RESISTANCE OF A MAIZE POPULATION, FAWCC(C5), TO FALL ARMYWORM LARVAE (LEPIDOPTERA: NOCTUIDAE)

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ABSTRACT

Field tests at Mississippi State, MS, and Tifton, GA, were conducted to evaluate the effect of resistance of a maize, *Zea mays* (L.), germplasm population, 'GT-FAWCC(C5)', to feeding by larvae of the fall armyworm, *Spodoptera frugiperda* (J. E. Smith). Plants of selected maize entries were infested at the 8 and 12 leaf stage with two applications of 15 larvae per plant. Resistance traits measured were leaf damage at 7 and 14 days after infestation and number and weight of surviving larvae per plant at 7 and 10 days after infestation. Leaf damage ratings at both 7 and 14 days after infestation and the number and weight of surviving larvae per plant on GT-FAWCC(5) at 7 and 10 days after infestation on GT-FAWCC(C5) equalled the number and weight of surviving larvae on 'MpSWCB-4', the resistant check. Both the resistant check and GT-FAWCC(C5) were significantly more resistant to whorl damage than the susceptible check, 'Ab24E × SC229', for all resistance traits. It is evident that antibiosis (low weight) and nonpreference (fewer larvae per plant and fewer larvae preferring leaf samples) mechanisms of resistance are present in the GT-FAWCC(C5) population as well as for MpSWCB-4.

Key Words: Leaf-feeding resistance, antibiosis, nonpreference, artificial infestations

RESUMEN

Fueron realizados estudios de campo en el estado de Mississippi y en Tifton, Georgia, para evaluar la resistencia de una población de germoplasma de maíz, *Zea mays* "GT-FAWCC(C5)" al daño producido por larvas de *Spodoptera frugiperda* (J. E. Smith). Plantas de entradas seleccionadas de maíz fueron infestadas en el estado de 8-12 hojas con dos aplicaciones de 15 larvas por planta. Las variables de resistencia medidas fueron el daño a las hojas y el número y peso de las larvas sobrevivientes por planta a los 7 y 14 días después de la infestación. El daño foliar a los 7 y 14 días después de la infestación y el número y peso de las larvas sobrevivientes por planta en GT-FAWCC(C5) a los 7 y 10 días después de la infestación igualaron al número y peso de las larvas sobrevivientes en "MpSWCB-4", el testigo resistente. Tanto el testigo resistente como el GTT-FAWCC(C5) fueron significativamente más resistentes al daño del cogollo que el testigo susceptible, "Ab24E × SC229". Es evidente que los mecanismos de resistencia mediante antibiosis (bajo peso) y no preferencia (pocas larvas por planta y pocas larvas prefiriendo muestras de hojas) están presentes en las poblaciones de GT-FAWCC(C5) y MpSWCB-4.

Maize, *Zea mays* (L.), is a crop upon which fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), infestations often reach devastating levels in the southeastern United States. In 1975, losses in Georgia were estimated at over 20 million dollars

(Sparks 1979). Yield losses attributed to the fall armyworm for the U. S. have been estimated at 2% annually (Wiseman & Morrison 1981). Wiseman & Isenhour (1993) showed that commercial maize hybrids suffered greater yield losses (32.4%) when manually infested with 2 applications of 20 neonates per plant at the 8-leaf stage than at the 12-leaf stage (15.4%).

Maize is the most valuable field cereal crop in the U. S. (Anonymous 1995). Although the number of acres planted with maize and the value of the crop fluctuate annually, 72.9 million acres were harvested in 1994 in the U. S. with a production of 10.1 billion bushels and a value of 22.2 billion dollars (Anonymous, 1995). Thus, the continued development and release of new maize germplasm with resistance to the FAW is important. Understanding the mechanisms of resistance or the biological effects of resistant cultivars on the FAW is important in managing the insect pest. Therefore, the objective of this study was to determine leaf damage at 7 and 14 days after infestation (DAI) and biological responses of FAW when feeding on a newly released resistant germplasm population, 'GT-FAWCC(C5)' (Widstrom et al. 1993).

Materials and Methods

Two dent maize entries, (resistant 'MpSWCB-4' or susceptible 'Ab24E × SC229'), were selected for comparison with GT-FAWCC(C5) because of their response to FAW in field tests (Scott & Davis 1981; Widstrom et al. 1993). The three entries were seeded in separate experiments on 5 April, 1995 at Tifton, GA and on 17 April, 1995 at Mississippi State, MS. Test plots consisted of 3 rows 6.1 m long and 0.9 m apart. Plants were thinned to about 30 cm apart. Recommended agronomic practices were followed at both locations.

A split plot design with 6 replications was used with whole plots being leaf-stage at the time of infestation: 8-leaf stage (V4 at Tifton and V8 at Mississippi State) or 12-leaf stage (V8 at Tifton and V12 at Mississippi State) (Ritchie & Hanway 1982). Subplots consisted of maize entries. At Tifton, leaf stage was determined by counting the total number of emerged leaves, and at Mississippi State, leaf stage was determined by counting only leaves with their collars exposed. Whole plots were bordered with 2 rows of a commercial maize hybrid. Each plant within the 8- or 12-leaf stage treatments was infested with 2 applications of 15 neonate FAW on the same day (Wiseman 1989). By infesting with two applications, noninfested plants within the experiments do not exist. From row one and two of each sub-plot, 10 plants were harvested at soil level at both 7 and 10 DAI and taken to the laboratory to determine the number and weight of surviving larvae per plant. Plants on the third row of each subplot were rated at 7 and 14 DAI using a visual rating scale of 0-9 (Davis 1992) where 0 = no damage and 9 = whorl destroyed.

FAW larvae used to infest plants were obtained from colonies maintained at the Insect Biology and Population Management Research Laboratory, Tifton, GA and the Crop Science Research Laboratory, Mississippi State, MS, respectively (Perkins 1979; Davis 1989).

A laboratory test was designed to determine nonpreference for leaf samples of the three maize entries. Whorl samples were obtained from the 8- leaf stage at Mississippi State on May 25, 1995, taken to the laboratory and excised into disks of about 2 cm diam (Davis et al. 1989). The leaf disks of each entry were randomly placed on the outer inside edge of a large dish (15.3 cm diam, 2.7 cm deep). One FAW egg mass in the blackhead stage containing about 50 eggs was placed in the center of each dish and the dish was placed in darkness. The experiment was arranged as a randomized complete block with 22 replications. The experiment was held in a controlled environment room maintained at 27° C and 50-60% RH. Total number of larvae found on each maize entry leaf section (if larvae were not actually on the leaf section at the time of recording, they were not counted) per dish was recorded 24 h after egg hatch.

Damage ratings, the number and weight of surviving larvae and number of larvae preferring a leaf sample were analyzed by PROC GLM (SAS Institute 1989). When significant differences were indicated, means were separated by least significant differences (LSD) at $P = 0.05$ (SAS Institute 1989).

RESULTS AND DISCUSSION

A significant ($P \le 0.05$) leaf-stage × entry interaction was found for the 7-day leaf damage ratings at Mississippi State, but not at Tifton (Table 1). Plants from all three entries at Mississippi State and two (Ab24E × SC229 and MpSWCB-4) at Tifton received more damage at the 8-leaf stage than at the 12-leaf stage. Both, GT-FAWCC(C5) and MpSWCB-4 had significantly ($P \le 0.05$) less damage 7 DAI in the 8- and 12-leaf stages than Ab24E × SC229 at both locations. GT-FAWCC(C5) was significantly less damaged at the 8-leaf stage than MpSWCB-4 at Tifton.

A significant ($P \le 0.05$) leaf-stage × entry interaction also was found for leaf damage ratings 14 DAI at Mississippi State, but not at Tifton (Table 1). At Tifton, plants of all entries infested at the 8-leaf stage yielded significantly higher damage ratings (8.2 vs 4.7) than plants of all entries at the 12-leaf stage. Plants from all three entries at both locations received more damage at the 8-leaf stage than at the 12-leaf stage. Both GT-FAWCC(C5) and MpSWCB-4 were damaged significantly ($P \le 0.05$) less 14 DAI in the 8- and 12-leaf stages than Ab24E × SC229 at Mississippi State and Tifton. MpSWCB-4 was damaged significantly less than GT-FAWCC(C5) at Mississippi State at the 8-leaf stage but not at Tifton.

A significant ($P \le 0.05$) leaf-stage × entry interaction was found for the number of larvae recovered per plant 7 DAI at each location (Table 2). Significant differences in the number of larvae per plant were found 7 DAI between the 8- and 12-leaf stages for each entry at each location. In each case, plants infested at the 12-leaf stage had fewer larvae 7 DAI than plants infested at the 8-leaf stage of each entry. Both GT-FAWCC(C5) and MpSWCB-4 had significantly fewer larvae per plant than the susceptible check, Ab24E × SC229, at both leaf stages and locations.

A significant ($P \le 0.05$) interaction (leaf-stage × entry) was found for number of larvae recovered per plant 10 DAI at Tifton, but not at Mississippi State (Table 2). The mean number of larvae recovered 10 DAI at Mississippi State at the 8-leaf stage was significantly higher (4.7 vs 3.0) than the mean number recovered at the 12-leaf stage. Significant differences between the number of larvae per plant 10 DAI at the 8- and 12-leaf stages for each entry occurred at Mississippi State, but differences between plant growth stages were noted only for GT-FAWCC(C5) at the Tifton location. GT-FAWCC(C5) and MpSWCB-4 had significantly fewer larvae per plant than the susceptible check, Ab24E × SC229, at the 8-and 12-leaf stages at Mississippi State, these differences were noted only for the 12-leaf stage at Tifton.

Total weight of larvae per plant recovered 7 DAI from plants of entries infested at the 8-leaf stage at Tifton was significantly ($P \le 0.05$) greater than weight of larvae recovered from plants of entries infested at the 12-leaf stage (Table 3). No differences in weight of larvae were found between the 8- and 12-leaf stages at Mississippi State. Larvae feeding on and collected from 8- or 12-leaf stage plants of GT-FAWCC(C5) and MpSWCB-4 weighed significantly less than larvae feeding on and collected from Ab24E × SC229 at both locations.

Total weight of larvae per plant recovered 10 DAI from plants of entries infested at the 8-leaf stage at Mississippi State (164 vs 79) was significantly ($P \le 0.05$) heavier

TABLE 1. MEAN LEAF-DAMAGE RATINGS FOR MAIZE AT 7 AND 14 DAYS AFTER INFESTATION WITH TWO APPLICATIONS OF FIFTEEN FALL ARMYWORM LARVAE PER PLANT.

	$\bar{x}$ Damage Rating[1]											
	7DAI						14 DAI					
	Mississippi State			Tifton			Mississippi State			Tifton		
Entry	8 Leaf		12 Leaf	8 Leaf		12 Leaf	8 Leaf		12 Leaf	8 Leaf		12 Leaf
Ab24E × SC229	7.2 a	*	6.7 a	8.3 a	*	6.0 a	8.6 a	*	7.3 a	8.8 a	*	7.8 a
GT-FAWCC(C5)	5.0 b	*	3.2 b	3.0 c		2.7 b	6.4 b	*	4.2 b	7.3 b	*	3.7 c
MpSWCB-4	4.2 b	*	3.7 b	5.5 b	*	3.0 b	5.1 c	*	4.5 b	7.7 b	*	4.7 b
SEM	0.11		0.11	0.56		0.56	0.27		0.27	0.31		0.31

[1]Mean damage ratings within a column not followed by the same letter or horizontal column means separated by * are significantly different ($P \leq 0.05$). SEM = standard error of the least significant mean was based on pooled error mean square in the analysis (SAS Institute 1989).

TABLE 2. MEAN NUMBER OF LARVAE RECOVERED PER PLANT OF MAIZE ENTRIES AT 7 AND 10 DAYS AFTER TWO APPLICATIONS OF FIFTEEN FALL ARMYWORM LARVAE PER PLANT.

Entry	$\bar{x}$ No. Larvae Recovered at[1]											
	7 DAI						10 DAI					
	Mississippi State			Tifton			Mississippi State			Tifton		
	8 Leaf		12 Leaf	8 Leaf		12 Leaf	8 Leaf		12 Leaf	8 Leaf		12 Leaf
Ab24E × SC229	11.8 a	*	6.4 a	11.8 a	*	9.9 a	7.1 a	*	4.4 a	4.2 a		4.9 a
GT-FAWCC(C5)	6.0 b	*	0.7 b	6.8 b	*	1.9 b	4.1 b	*	2.2 b	3.5 a	*	1.9 b
MpSWCB-4	2.9 c	*	1.1 b	6.1 b	*	2.4 b	4.4 b	*	2.2 b	3.9 a		2.9 b
SEM	0.81		0.81	0.71		0.71	0.74		0.74	0.26		0.26

[1]Mean number of larvae within a column not followed by the same letter or horizontal column means separated by * are significantly different ($P \leq 0.05$). SEM = standard error of the least significant mean was based on pooled error mean square in the analysis (SAS Institute 1989).

TABLE 3. MEAN WEIGHT (MG)[1] PER PLANT FOR FALL ARMYWORM LARVAE INFESTED WITH TWO APPLICATIONS OF FIFTEEN LARVAE PER PLANT AND FED FOR 7 AND 10 DAYS ON RESISTANT AND SUSCEPTIBLE MAIZE GENOTYPES.

	$\bar{x}$ Weight per Plant[2]							
	7 DAI				10 DAI			
	Mississippi State		Tifton		Mississippi State		Tifton	
Entry	8 Leaf	12 Leaf	8 Leaf	12 Leaf	8 Leaf	12 Leaf	8 Leaf	12 Leaf
Ab24E × SC229	129 a	141 a	158 a	201 a	370 a *	223 a	387 a	420 a
GT-FAWCC(C5)	19 b	1 b	27 b	65 b	65 b	3 b	120 b	114 b
MpSWCB-4	9 b	9 b	39 b	88 b	56 b	12 b	203 c	166 b
SEM	7.8	7.8	16.5	16.5	25.1	25.1	19.7	19.7

[1]Total weight of larvae per plant.
[2]Mean weight of larvae within a column not followed by the same letter are significantly different ($P \leq 0.05$). SEM = standard error of the least significant mean was based on pooled error mean square in the analysis (SAS Institute 1989).

than weight of larvae recovered from plants of entries infested at the 12-leaf stage, but not at Tifton (Table 3). Weight of larvae per plant was significantly more for larvae feeding on, and collected from, Ab24E × SC229 from the 8-leaf stage at Mississippi State than from the 12-leaf stage. The total weight of larvae per plant or weight per larva from both GT-FAWCC(C5) and MpSWCB-4 was significantly less 10 DAI than the weight of larvae from the susceptible check (Ab24E × SC229) for both the 8- and 12-leaf stages and locations.

Results from the laboratory nonpreference study indicated that leaf sections of GT-FAWCC(C5) were less preferred by FAW neonate than those for Ab24E× SC229 [Ab24E × SC229 15.46a larvae per dish; MpSWCB-4 10.09ab larvae per dish and GT-FAWCC(C5) 7.96b larvae per dish; number of larvae followed by the same letter are not significantly different $P \leq 0.05$]. MpSWCB-4 and AB24E × SC229 were equally preferred as was MpSWCB-4 and GT-FAWCC(C5). Wiseman et al. (1981) reported that FAW larvae preferred MpSWCB-4 similar to the susceptible check but possessed higher antibiosis than the susceptible check and that 'Antigua 2D-118' was more nonpreferred by FAW larvae than MpSWCB-4. This appears to be the case here for GT-FAWCC(C5) except that both MpSWCB-4 and GT-FAWCC(C5) are similar in antibiosis.

In summary, though the 8- and 12- leaf stages at Mississippi State and Tifton were measured differently, the leaf damage ratings 7 and 14 DAI, number and weight of larvae per plant at 7 and 10 DAI at both locations for GT-FAWCC(C5) equalled those of MpSWCB-4, the resistant check. MpSWCB-4 and GT-FAWCC(C5) were significantly more resistant than the susceptible check, Ab24E × SC229, when weight per larva was also calculated. It is evident that antibiosis (low total weight of larvae per plant or weight per larva) and nonpreference (less establishment per plant and numbers preferring leaf samples) mechanisms of resistance are present in the GT-FAWCC(C5).

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