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DIFFERENTIAL GROWTH RESPONSES OF FALL ARMYWORM[1] LARVAE ON DEVELOPING SORGHUM SEEDS INCORPORATED INTO A MERIDIC DIET[2]

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ABSTRACT

Seed of developing sorghum, *Sorghum bicolor* (L.) Moench, mixed in a substandard meridic diet, was fed to larvae of fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith). Larval weight differences were measured at 8-14 days after infestation. Differences between weights of FAW larvae fed NK 'Savanna 5' and 'Funk 5245' were found at the following stages of plant development: milk stage, soft dough stage, hard dough stage, high moisture dry seed, and low moisture dry seed. The larvae that were fed diets of NK 'Savanna 5' were consistently smaller over all stages tested. Forty to 80 g of immature or mature seed per diet resulted in detectable differences between the 2 sorghum genotypes. An evaluation of 10 randomly selected sorghums mixed in the diets produced weights of larvae that showed significant differences among cultivar responses at the milk stage and dry seed stage. The FAW larvae that were fed diets of NK 'Savanna 5' and 'TAM 2566' were consistently smaller over several tests as compared with other sorghums evaluated. A nonsignificant relationship was found between FAW feeding responses on the fresh-milk stage cultivars mixed in diets and feeding responses on those diets made from frozen milk-stage seed. Indications were that the smaller larvae were produced on resistant sorghum cultivars and that this may have been due to a lack of adequate nutrients. No apparent relationship was found between tannin content of the dry seed and FAW growth responses.

RESUMEN

Larvas del gusano cogollero (FAW), *Spodoptera frugiperda* (J. E. Smith), se alimentaron con semillas de sorgo, *Sorghum bicolor* (L.) Moench, mezcladas con una dieta artificial inferior. Las larvas se pesaron de 8 a 14 días después de la infestación. Hubieron diferencias entre los pesos de las larvas FAW alimentadas con 'NK Savanna 5' y con 'Funk 5245' en las siguientes etapas de desarrollo de las plantas: la de leche, la de masa suave, la de masa dura, la de smilla seca de alta humedad, y la de semilla seca de

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baja humedad. Las larvas que se alimentaron con dietas de NK Savanna 5 fueron consistentemente más pequeñas en todas las etapas probadas. Una cantidad de 40 a 80 g de semilla verde o madura en la dieta resultó en diferencias perceptibles entre los dos genotipos de sorgo. Una evaluación de 10 sorgos mezclados con la dieta, seleccionados al azar, produjeron larvas de pesos que muestran diferencias significativas entre la reacción a cultivares de la etapa de leche y a los de semilla seca. En comparación con otros sorgos evaluados, las larvas FAW que fueron alimentadas con dieta de NK Savanna 5 y TAM 2566 fueron consistentemente mas pequeñas en varias pruebas. Se encontró una relación no significativa entre la reacción de alimentació de FAW a cultivares de la etapa de leche fresca mezclados con la dieta y a dietas hechas de semillas congeladas de la etapa de leche. La indicación fué que las larvas más pequeñas fueron producidas en cultivares de sorgos resistentes, y que ésto puede haber sido el resultado de falta de suficientes nutrimentos. Aparentemente, ninguna relación existe entre el contenido de tanino en la semilla seca y la reacción de crecimiento de FAW.

The fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), continues to be an important economic pest in the southeastern United States. Wiseman and Davis (1979) noted that the FAW has been studied less from an insect-plant relationship than most other economically important insect pests. Davis (1980) reported only 1.4 entomological SYs were devoted by both SAES and USDA to research on the FAW in host plant resistance studies.

Grain sorghum, *Sorghum bicolor* (L.) Moench, is one of the most important food and feed grain crops in the world. The FAW attacks all stages of the developing plant. Initial screenings of 30 lines in the greenhouse for FAW leaf-feeding resistance was reported by McMillian and Starks (1967). Schwager et al. (1984) evaluated 25 sorghum lines varying in physiological and morphological characteristics for FAW leaf-feeding resistance in the field. However, none of the sorghums demonstrated acceptable levels of resistance. Wiseman and Gourley (1982) developed a system for infesting FAW larvae on sorghum seedlings in the greenhouse and on whorl-stage sorghum in the field. They identified genotypes that are resistant to leaf-feeding in screening some of the world sorghum collection.

Insect resistance is one of the most effective means of limiting insect damage and/or reducing insect numbers in our crops. Therefore, the development and use of plants resistant to pests is essential to most integrated control approaches. It is essential that researchers search for and/or incorporate genes for resistance to the FAW into their crop cultivars.

We report the results of tests designed to determine the stage of seed development and concentration of seed mixed in a meridic diet required to detect differences in the FAW feeding responses among diverse sorghum genotypes.

MATERIALS AND METHODS

A series of experiments was conducted that utilized the standard FAW meridic diet (pinto bean diet), with and without yeast (-y) (Perkins 1979, Burton 1967, Wiseman et al. 1984). The pinto bean diets, with or without yeast, were supplemented with a slurry of blended seed. The standard diets

were used in some cases where the sorghum-based diets indicated a lack of nutrients existed. The diets without the yeasts stressed the larvae sufficiently and then addition of an antibiotic factor would magnify cultivar differences (Wiseman et al. 1984). The experiments were designed to evaluate both stages of seed development and concentration of seed per diet.

Diet preparation consisted of the following:

(1) All diet ingredients were weighed individually for 3.85 *l* (1 gal.) of the standard diet or diet without the yeast (bean-y).

(2) Diet ingredients were mixed or blended with distilled water and a preheated agar solution was then added and blended with the diet ingredients.

(3) The plant material was thoroughly blended in 120 ml of distilled water.

(4) Then 300 ml of prepared diet was blended with the slurry of plant material for each treatment and/or sorghum cultivar.

(5) The diet-plant material mixture was dispensed into 36 15-ml (5/8 oz.) plastic cups, allowed to cool or air dry for ca. 2 h.

(6) One neonate FAW was placed onto each diet cup, after which the cup was capped.

(7) The treatment cups were numbered and arranged as per the design of each experiment. The experiments were maintained in a constant temperature room at 26.7 ± 2°C and 70 ± 5% RH.

Experiment 1 was designed to evaluate the stage of panicle development and FAW feeding responses. The experiment consisted of a split plot with 36 replications (1 larva/replicate). Two previously designated sorghums (the high tannin Northrup-King 'Savanna 5' and the low tannin 'Funk 5245'), and 4 stages of panicle development (before flower, early flower, flowered, and milk stage) were selected for evaluation. Forty g of plant material of each stage of seed development were mixed with 300 ml of pinto bean diet without yeast. Whole plots were sorghum cultivars; subplots were the stages of seed development. Larval weights were recorded 11 days after infestation.

Experiments 2-9 consisted of a split-plot design with 36 replications (1 larva/replicate) each to evaluate seed concentration per diet. Whole plots were sorghum cultivars ('Savanna 5' and 'Funk 5245') and subplots were concentrations of seed per diet at 0, 10, 20, 40, 80, and 120 g/300 ml of the standard pinto bean diet with or without yeast. Diets and plant materials were prepared as described earlier. Larval weights were recorded from 8-11 days of age after infestation depending upon the rapidity of development of the larvae on the check treatment for each particular experiment. (Larvae fed the diet-plant material mixture without the yeast developed more slowly than those on the standard diet).

Experiment 10 was designed to determine if larger FAW larvae were adversely affected by the sorghum seed diets. The experimental design was a split plot with 24 replications (1 larva/replicate). Whole plots were days FAW were fed the standard pinto bean diet (2, 4, or 6 days) before placing on the sorghum-pinto bean diet mixture without yeast. The subplots were the 2 sorghum cultivars and an untreated diet check. Larvae were weighed initially at 2, 4, or 6 days and at the end of the test period (11 days). Larval weights were adjusted for initial weight differences for analysis. Diets con-

sisted of 80 g of milk-stage seed blended and mixed as described above.

Experiment 11 was designed to evaluate 10 randomly selected sorghum cultivars in the milk stage. Each cultivar was tested at the rate of 80 g of plant material with 300 ml of pinto bean diet without yeast and an untreated pinto bean-y check. The experiment was arranged as an RCB with 36 replications (1 larva/replicate). The diets and plant materials were prepared as described earlier. Larval weights were recorded at both 11 and 14 days after infestation.

Experiment 12 was designed to evaluate the same 10 cultivars evaluated in Experiment 11 but which had been frozen for 2 months. Experimental design was an RCB design with 24 replications (1 larva/replicate). Preparation of the diets and plant materials was similar to that in experiment 11. Larval weights were recorded at both 11 and 14 days after infestation.

Experiment 13 was designed to evaluate the materials used in experiments 11 and 12, but which had been allowed to mature naturally. Moisture content was equalized at ca. 12%. The experiment was planned to determine if the seeds were contaminated in the field by biological organisms. Equal quantities of seed of each line were washed in a 10% hypochlorite solution for 30 seconds. The experimental design was a split plot with 12 replications. Whole plots were clorox washed and unwashed seed treatments; subplots were sorghum lines. Each replicate consisted of 3 larvae. The preparation of the seed, diet material, and handling of the insects was as described earlier. Tannin analysis of dry seed was made using the procedure described by Burns (1971).

ANOVA of the data was performed for each experiment and means were separated by Duncan's multiple range tests at $P = 0.05$.

Results and Discussion

Although techniques for FAW resistance evaluations have been developed for seedling and whorl-stage investigations (Wiseman and Gourley 1982), it is extremely difficult to evaluate for differences among genotypes at the seed developmental stage. Infestations have been made using the modified "Bazooka" to dispense larvae directly into the developing panicles (Wiseman, unpublished) but contamination by other lepidopterous pests such as the corn earworm, *Heliothis zea* (Boddie), and the sorghum webworm, *Celama sorghiella* (Riley), prevents an accurate assessment of insect resistance. Therefore, the experiments described in this study were conducted to develop not only a system for sorghum cultivar evaluation but to determine the stage of panicle development and the concentration of seed per diet necessary to differentiate resistance levels in FAW feeding and development among cultivars.

Experiment 1: Differential FAW feeding responses for sorghum cultivars were measured among the 4 test panicle stages of development as determined by larval weights (Exp. 1, Table 1). Overall, the greatest inhibition of larval growth was found on the milk stage of seed development. Also, only the milk stage of panicle development resulted in a significant mean larval weight difference for the combined sorghum cultivars 'Funk 5245' and NK 'Savanna 5'. Larvae that were fed diets of NK 'Savanna 5' weighed significantly less than those fed diets of 'Funk 5245'.

TABLE 1. FAW 11-DAY WEIGHTS (MG) AFTER FEEDING ON SORGHUM OF VARYING STAGES OF PANICLE DEVELOPMENT MIXED IN A PINTO BEAN DIET WITHOUT YEAST. EXPERIMENT 1.

Stage of seed development	Mean larval weights[1]			Mean
	'Funk 5245'		NK 'Savanna 5'	
Before flowered	171.5 a		156.5 a	164.0 a
Early flower	158.9 ab		147.2 a	153.1 a
Check	147.5 abc		147.5 a	147.5 a
Flowered	125.1 c		136.0 a	130.6 b
Milk	137.5 bc	*	43.0 b	90.3 c
Mean	148.1	*	126.1	

[1]Means within a column followed by the same letter are not significantly different ($P = 0.05$). Cultivar means separated by * are significantly different at $P = 0.05$.

Experiments 2-6: Experiments 2-6 (summarized in Table 2) were designed to determine independently (with different stages of panicle development) the concentration of seed necessary in the pinto bean diet without the yeast, to demonstrate significant differences among FAW larval weights for the sorghum cultivar NK 'Savanna 5' and 'Funk 5245'. In every case, larvae that had been fed NK 'Savanna 5' in the bean-y diet were significantly smaller than those fed 'Funk 5245'. The larvae that were fed 20, 40, and 80 g/diet of NK 'Savanna 5' were significantly smaller than those fed 10 or 0 g/diet. The larvae that were fed the smallest concentration of 10 g/diet weighed significantly less than the check. In every experiment, however, the weights of the larvae fed on 'Funk 5245' diets was not consistent with the concentrations per diet. That is, as concentrations of diet increased, FAW larval weights did not increase or decrease except at the hard-dough stage and generally the drier seed stage. For those 2 stages, weights of the larvae generally increased as concentration of seed per diet increased. This feeding is not inconsistent in that adding susceptible seed to the diet may or may not add additional nutrients to the diet. If susceptible seed adds nothing to the diet, then high concentrations of plant materials could dilute the base diet and result in small larvae similar to those fed on the resistant cultivar diet. Yet, at every concentration of milk stage seed per diet, a significant difference in larval weight resulted between NK 'Savanna 5' and 'Funk 5245'. Similar results were found for experiments 3-6, but only at the higher concentrations of seed per diet were significant FAW weight differences detected between the 2 cultivars. This may be due to a decrease in the factor(s) implicated, thus decreasing from the milk-stage of seed development.

Experiments 7-9: When the standard pinto bean diet (Table 3) was used as the base diet, fewer larval weight differences were found among the various concentrations of 'Funk 5245'. Generally, however, the higher concentrations of 'Funk 5245' produced the largest larvae, and the smallest larvae were fed NK 'Savanna 5', indicating that 'Funk 5245' was a susceptible cultivar and NK 'Savanna 5' a resistant cultivar. Again, significant larval weight differences were detected between the two sorghum cultivars at the various panicle developmental stages.

TABLE 2. FAW LARVAL WEIGHTS (MG) AFTER FEEDING FOR PERIODS OF 9-11 DAYS ON SORGHUM SEED OF VARYING STAGES OF MATURITY MIXED IN A PINTO BEAN DIET WITHOUT YEAST. EXPERIMENTS 2-6.[1]

	Mean larval weights at various stages of seed development[2]											
	Experiment 2			Experiment 3			Experiment 4			Experiment 5			Experiment 6		
	Milk			Soft dough			Hard dough			Dry seed #1			Dry seed #2		
G/diet	'Sav 5'		'F5245'	'Sav 5'		'F5245'	'Sav 5'		'F5245'	'Sav 5'		'F5245'	'Sav 5'		'F5245'
0	109.5 a		96.1 c	68.5 a		70.8 b	65.5 a		59.9 c	71.0 a		71.9 c	121.1 a		131.1 c
10	58.2 b	*	125.2 b	—		—	—		—	—		—	—		—
20	40.0 c	*	139.3 b	20.6 b	*	100.0 a	57.7 a		73.7 b	63.1 a		93.7 b	133.3 a		171.7 ab
40	36.6 c	*	158.1 a	11.2 bc	*	64.9 b	40.2 b	*	91.9 a	55.2 a	*	118.2 a	113.1 a		193.6 a
80	22.3 c	*	130.7 b	1.8 c	*	18.2 c	25.3 c	*	81.9 ab	26.3 b	*	31.7 d	65.6 b	*	194.6 a
120	—		—	—		—	—		—	—		—	22.0 c	*	157.4 bc
Mean	53.3	*	129.9	25.5	*	63.5	47.2	*	76.9	53.9	*	78.9	91.0	*	170.6

[1]Age of larvae for larval weights for the following stages are: milk = 11 days; soft and hard dough = 9 days, dry seed = 10 days, and drier seed = 11 days. Moisture content of dry seed #1 = 18.1% and 19.0% for 'F5245' and 'Sav 5', respectively, and dry seed #2 = 15.1% and 16.4% for 'F5245' and 'Sav 5', respectively.

[2]Means within a column followed by the same letter are not significantly different (P = 0.05). Cultivar means separated by * are significantly different (P = 0.05).

TABLE 3. FAW LARVAL WEIGHTS (MG) AFTER FEEDING FOR PERIODS OF 8-11 DAYS ON SORGHUM SEEDS MIXED IN A STANDARD PINTO BEAN DIET[1].

	Mean larval weights at various stages of seed development[2]								
	Experiment 7			Experiment 8			Experiment 9		
	Soft dough			Dry seed			Drier seed		
G/diet	'Sav 5'		'F5245'	'Sav 5'		'F5245'	'Sav 5'		'F5245'
0	199.7 a	n.s.	194.3 c	125.7 a	n.s.	121.8 b	313.9 a	n.s.	322.0 ab
20	137.7 b	n.s.	275.0 a	49.9 b	*	122.7 b	214.4 b	n.s.	297.1 b
40	71.7 c	*	236.8 b	47.2 b	*	162.4 a	180.7 bc	n.s.	302.9 b
80	15.4 d	*	235.6 b	39.5 b	*	156.0 a	143.2 c	*	359.5 a
120	—		—	—		—	62.4 d	*	317.8 ab
Mean	106.1	*	235.4	65.6	*	140.7	182.9	*	319.9

[1]Age of larvae for larval weights for the following stages are: soft dough = 9 days; dry seed = 8 days; drier seed = 11 days. Moisture content of dry seed = 18.1% and 19.0% for 'F5245' and 'Sav 5', respectively; for drier seed = 15.1% and 16.4% for 'F5245' and 'Sav 5', respectively.

[2]Means within a column followed by the same letter are not significantly different (P = 0.05). Cultivar means separated by * are significantly different (P = 0.05).

Experiment 10: Table 4 shows the data for the FAW larvae fed the regular pinto bean diet for 2, 4, or 6 days and then transferred to the pinto bean-y diet and 80 g of NK 'Savanna 5' or 'Funk 5245'. The larvae fed 'Savanna 5' weighed less than those fed 'Funk 5245' and those that fed longest on the sorghum and bean-y diet weighed less than those fed the shortest period of time. Weights of larvae fed 6 days on the regular diet and then transferred to the sorghum seed and bean-y diet were not significantly different. This may indicate that the larger larvae may overcome or tolerate the factor(s) causing the growth inhibition that is produced as a result of feeding on the NK 'Savanna 5' diet for their entire feeding period.

TABLE 4. WEIGHTS OF FAW LARVAE FED REGULAR BEAN DIET FOR 2, 4, 6 DAYS, THEN TRANSFERRED TO MILK STAGE SORGHUM SEED BEAN-Y DIET AND WEIGHED AT 11 DAYS—1983. EXPERIMENT 10

Cultivar	Mean larval weights (mg) at 11 days[1] for larvae previously fed on standard diet for			Mean
	2 day	4 day	6 day	
'Funks 5245'	414.20 a	461.99 a	459.81 a	445.34 a
Check	438.85 a	415.41 b	340.65 b	398.30 b
NK 'Savanna 5'	314.89 b	340.88 c	444.50 a	366.76 c
Day means	389.31 y	406.09 xy	414.99 x	

[1]Means within a column followed by the same letter are not significantly different ($P = 0.05$). Day means followed by the same letter are not significantly different ($P = 0.05$).

Experiments 11-12: Table 5 shows the data for 11- and 14-day weights of FAW fed both fresh and frozen samples of 10 sorghum cultivars mixed in a bean-y diet plus a bean-y check. FAW larvae that were fed fresh 'Paymaster GR 1138' diet mixtures were the largest larvae of the 10 cultivars evaluated. The weights for FAW feeding on a number of the fresh cultivars mixed in diets indicate that several are quite unacceptable, as indicated by the extremely poor larval growth produced by the 14th day. There was no apparent relationship between tannin content of the dry seed and larval growth (e.g., 'TAM 2566 x PI 383856' (6)-5) or the lack of growth ($P = 0.05$) on the fresh or frozen seed diets. A comparison of the weights of FAW larvae fed fresh or frozen seed diets indicated no significant relationship existed at the 5% level of confidence. But, at 14 days, a significant relationship was found at the 9% level of confidence. We do not know why a stronger relationship between weights of larvae fed the same cultivars did not exist. Therefore, the factor(s) causing the growth inhibition on the fresh or frozen seed diets cannot be explained. The procedure of freezing the samples for 2 months may have changed some seed samples and not others. The frozen milk-stage samples may have been altered chemically for some cultivars and not others, or the fresh seed may have been contaminated with disease organism(s).

Experiment 13: In comparisons of the 10 sorghum diets tested as dry seed washed in clorox or with no clorox wash, the larvae fed 'Coker 7737' and 'Paymaster GR 1138' diets were the largest over both treatments, and

TABLE 5. MEAN WEIGHTS (MG) OF FAW FED 10 SORGHUM LINES, FRESH OR FROZEN, TWO MONTHS IN THE MILK STAGE AND MIXED IN BEAN-Y DIETS. EXPERIMENTS 11-12[1]

Entry	Mean larval weights (mg)			
	11 day		14 day	
	Fresh	Frozen	Fresh	Frozen
'Coker 7737'	8.5 f	131.7 a	6.7 f	264.6 a
'Paymaster GR 1138'	164.1 b	119.9 a	360.1 b	217.6 b
(TAM 2566 x PI 383856) (6)-5	28.3 cde	114.0 a	40.9 de	214.0 b
(TAM 2566 x PI 383856) (6)-8 x 1460 cm	38.3 c	82.4 b	97.4 c	193.2 bc
'Funks G1498'	11.2 f	77.9 b	14.0 f	110.7 d
Bean-y check	186.4 a	51.7 bc	411.0 a	162.0 c
'GroAgr GSC 1299'	10.1 f	29.1 cd	10.1 f	40.0 e
(TAM 2566 x PI 383856) (6)-6	15.6 ef	16.1 d	23.3 ef	19.1 e
(TAM 2566 x PI 383856) (6)-11	19.4 def	7.5 d	25.9 ef	8.0 e
NK 'Savanna 5'	8.1 f	7.1 d	11.3 f	7.9 e
'TAM 2566'	33.1 cd	6.4 d	49.3 d	6.7 e

[1]Means within a column followed by the same letter are not significantly different P = 0.05.

larvae fed NK 'Savanna 5' and 'TAM 2566' diets were the smallest. Only in one case did a significant difference exist between clorox washed and unwashed seed of the same cultivar at 11 days, whereas significant effects were observed at 14 days. However, at both 11 and 14 days, a highly significant positive correlation (P = 0.0001) was found, indicating that most of the lines performed the same with or without clorox, even though differences were found between the washed and unwashed cultivars. Their general ranking was not altered.

The small, stunted larvae that were produced on some of the sorghum seed diets, such as 'Coker 7737' at the fresh stage and 'TAM 2566' at the dry stage, were examined by Dr. J. J. Hamm (insect pathologist, USDA, Tifton, GA) and found to be free of disease. Therefore, the small larvae that were produced on some of the sorghum seed diets could be due to a feeding deterrent or nutritional differences among the cultivars. Based on these tests, tannin content of the seed does not appear to be related to the differences between cultivars since a nonsignificant correlation was found for Experiment 12 and also for Experiment 13. Two of the highest tannin lines with 3.45% and 2.21% and 2 of the lowest tannin lines with 0.43% and 0.92% all produced some of the smallest larvae found at the conclusion of the test. However, the highest tannin concentration has been found to be at the milk-stage of seed development (Hoshino and Duncan 1982). Some of our best detectable differences were found at the milk stage of development and between low and high tannin cultivars. Therefore, if tannin or tannin-like compounds are implicated in the resistance measured in these tests, the reason(s) for the lack of a significant correlation cannot be explained.

In summary, differences in FAW feeding responses can be measured among cultivars in a substandard bean-y diet mixed with developing

TABLE 6. MEAN WEIGHTS OF FAW FED 10 SORGHUM LINES (DRY SEED) WITH AND WITHOUT A CLOROX WASH AND MIXED IN BEAN-Y DIETS[1].

Entry	Mean larval weights (mg)							
	11 day			14 day				
	With clorox		W/o clorox	With clorox		W/o clorox	Mean	% tannin
'Coker 7737'	106.4 a		119.0 a	227.2 a		238.0 a	172.7	1.04
'Paymaster GR 1138'	91.7 ab		92.1 b	218.3 a		220.2 ab	157.1	0.82
(TAM 2566 x PI 383856) (6)-11	88.2 abc		100.6 b	218.1 a	*	181.1 c	147.2	0.66
'GroAgr GSC 1299'	88.2 abc		88.5 bc	238.0 a	*	188.7 bc	150.9	0.75
B-y check	47.2 e		60.3 de	176.7 b		201.3 bc	121.9	0.00
(TAM 2566 x PI 383856) (6)-6	78.0 bc		71.4 cd	181.5 b	*	139.2 d	121.6	0.89
NK 'Savanna 5'	45.0 e		47.2 e	146.2 bc		128.2 e	91.7	2.21
(TAM 2566 x PI 383856) (6)-5	70.5 cd		41.9 e	154.5 bc	*	67.0 e	83.5	3.45
(TAM 2566 x PI 383856) (6)-8 x 1460 cm	55.8 de		49.5 de	135.3 cd	*	90.3 e	83.3	0.43
'Funks G1498'	54.2 de		55.4 de	109.1 d		90.4 f	76.2	0.85
'TAM 2566'	19.3 f		10.4 f	25.7 e		13.1	19.4	0.92
Mean	67.7	ns	66.9	166.4	*	141.6		

[1]Means within a column followed by the same letter are not significantly different (P = 0.05). Entry means within days separated by * are significantly different P = 0.05.

sorghum seed. The stage of plant development where the greatest differences were expressed was in the milk stage of seed development. The small, stunted larvae from some of the sorghum seed diet mixtures were apparently not produced by external factors and appeared to be a nutritional problem associated with the FAW feeding responses. No causative statistical relationship was found between tannin content and the seed and FAW growth responses, even though the biological basis points in this direction.

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