand with fewer sorghum plants than were evaluated in 1982. Treatment plots consisted of four rows, 0.97 m wide and 3.6 m long, arranged in a randomized complete block with four replications per treatment. Because natural fall armyworm infestation in the study plots was low, four egg masses of equal size were placed in each plot, one per row, in a zig-zag pattern equally distant along the rows on July 29. Egg masses of equal size were stapled to the underside of leaves. Plant damage by FAW larvae was recorded on 24 plants selected at random from each plot on day 52 (August 5) after planting (7 days after infestation).

TEST 3

Three different sorghum plant densities were tested in 1984: sorghum planted 1, 2, and 38 plants per meter of row. The high density is conventional drill planting in the United States. These plant densities were used to make inference between high technology practices, as used in the United States, and low technology practices used by sorghum farmers in Central America (eg., Honduras - where 10-20 seeds are commonly planted in hills ca. 1 m to 1.2 m apart by subsistence farmers). Plots consisted of 8 rows, each 12.1 m long and 0.97 m wide arranged in a randomized complete block with four replications per treatment. Twenty plants were selected at random from each plot on each sample date. Whorl stage plants were sampled on July 3 and July 9. FAW infestations were not determined during the remaining part of the whorl stage, so that plant stands would not be significantly altered in the small plots. Panicle samples were taken on August 14 and August 21. The plants were examined for FAW larvae using the destructive sample technique and plant damage was recorded on August 8 using procedures described above.

TEST 4

In 1985 a test was conducted using planting densities used by subsistence farmers, including sorghum seed planted 1 hill per meter of row, 2 hills per meter of row, 1 hill per 1.5 meter of row, representing low technology treatments, and 38 plants per meter of row (conventional drill planting) representing high technology treatments; on average each hill contained 3 plants. Treatment plot size and test design were described in Test 3. Observed plant damage was recorded on July 11 and July 19. To prevent altering plant stands in the small plots, no destructive plant samples were taken during the whorl stage. Numbers of FAW larvae per panicle were determined by randomly collecting 10 panicles per plot, shaking them over a plastic tray, and counting the number of larvae dislodged from the panicles. The samples were taken weekly starting July 24 and ending August 13.

RESULTS

TEST 1. The results of planting sorghum 7, 13 and 20 plants per meter of row indicate that observed sorghum plant damage by FAW larvae was greater in plots with fewer number of plants, i.e., plant damage became less as plant population increased (Table 1). There was at least a two-fold decrease in the apparent plant damage rating with each treatment increase in plant population.

Table 1. Effect of sorghum plant population on fall armyworm damage. Oktibbeha Co., MS, 1982.

No. plants per 1 meter row	Plant damage rating1/ on dates 8/20	8/31
7	4.2 a2/	6.3 a
13	2.1 a	3.1 ab
20	1.4 a	1.4 b

1/ Visual damage rating scale: 0=no leaf damage; 9=plant dead, recorded on days 42 and 53 after planting.
2/ Means in a column not followed by the same letter are significantly different at $P \leq 0.05$ by Duncan's multiple range test.

TEST 2. Damage caused by FAW larvae on 1.7, 3.3, 6.6 and 13.2 sorghum plants per meter of row was not significantly ($p \leq 0.5$) different among the four treatments (Table 2).

TEST 3. In comparing FAW larval infestations on sorghum in wide spatial planting patterns (1 and 2 plants per meter of row) with conventional wide row drill planting (38 plants per meter of row), no treatment differences were observed on whorl stage plants on the two sample dates, although significant differences ($P \leq 0.05$) were observed in early seed development on one of two sample dates during the reproductive stage (Table 3).Treatment with 1

Table 2. Effect of sorghum plant population on fall armyworm damage. Oktibbeha Co., MS, 1983.

No. plants per 1 meter row	Plant damage rating1/ on 8/5
1.7	1.7 a2/
3.3	1.9 a
6.6	1.8 a
13.2	1.6 a

1/ Visual damage rating scale: 0=no leaf damage; 9=dead plant, recorded on day 52 after planting.
2/ Means are not significantly different at P ≤ 0.05 by Duncan's multiple range test.

Table 3. Effects of sorghum plant population on fall armyworm infestation. Oktibbeha Co., MS, 1984.

No. plants per 1 meter row	Percentage of sorghum plants infested with larvae on dates			
	Whorl		Panicle	
	7/3	7/9	8/14	8/21
1	0 a1/	10.0 a	55.0 a	55.0 a
2	2.5 a	7.5 a	48.8 ab	56.3 a
38	3.8 a	6.3 a	33.8 b	63.8 a

1/ Means in a column not followed by the same letter are significantly different at P ≤ 0.05 by Duncan's multiple range test.

and 2 plants per meter of row were not sampled for larvae throughout the season because of the limited number of plants in those plots. Thus, the treatment with 38 plants per one meter of row also was not sampled. In general, plots with lower numbers of plants appeared to have a higher percentage of infested plants, but the total number of FAW per unit area was highest in plots with high plant populations. No significant differences ($P \leq 0.05$) in plant damage were observed among the treatments.

TEST 4. There were no significant differences ($P \leq 0.05$) in foliage damage by FAW larvae among the four treatments where plant population ranged from 0.66 to 38 plants per meter of row. However, there were significant differences in number of larvae per 10 panicles among treatments on one (August 13) of four samples dates (Table 4). In general, there was a trend for higher numbers of FAW larvae on the widely spaced sorghum plants than on the plants in the closely spaced drill planting

Table 4. Effect of sorghum plant population on fall armyworm infestation. Oktibbeha Co., MS, 1985.

No plants per 1 mẽter row	No. fall armyworms per 10 panicles on dates 7/24	7/30	8/6	8/13
0.66	9.8 a1/	4.3 a	3.5 a	1.5 ab
1	13.3 a	14.0 a	2.8 a	3.0 a
2	7.5 a	0.0 a	2.3 a	1.0 ab
38	5.8 a	9.0 a	2.3 a	0.8 b

1/ Means in a column not followed by the same letter are significantly different at $P \leq 0.05$ by Duncan's multiple range test.

DISCUSSION

Results presented herein show consistent trends during the 4 years that tests were conducted to investigate the influence of plant population on FAW infestation and/or damage to sorghum. When sorghum plants were sparsely spaced, increased insect densities caused increased crop damage. Clavijo (1981) reported, however, that corn plant density did not affect the percentage of plants infested by *S. frugiperda*. This phenomenon was observed by Pimentel (1961) who reported that with increased plant density, the increased quantity of vegetation appreciably aids in reducing insect damage. The higher quantity of plant material available in dense plantings generally is associated with a lower herbivore density because the latter is usually measured relative to plant surface area.

When significant differences were not detected in these tests, even though numerical differences were observed, we might speculate that favorable conditions existed for carnivores at the expense of the herbivores in sparse plantings, allowing for increased carnivore efficiency (Pimentel, 1961). Additionally, herbivore populations in sparse plantings may decline from higher populations because of a food shortage, thus the herbivore population decreases in the sparse planting to the level similar to that in dense planting (Adesiyun, 1978; Ralph, 1977). Davis (1966) observed that fewer differences might be expected to exist between treatments when crops are grown under good agronomic practices.

This study suggests that the sorghum crop environment may be manipulated by varying planting practices to influence insect pest colonization and subsequent damage to the plants. Although FAW infestations generally were higher in low plant populations, the total number of FAW per unit area was highest in high plant populations. Plant damage ratings by this pest were lowest in the more dense plantings, due in part to the spread of the large insect population over an even larger plant population. These observations indicate that FAW population size is not entirely dependent on host plant density, e.g., higher plant populations ostensibly result in lower FAW infestations and therefore less plant damage. But, reproduction by the insects that develop in increased number (per unit area) in fields with high plant populations may influence FAW population dynamics. The increased populations in subsequent generations could be very damaging to crops later in the growing season or to crops planted late.

More work is needed on production farms to determine the optimum planting rate to obtain a plant population in which FAW damage to the sorghum crop is minimized. This information has value in developing countries in Central (i.e., Honduras) and South America where current low technology sorghum production practices include widely spaced seed planting patterns which result in sparse plant populations. The sparse plant stands of these field crops may be heavily colonized by herbivore pest species resulting in serious reductions in harvestable yield.

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