Executive Summary

Second Year Annual Report -- November 1, 1999

Establish a Regional Center to Identify Genetic Insect & Mite Pest Resistance

(USGA Green Section Research & Texas Research Foundation Project 440291-0001)

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The Project has established a Regional Center to screen and evaluate turfgrass germplasm for resistance to insect and mite pests. The primary goal of this project is to identify genetic lines of several turfgrass species (bermudagrass, zoysiagrass, buffalograss, seashore paspalum, bentgrass and bluegrass) with resistance to the primary pests; caterpillars (fall armyworms, black cutworms, sod webworms), white grubs and host specific eriophyid mites, and to characterize the mechanisms of resistance. An important part of the project is the development of efficient screening procedures to effectively identify genetic resistance. A secondary goal is for the cooperative grass breeders to incorporate the resistance into new cultivars to help eliminate our dependancy on pesticides in the multi-billion dollar turf industry.

Work has continued with the elite germplasm of bermudagrass (*Cynodon* spp.) from the breeding program under Dr. Charles Taliaferro at Oklahoma State University, Stillwater. Thirty-two bermudagrass hybrids and four commercial cultivars were evaluated for resistance to newly hatched or neonate larvae of fall armyworm in no-choice feeding studies. This was a second set of experiments with many of these bermudagrasses. Among the hybrids, 3200W 18-11 provided the highest mortality (25%) along with four other genotypes, and larvae fed on this genotype were the smallest (38.16 mg) when weighed as 10-day-old larvae. Larvae fed on this cultivar required 32 days from egg hatch to adult emergence which was four to five days longer than on many of the other genotypes. Small larvae weighing less than 70 mg and also taking 31-32 days for development from egg to adult were recorded from 3200W 70-18 and 3200W 94-2. In a second experiment, highest mortality was recorded for 4200W 56-14 and 4200W 74-3, with 16.67 and 12.50%, respectively. These two cultivars along with CCB 24-4, CCB 10-9 and Greg Norman1 also produced larvae weighing less than 70 mg after 10 days feeding. Larvae feeding on CCB 24-4, 4200W 25-7 and Greg Norman 1 also required 31-32 days from egg to adult emergence. The largest larvae (>160 mg) were produced on 3200W 6-12, Tifway, 4200W 53-1 and 4200W 47-1. Larvae developed fastest on 4200W 47-1 and took only 26.51 days from egg to adult. Additional studies are planned with this germplasm base to identify potential resistance to the other important pests.

Progress has been made to identify the heritability of fall armyworm resistance in hybrids of zoysiagrass (*Zoysia* spp.) from the breeding program under Dr. M. C. Engelke at Texas A&M University, Dallas. In two experiments, 18 *Zoysia* hybrids were compared with 'Cavalier' (high antibiosis), 'Diamond' and 'Crowne' (each, parents of several of the hybrids) and 'Meyer' an industry standard. Cavalier, TAES 4374 and Meyer, each provided significant mortality of the developing larvae with at least 75% mortality before adult emergence. Larval mortality on Meyer was much higher in this test than in previous experiments. Feeding on each of these grasses was significantly less than on any of the other grasses in the study. In a second experiment, Cavalier and TAES 4374 again produced the highest larval mortality. TAES4373, TAES4359 and TAES4362 also provided larval mortality greater than 95%. Surviving larvae were smallest on these five hybrids (<28 mg), while the hybrid (TAES 4355) produced the largest larvae (mean =163 mg).

These experiments have identified several hybrids of *Zoysia* with high levels of resistance to the fall armyworm. An additional form of resistance, the lengthing of the developmental period was documented. This has the added benefit of increased mortality under field conditions by longer exposure to natural predators and parasites. Additional tests are underway to confirm these results and to identify the range of resistance produced among hybrids with Cavalier as a parent. Experiments are also planned to identify additional resistance to the zoysiagrass eriophyid mite which has become a serious pest across the Zoysia Belt.

A third area of work was designed to identify potential resistance to white grubs (*Phyllophaga* spp.) in Texas bluegrass (*Poa arachnifera*) and its hybrids with Kentucky bluegrass (*Poa pratensis*) from the breeding program under Dr. James Read at Texas A&M University, Dallas. A two-year-old replicated planting of 36 genotypes of Texas bluegrass and three hybrids with Kentucky bluegrass was evaluated for resistance to *Phyllophaga* white grub damage. Two visual ratings and total grub population counts were made. TX 6-10 and TX32-7 each exhibit no visual grub damage on any of the 8 reps when evaluated in April 1999. Also, TX 31-2, TX 5-6, TX 16-9 and TXKY 37-25 each exhibited visible grub damage in only one of the 8 plots/genotype during the April evaluation. These same genotypes along with TX 12-8 were rated 3.75 to 4.00 (scale 1-5; 5 = no damage) during a second evaluation in May 1999. Surprisingly, these same plots had some of the highest grub populations (means of 5.50 to 10.50 grubs per plot) feeding on their roots. The two genotypes, (TX 6-10 and TX 32-7) which ranked so high in both visual evaluations had mean populations of 7.88 and 8.20 grubs per plot, respectively. Highest grub damage was observed on TX 28-2 and TXKY 37-10 with seven and six of the 8 plots, respectively, showing grub damage, even though neither genotype had exceptionally high grub populations.

This experiment yielded rather unexpected set of results. The best looking grasses had some of the highest grub populations feeding within the roots, but these plants were still well anchored and exhibited a very solid and undisturbed root mass. This data indications that we have discovered several genotypes of Texas bluegrass with a high level of tolerance to *Phyllophaga* white grubs. New cultivars with this form of resistance can be very beneficial in the landscape when they are made available. Additional studies are planned to confirm the tolerance resistance.

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Support Personnel: Mr. Steven J. Maranz, Research Associate and Mr. Dennis Hays, Research Assistant.

Purpose: A Regional Center was established to screen and evaluate turfgrass germplasm for resistance to insect and mite pests. The primary goal of this project is to identify genetic lines of several turfgrass species (bermudagrass, zoysiagrass, buffalograss, seashore paspalum, bentgrass and bluegrass) with resistance to the primary pests; caterpillars (fall armyworms, black cutworms, sod webworms), white grubs and host specific eriophyid mites, and to characterize the mechanisms of resistance. This process requires the development of efficient screening procedures to effectively identify genetic resistance to target pests. A secondary goal is for the cooperative grass breeders to incorporate the insect and mite pest resistance into agronomically acceptable cultivars to help eliminate our dependency on pesticides in the multi-billion dollar turf industry.

Progress: Work has continued with the elite germplasm of bermudagrass (*Cynodon* spp.) from the breeding program under Dr. Charles Taliaferro at Oklahoma State University, Stillwater, and with commercial cultivars of bermudagrass under culture at the TAMU-Dallas Center. Progress has been made to evaluate hybrids of several zoysiagrass (*Zoysia* spp.) from the breeding program under Dr. M. C. Engelke at Texas A&M University, Dallas, to identified the heritability of fall armyworm resistance. A third area of work was designed to identify potential resistance to white grubs (*Phyllophaga* spp.) in Texas bluegrass (*Poa arachnifera*) and its hybrids with Kentucky bluegrass (*Poa pratensis*) from the breeding program under Dr. James Read at Texas

A&M University, Dallas, TX.

Bermudagrass hybrids – evaluation for Fall Armyworm resistance:

Methods --

Bermudagrass genotypes (Table 1) were maintained in the greenhouse and grown in 18-cell trays (each cell measuring 7.5 x 7.5 cm and 4 cm deep). Clippings from these plants were used to feed the fall armyworm larvae in no-choice laboratory experiment. The two experiments were conducted when plants were actively growing. Each experiments was set up in the laboratory using 9-cm diam. x 20 mm deep plastic petri dishes as larvae feeding chambers. Each dish was provided with two water saturated 7.5-cm filter paper discs. Water was added to the filter paper as needed to keep it saturated to help maintain the grass cuttings. Each dish was provided with a small amount of fresh leaf tissue (ca. 3 g) of the respective grass entries. Grass was added or replaced daily or every-other-day throughout the experiment so that turgid fresh grass was always available to the developing larvae.

For Experiment 1 and 2, three newly hatched larvae or neonate (larvae had not been allowed to feed after egg hatch) were selected from the colony and placed on the respective grasses (listed in Table 1) in each dish and the dishes were arranged in a randomized complete block design with eight replicates. Survivorship was recorded 4 days after each test was established, and when clippings were added either daily or every-other-day until pupation and at adult emergence. Each surviving larva was weighed when 10-days-old which was well before any pupation occurred and pupa were weighed within 1 day after pupation. Days-to-pupation and adult emergence were calculated for all surviving individuals.

The data will be analyzed using the General Linear Model procedure and means separated by Waller-Duncan k-ratio t test ($P = 0.05$). Mortality data will be transformed to arcsine for analysis (SAS Institute, Release 6.12 1989-1996).

Results and Discussion –

This was a second set of experiments with many of these bermudagrass genotypes. A second run was needed since during the first experiments, plant material was limited and we ran out of plant material for several of the genotypes and were not able to get replicated mortality data for the later life stages. In these experiments, each of the bermudagrasses (Table 2-3) were evaluated by feeding neonates on them in no-choice feeding studies. Among the hybrids in Experiment 1, 3200W 18-11 provided the highest mortality (25%) along with four other genotypes and larvae fed on this genotype were the smallest (38.16 mg) when weighed as 10-day (Table 2). Additionally, larvae fed on this cultivar required 32 days from egg hatch to adult emergence which was four to five days longer than on many of the other genotypes. Small larvae that weighed less than 70 mg and also took from 31-32 days for development to adult emergence were recorded for 3200W 70-18 and 3200W 94-2. In Experiment 2, highest mortality at adult emergence was recorded for 4200W 56-14 and 4200W 74-3, with 16.67 and 12.50%, respectively (Table 3). These two cultivars along with CCB 24-4, CCB 10-9 and Greg Norman1 also produced larvae weighing less than 70 mg after 10 days of feeding. Additionally, larvae feeding on CCB 24-4, 4200W 25-7 and Greg Norman 1 also required 31-32 days for development from egg to adult emergence. In the two experiments, the largest larvae (>160 mg) were produced on 3200W 6-12, Tifway, 4200W 53-1 and 4200W 47-1. Larvae developed the fastest on 4200W 47-1 and took only 26.51 days from egg to adult emergence. Additional studies are planned with this germplasm base to identify potential resistance to the other important pests of bermudagrass.

Zoysiagrass hybrids – evaluation for Fall Armyworm resistance:

***Methods* --**

Zoysiagrass genotypes (Tables 4-5) were maintained in the greenhouse and grown in 18-cell trays (each cell measuring 7.5 x 7.5 cm and 4 cm deep). Clippings from these plants were used to feed the fall armyworm larvae in no-choice laboratory experiment. The two experiments were conducted in the Spring when plants were actively growing and established on 11 April 1997 and 22 May 1997 for Experiment 1 and 2, respectively. Both experiments were set up in the laboratory using 9-cm diam. x 20 mm deep plastic petri dishes as larvae feeding chambers. Each dish was provided with two water saturated 7.5-cm filter paper discs. Water was added to the filter paper as needed to keep it saturated to maintain the grass cuttings. Each dish was provided with a small amount of fresh leaf tissue (ca. 3 g) of the respective grass entries. Grass was added or replaced daily or every-other-day throughout the experiment so that turgid fresh grass was always available to the developing larvae.

For these studies, a colony of fall armyworm larvae was reared on fresh tissue of 'Laser' rough bluegrass (*Poa trivialis*), which serves as an excellent host with high survival. In each experiment, three, 4-day-old larvae were randomly selected from the colony and placed on the grass in each dish and dishes were arranged in a randomized complete block design with eight replicates. Survivorship was recorded 3 days after each test was established (7-day-old larvae) and when clippings were added either daily or every-other-day until pupation and at adult emergence. Each surviving larva was weighed when 17-days-old which was well before any pupation occurred and pupa were weighed within 1day after pupation. Days to pupation and adult emergence were calculated for all surviving individuals.

Data were analyzed using the General Linear Model procedure and means separated by Waller-Duncan k-ratio t test (P = 0.05). Mortality data was transformed to arcsine for analysis, but actual percentage mortality is presented (SAS Institute, Release 6.12 1989-1996).

***Results and Discussion* –**

Two experiments were conducted to compare the various *Zoysia* hybrids with 'Cavalier', a cultivar previously identified with high resistance (antibiosis) to fall armyworm and with 'Diamond' and 'Crowne' (each, parents of several of the hybrids) and with 'Meyer' used as an industry standard. In Experiment 1 (Table 4), Cavalier, TAES 4374 and Meyer, each provided significant mortality of the developing larvae with at least 75% of the larvae dead before adult emergence. The larval mortality on Meyer in this test was much higher than in previous experiments. Additionally, larvae feeding on each of these grasses was significantly less than exhibited by larvae that fed on any of the other grasses in the study.

In Experiment 2 (Table 5), Cavalier and TAES 4374 again produced the highest mortality of the confined larvae. TAES4373, TAES4359 and TAES4362 also provided larval mortality greater than 95%. Surviving larvae were smallest on these five hybrids (<28 mg), while the hybrid (TAES 4355) produced the largest larvae (mean = 163 mg).

These experiments have identified several hybrids of *Zoysia* with high levels of resistance to the fall armyworm. Resistance in the form of larval mortality and an extended developmental period were documented. Slowed larval development has an added benefit of increased mortality due to natural predation since the foraging larvae would be exposed longer to their natural enemies. Also, past experience reminds us that there is a high probability that these same genotypes may also be resistant to other species of the caterpillar complex such as black cutworm and sod webworms. Additional tests are underway to confirm these results and to identify the range of resistance produced among hybrids with Cavalier as a parent. Experiments are also planned to identify additional resistance to the zoysiagrass mite which has become a serious pest across the Zoysia Belt.

Texas bluegrass hybrids – evaluation for White Grub resistance:

Methods --

A two-year-old replicated planting of 36 genotypes of Texas bluegrass, *Poa arachnifera* Torr., and three Texas bluegrass X Kentucky bluegrass, *P. pratensis* L., hybrids was evaluated for resistance to white grub damage. Each genotype was growing in plots measuring ca. 16 x 22 in. (ca. 2.44 ft^2) in a randomized complete block design with 8 replications. A field population of *Phyllophaga* spp. had established in the plots and was causing significant damage to many of the genotypes. Two visual damage ratings were taken for each plot on 21 April 1999 and on 28 May 1999. During the April rating, only a presence or absence of white grub damage was recorded by first visually examining each plot and then checking for good root attachment by pulling upwards on the plants at several locations within the plot. In May, each plot was rated on a scale of 1-5; with 1 = most damage with plant yellowing and almost totally dead with severe loss of root anchoring, and 5 = plant undamaged, vigorous and no indication of loss of root attachment. Plots were visually examined and the leaves of 4 or 5 random plants within the plot were pinched and pulled to indicate potential root damage and loss of anchoring. If none of these plants easily pulled, the grass was ranked as a 5, however, if several of these plants were easily pulled indicating the roots had been severed, up to 10 plants, were then evaluated. Within a week and a half after the May visual evaluation, each of the plots was excavated to a depth of 6 to 10 inches, depending upon the individual root structure, and the soil and root were carefully raked so that all grubs were removed for identification and counting.

Data were analyzed using the General Linear Model procedure and means separated by Waller-Duncan k-ratio t test (P = 0.05) (SAS Institute, Release 6.12 1989-1996).

Results and Discussion –

Results of the two visual ratings and the population counts for *Phyllophaga* white grubs on the bluegrass genotypes are presented in Table 1. The parent plant from which each selection was made is also listed. TX 6-10 and TX32-7 each exhibit no visual grub damage on any of the 8 reps when evaluated on 21 April 1999. Additionally, TX 31-2, TX 5-6, TX 16-9 and TXKY 37-25 each exhibited visible grub damage in only one of the 8 plots during the April evaluation. These same genotypes along with TX 12-8 were rated 3.75 to 4.00 for the 28 May 1999 evaluation. Surprisingly, however, these same plots had some of the highest grub populations (means of 5-50 to 10.50 grubs per plot) feeding on their root systems. The two genotypes, TX 6-10 and TX 32-7 which ranked so high in both visual evaluations had mean populations of 7.88 and 8.20 grubs per plot, respectively, and highest populations of 17 and 14 grubs, respectively. The highest variation in population was excavated from under the TX 5-6 plots with a range of 3 to 28 grubs per plot. Highest damage was observed on TX 28-2 and TXKY 37-10 with 7 and 6 plots, respectively, showing grub damage, even though neither genotype had exceptionally high grub populations. Among the nine unselected TX Syn-1 plantings, there was also considerable variation in damage and grub populations.

This experiment yielded a rather unexpected data set. The best looking grasses had some of the highest grub populations feeding within the roots, but the plants were still well anchored and exhibited a very solid and undisturbed root mass. Indications are that we have discovered several genotypes of Texas bluegrass with a high level of tolerance to *Phyllophaga* white grubs. New cultivars with this form of resistance can be very beneficial in the landscape when they are made available. Additional studies are planned to confirm the tolerance resistance.

Publications by the Project Leader:

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Table 1. bermudagrass genotypes and cultivars evaluated:

Genotype/ Cultivar [1]	Cross
3200W 1-20	4200 36-10 Cda X 3200 22-4 Ctr
3200W 6-12	4200 TN 19-6 Ctr X 3200 Cda (Aust)
3200W 18-11	3200 TN Beijing X 4200 TN 32-6 Ctr
3200W 30-20	4200 TN 24-2 Ctr X 3200 E PRC-7 Cda
3200W 70-18	3200E TN Ctr X 3200E 7-5 Cda (Aust)
3200W 78-10	Beijing Cda X 4200 TN 24-2 Ctr
3200W 94-2	4200 TN Ctr X 4200 TN 36-10 Cda
3200W 9-4	4200 TN 36-10 X 3200E 4-7 Ctr 1397
4200W 19-18	3200W 41-8 op
4200W 20-6	3200W 41-8 op
4200W 22-10	3200W 41-8 op
4200W 22-13	3200W 41-8 op
4200W 25-7	3200W 41-8 op
4200W 25-15	3200W 41-8 op
4200W 26-13	3200W 41-8 op
4200W 46-4	3200W 41-8 op
4200W 47-1	3200W 41-8 op
4200W 47-7	3200W 41-8 op
4200W 49-17	3200W 41-8 op
4200W 51-14	3200W 41-8 op
4200W 52-15	3200W 41-8 op
4200W 53-1	3200W 41-8 op
4200W 55-5	4200 TN 36-10 op
4200W 25-1	Beijing op
4200W 38-2	PRC-7
4200W 56-14	
4200 74-3	
4200W 68-9	
CCB 10-9	
CCB 24-4	
CCB 25-6	
ERS-Turf	
Greg Norman 1	
Midlawn	
Tifway	
Tift 94	

[1] Hybrid bermudagrasses obtained from Dr. Charles Taliaferro's breeding program at Oklahoma State University, Stillwater, OK.

Table 2. Survival and larval weight and survival and days to adult emergence for fall armyworm fed as neonate larvae on clippings of bermudagrass genotypes (Jan.-Feb. 1999).

Bermudagrass	10-day-old larvae		Adult	
	% alive[1]	Wt. (mg)[2]	% alive[1]	Days to adult[3]
3200W 18-11	95.83	38.16	75.00	31.94
3200W 70-18	91.67	49.60	87.50	32.00
3200W 94-2	100	68.98	95.83	30.74
3200E 9-4	100	87.48	83.33	30.60
3200W 30-20	91.67	95.55	83.33	30.40
4200W 52-15	100	96.22	75.00	29.11
4200W 19-18	95.83	100.72	75.00	28.39
3200W 78-10	100	102.45	87.50	29.48
4200W 20-6	95.83	104.71	79.17	28.89
Greg Norman 1	100	113.93	91.67	28.91
4200W 49-17	95.83	114.20	75.00	28.22
4200W 22-10	91.67	114.40	87.50	28.57
4200W 51-14	87.50	136.62	75.00	27.72
4200W 47-7	87.50	138.82	83.33	29.10
3200W 1-20	83.88	142.00	79.17	27.89
4200W 22-13	91.67	145.26	70.83	28.35
4200W 53-1	95.83	164.91	87.50	27.81
Tifway	95.83	182.42	79.17	26.95
3200W 6-12	100	195.90	79.17	29.16

[1] Mean % of larvae alive at 10 days after egg hatch and % that emerged as adults.
[2] Mean weight of surviving 10-day-old larvae after feeding on each genotype.
[3] Mean number of days from egg hatch to adult emergence for surviving insects.

Table 3. Survival and larval weight and survival and days to adult emergence for fall armyworm fed as neonate larvae on clippings of bermudagrass genotypes (Feb.-Mar. 1999).

Bermudagrass	10-day-old larvae		Adults	
	% alive[1]	Wt. (mg)[2]	% alive[1]	Days to adult[3]
4200W 56-14	83.33	48.67	16.67	28.00
CCB 24-4	100	56.29	41.67	32.40
CCB 10-9	100	60.29	88.00	30.86
Greg Norman 1	100	64.90	95.83	31.09
4200W 25-7	66.66	67.64	12.50	32.67
4200W 74-3	88.00	78.57	83.33	30.50
ERS-Turf	100	96.29	100	29.38
4200W 68-9	95.83	102.43	58.33	28.86
CCB 25-6	88.00	108.96	75.00	29.44
4200W 55-5	95.83	114.79	83.33	28.40
4200W 25-1	100	116.09	95.83	27.83
Tift 94	100	129.66	95.83	28.09
Tifway	100	137.54	95.83	28.22
4200W 38-2	91.67	140.66	58.33	27.36
4200W 26-13	100	141.44	95.83	27.70
Midlawn	95.83	142.40	87.50	27.05
4200W 25-15	100	148.01	100	28.17
4200W 47-1	95.83	163.20	95.83	26.51

[1] Mean % of larvae alive at 10 days after egg hatch and % that emerged as adults.
[2] Mean weight of surviving 10-day-old larvae after feeding on each genotype.
[3] Mean number of days from egg hatch to adult emergence for surviving insects.

Table 4. Resistance among *Zoysia* hybrids to fall armyworm fed as 4-day-old larvae (6 replications).

Genotypes	Pedigree	10 day[1,3] mort (%)	17 day[1,3] mort (%)	Adult[1] mort (%)	17 day[2] larvae wt (mg)
TAES4374	DALZ8501 x Diamond	62.5 a	79.2 a	83.3 a	22.6 a
Cavalier		54.2 ab	79.2 a	79.2 a	29.2 a
Meyer		50.0 abc	70.8 a	75.0 a	34.0 a
TAES8501	parent	12.5 fg	33.3 b	50.0 b	84.2 bc
TAES4378	Diamond x DALZ8501	37.5 bcd	37.5 b	37.5 bc	77.9 b
Diamond	parent	33.3 cde	37.5 b	37.5 bc	86.4 bc
TAES4360	DALZ8501 x Crowns	4.2 fg	20.8 bcd	33.3 bcd	56.7 ab
TAES4375	DALZ8501xCrowne	20.8 def	25.0 bc	29.2 b-e	53.2 ab
TAES4372	Crowns x Diamond	16.7 efg	25.0 bc	29.2 b-e	114.9 cd
TAES4361	DALZ8501 x Crowns	12.5 fg	20.8 bcd	25.5 c-f	169.7 ef
Crowns	parent	20.8 def	20.8 bcd	25.0 c-f	134.7 de
TAES4368	Crowns x DALZ8501	0.0 g	0.0 e	16.7 c-f	173.9 f
TAES4376	DALZ8501 x Crowns	8.3 fg	8.3 cde	12.5 def	87.6 bc
TAES4370	Crowns x Diamond	8.3 fg	8.3 cde	8.3 ef	151.4 ef
TAES4377	DALZ8501 x Diamond	0.0 g	0.0 e	4.2 f	149.2 def

[1] Mean % of larvae alive at days after egg hatch, % pupation and % that emerged as adults.
[2] Mean weight of surviving larvae after feeding on each genotype for 10 days.
[3] Analysis was made on arc sine transformation of the percent mortality data: Percent mortality is presented.
[4] Means in a column not followed by the same letter are significantly different by Waller-Duncan k-ratio t test (k = 100) P = 0.05).

Table 5. Resistance among *Zoysia* hybrids to fall armyworm fed as 4-day-old larvae (6 replications).

Genotypes	Pedigree	10 day[1,3] mort (%)	17 day[1,3] mort (%)	Adult[1] mort (%)	17 day[2] larvae wt (mg)
TAES4374	DALZ8501 x Diamond	87.5 ab	100 a	100 a	0 a
Cavalier		95.8 a	95.8 a	95.8 a	22.3 ab
TAES4362	DALZ8501xCrowne	70.8 bc	91.7 ab	95.8 a	28.1 abc
TAES4373	DALZ8501xDiamond	79.2 ab	83.3 abc	83.3 ab	14.9 a
TAES4359	DALZ8501xCrowne	79.2 ab	83.3 abc	83.3 ab	19.1 ab
Meyer		66.7 bc	66.7 cd	70.8 bc	90.5 d
TAES8501	Parent	50.0 cd	75.0 c	75.0 bc	64.4 a-d
TAES4357	DALZ8501xCrowne	37.5 de	45.8 e	50.8 bc	66.4 bc
Diamond	Parent	33.3 de	41.7 e	50.0 de	91.0 d
Crowns	Parent	33.3 de	37.5 e	50.0 de	84.6 d
TAES4363	DALZ8501xCrowne	25.0 e	37.5 e	41.7 e	77.5 cd
TAES4355	DALZ8501xCrowne	16.7 e	16.7 f	20.8 f	163.1 d

[1] Mean % of larvae alive at days after egg hatch, % pupation and % that emerged as adults.
[2] Mean weight of surviving larvae after feeding on each genotype for 10 days.
[3] Analysis was made on arc sine transformation of the percent mortality data: Percent mortality is presented.
[4] Means in a column not followed by the same letter are significantly different by Waller-Duncan k-ratio t test (k = 100) P = 0.05).

Table 6. Visual damage and white grub populations on plots of Texas bluegrass and Texas bluegrass X Kentucky bluegrass hybrids (Summer 1999) (8 replicates).

Bluegrass Genotype	Parent Genotype	Visual evaluations: No. of plots[1] with damage (21 Apr. 99)	Visual evaluations: Rating[2] (1-5) (28 May 99) mean	No. grubs /plant mean	No. grubs /plant range
TX 6-10	TX 25-11	0	4.00	7.88	1-17
TX 31-2	TX 25-11	1	4.00	8.50	1-23
TX 12-8	TX 27-7	2	4.00	7.00	0-21
TX 32-7	TX 25-11	0	3.75	8.2	1-14
TX 5-6	TX 25-11	1	3.75	10.50	3-28
TX 13-9	TX 27-7	4	3.75	5.75	0-16
TX 16-9	TX Syn-1	1	3.75	5.50	1-12
TX 39-1	TX 20-16	4	3.63	3.75	0-14
TXKY 37-25	TXKY 94-27-2	1	3.63	6.63	2-15
TX 14-22	TX 27-7	3	3.50	6.38	2-13
TX 27-1	TX 20-16	2	3.38	5.25	0-10
TX 33-7	TX Syn-1	2	3.38	8.13	0-21
TX 20-13	TX 27-7	2	3.25	8.00	2-18
TX 11-19	TX 20-16	4	3.25	7.13	0-15
TX 6-8	TX 25-11	4	3.25	9.13	2-22
TX 13-24	TX 27-7	2	3.38	9.75	1-15
TX 32-6	TX 25-11	4	3.13	5.75	0-11
TX 27-5	TX 20-16	2	3.00	7.13	2-10
TXKY 37-24	TXKY 94-27-1	2	3.00	6.75	1-17
TX 27-6	TX 20-16	4	2.88	8.25	3-21
TX 28-1	TX 20-16	4	2.88	10.75	3-20
TX 3-13	TX 20-16	4	2.75	3.75	0-13
TX 3-2	TX 20-16	4	2.75	4.14	3- 6
TX 10-25	TX Syn-1	4	2.63	7.38	1-13
TX 27-8	TX 20-16	6	2.50	6.75	1-15
TX 25-3	TX 15-10	3	2.38	6.50	0-24
TX 12-19	TX 20-16	5	2.29	4.25	0-10
TX 27-10	TX 20-16	3	2.00	7.63	2-15
TX 28-2	TX 20-16	7	2.00	5.25	0- 8
TXKY 37-10	TXKY 94-29-10	6	2.00	5.13	1-12
Unselected 39	TX Syn-1	2	3.63	4.50	0-12
Unselected 34	TX Syn-1	3	3.13	4.75	1-11
Unselected 36	TX Syn-1	3	3.13	5.25	0-16
Unselected 33	TX Syn-1	2	3.00	4.38	1-13
Unselected 38	TX Syn-1	3	3.00	6.38	0-12
Unselected 35	TX Syn-1	5	2.50	7.00	3-14
Unselected 37	TX Syn-1	4	2.50	4.50	1-10
Unselected 32	TX Syn-1	4	2.38	7.50	1-19
Unselected 40	TX Syn-1	4	2.29	5.25	3- 9

[1] Visual rating, only a presence or absence of white grub damage was recorded.

[2] Visual rating on a scale of 1-5; with 1=most damage with plant yellowing and almost totally dead and loss of root attachment and 5=plant undamaged, vigorous and no loss of root anchoring.