Executive Summary

First Annual Report -- November 2, 1998

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 the project is to identify genetic lines of bermudagrass, zoysiagrass, buffalograss, seashore paspalum, bentgrass and bluegrass with resistance to the primary pests; caterpillars (fall armyworms, black cutworms, sod webworms) and host specific eriophyid mites, and characterize the mechanisms of resistance.

Initial work has been initiated with elite germplasm of bermudagrass (*Cynodon* spp.) from Dr. Charles Taliaferro's breeding program at Oklahoma State University and with commercial cultivars under culture at the TAMU-Dallas Center.

Thirty-two bermudagrass hybrids and nine commercial cultivars were evaluated by feeding 4-day-old larvae on them in no-choice feeding studies. Among the hybrids, 4200W 49-17, 4200W 53-1, and 4200W 55-5 (Table 3) produced the highest mortality with from 42 to 52% mortality, identified as failure of the individuals to emerge as adults from the pupa stage. Also, 3200W 70-18 provided 37% mortality at adult emergence with 3200W 94-2, 4200W 38-2, 3200W 18-11 and 3200W 30-20 each producing 33% mortality. These same grasses with the exceptions of 4200W55-5 and 4200W 38-2, usually produced the smaller larvae when weighed at 10 days. At the other end on the gradient, CCB 24-4 and 3200W 6-12 were the most susceptible hosts and produced only 4% mortality of the fall armyworm larvae.

Among the commercial bermudagrass cultivars, mortality was 8.25% or less at 17 days for all of the cultivars and 20.6% or less at adult emergence. Fall armyworm development was slowest with the smallest larvae and pupa on Common, but this experiment supports previous experiments that Common is not resistant and is a

relatively good host for this insect pest. None of the cultivars of bermudagrass in this experiment or in the above experiments exhibit an acceptable level of resistance to the fall armyworm. These experiments support the hypophysis that new cultivars may be developed that are superior to existing cultivars in pest resistance.

Residential landscapes are frequently invaded by large populations of grasshoppers that develop in adjacent landscapes or in agricultural lands. These invasions occur annually in late summer to autumn in some areas, but high populations tend to cycle every three to five years across the southern or southwestern states. Representative cultivars of cool and warm season turfgrasses (Tall fescue, 'Reveille' hybrid bluegrass, Syn1 Texas bluegrass, 'Tifway' bermudagrass, 'Common' bermudagrass, 'Raleigh' St. Augustinegrass, 'Meyer' zoysiagrass, 'Cavalier' zoysiagrass, 'Prairie' Buffalograss and Johnsongrass were evaluated for feeding preference or resistance to adult feeding by the differential grasshopper (*Melanoplus differentialis*). The degree of feeding was ranked (rank = 0 - 5: 0 = no feeding during the test period, 5 = near complete consumption of ration) and measured by the number and weight of fecal pellets produced during the feeding period.

Based upon ranked feeding and the number and weight of fecal pellets after 2-days of feeding, tall fescue was the most preferred host evaluated. 'Reveille' hybrid bluegrass, Tifway and Common bermudagrass, Syn1 Texas bluegrass and Meyer zoysiagrass were also highly preferred hosts based upon fecal pellet weights. 'Prairie' buffalograss and 'Cavalier' zoysiagrass were resistant to the grasshoppers and exhibited very low feeding damage, and fecal pellets. These trends held true throughout the 8-day feeding period of the test.

Table. Mortality of life stages, weight of larvae and pupa, days-to pupation and adult emergence for fall armyworms fed as 4-day-old larvae on field grown clippings of bermudagrass cultivars in Summer 1998 (Table 4 in full report).

Bermudagrass	% Mortality[1,5]					Wt (mg)[2,3]		Days to[4]	
Cultivar	7 d	10 d	17 d	Pupa	Adult	10 d larvae	Pupa	Pupa	Adult
Texturf 10	0 a[6]	8.25 ns	8.25 ns	8.25 ns	16.50 bc	37.38 a	206.56 a	15.59 e	27.52 c
Baby	0 a	0	0	8.25	20.63 c	36.99 a	197.01 ab	15.73 e	27.60 c
Tifway	0 a	0	0	0	0 a	32.50 ab	201.55 ab	16.21 de	28.00 bc
Tifway	0 a	4.13	4.13	4.13	4.13 ab	31.12 ab	193.87 bc	16.57 cd	27.78 c
Tifton 10	0 a	0	0	4.13	4.13 ab	31.70 ab	185.44 cd	16.22 de	27.65 c
Tif 94	8.25 b	8.25	8.25	8.25	20.63 c	26.96 bc	184.46 de	16.27 cd	27.95 c
Quicksand	0 a	0	0	4.13	4.13 ab	32.10 ab	176.74 e	16.92 c	28.61 b
Midiron	4.13 a	4.13	4.13	4.13	8.25 abc	24.16 c	152.03 f	17.91 b	28.64 b
Common	4.13 a	4.13	4.13	8.25	8.25 abc	13.81 d	141.74 f	19.68 a	30.32 a

[1] Mean % of larvae alive at 7, 10 and 17 days after egg hatch, % pupation and % that emerged as adults.
[2] Mean weight of surviving 10-day-old larvae after feeding on each genotype for 6 days.
[3] Mean pupa weight for only individuals that pupated (weight taken within 1 day after pupation).
[4] Mean number of days from egg hatch to pupation and to adult emergence for surviving insects.
[5] Analysis was made on arcsine transformation of the % mortality: % mortality is presented.
[6] 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). ns = not significant.

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

Progress: The Project has established a Regional Center to screen and evaluate turfgrass germplasm for resistance to insect and mite pests. The primary goal of the project is to identify genetic lines of bermudagrass, zoysiagrass, buffalograss, seashore paspalum, bentgrass and bluegrass with resistance to the primary pests; caterpillars (fall armyworms, black cutworms, sod webworms) and host specific eriophyid mites, and characterize the mechanisms of resistance. This process required development of effective screening procedures to efficiently identify genetic resistance to target pests. A secondly goal is for the respective grass breeder to incorporate the pest resistance as identified into agronomically acceptable cultivars for use in the multi-billion dollar turf industry.

Initial work has been initiated with elite germplasm of bermudagrass (*Cynodon* spp.) from the breeding program under the direction of Dr. Charles Taliaferro at Oklahoma State University and with commercial cultivars under culture at the TAMU-Dallas Center. The cultivars and genotypes evaluated are listed in Table 1.

Bermudagrass hybrids – evaluation for Fall Armyworm resistance:

Methods --

Bermudagrass genotypes (Tables 2-4) 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 FAW larvae in no-choice laboratory experiment. The three 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 (Table 2-3), a colony of fall armyworm larvae was reared on fresh tissue of 'Tifway' bermudagrass which serves as an excellent host with high survival of larvae through the adult stage. For these two experiments, three 4-day-old larvae were randomly selected from the colony and placed on the respective grass (listed in Table 2-3) 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 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.

For Experiment 3, neonate larvae (no feeding allowed after egg hatch) were placed on the respective grasses (Table 4) and allowed to develop as aforementioned. The aforementioned parameters of growth and development were measured.

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 –

Each of the bermudagrass hybrids (Table 2-3) were evaluated by feeding 4-day-old larvae on them in no-choice feeding studies. Among the hybrids in Experiment 2, 4200W 49-17, 4200W 53-1, and 4200W 55-5 (Table 3) produced the highest mortality with from 42 to 52% mortality, identified as failure of the individuals to emerge as adults from the pupa stage. Also, in Experiment 1, 3200W 70-18 provided 37% mortality at adult emergence with 3200W 94-2, 4200W 38-2, 3200W 18-11 and 3200W 30-20 each producing 33% mortality. These same grasses with the exceptions of 4200W55-5 and 4200W 38-2, usually produced the smaller larvae when weighed at 10 days. At the other end on the gradient, CCB 24-4 and 3200W 6-12 were the best hosts and produced only 4% mortality of the fall armyworm larvae.

Among the hybrids that were feed on by neonate larvae (Table 4), no significant differences in mortality or larval weight at 10 days were documented. Survivorship of developing larvae was very high on all of the hybrids evaluated in this experiment.

Bermudagrass cultivars – evaluation for Fall Armyworm resistance:

Methods --
Bermudagrass cultivars (Tables 5) were maintained in replicated field plots at the TAMU-Dallas Center. All entries were established as sod on a native blackland prairie soil in a randomized complete block design with 3 replications. The planting was watered as needed to prevent water stress, and was maintained at a 5.0 cm mowing height. Leaf and stem clippings from these plants were used to feed the fall armyworm larvae in a no-choice laboratory experiment. This experiment was set up and maintained in the laboratory by the procedures described above using 4-day-old larvae that had been reared on clippings of 'Tifway' bermudagrass. 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 before any pupation occurred and pupa were weighed within 1 day after pupation. Days to pupation and adult emergence were also 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 –
Each of the bermudagrass cultivars (Table 5) were evaluated by feeding 4-day-old larvae on them in no-choice feeding studies. Mortality was 8.25% or less at 17 days for all the cultivars and 20.6% or less at adult emergence. Fall armyworm development was slowest with the smallest larvae and pupa on Common, but this experiment supports previous experiments that tell us that Common is not resistant and is a relatively good host for this insect pest. None of the cultivars of bermudagrass in this experiment or in the above experiments exhibit an acceptable level of resistance to the fall armyworm.

Turfgrass species – evaluation for resistance to Differential Grasshoppers:

Methods --

Residential landscapes are frequently invaded by large populations of grasshoppers that develop in adjacent landscapes or in agricultural lands. These invasions occur annually in late summer to autumn in some areas, but high populations tend to cycle every three to five years across the southern or southwestern states. The summer of 1998 was one of these high population years for the differential grasshopper (*Melanoplus differentialis*) and extensive feeding damage was present in urban landscapes.

For this experiment, representative cool and warm season turfgrasses (Tall fescue, *Festuca arundinacea* Schreb., TXKY16-1 bluegrass, *Poa arachnifera* Torr X *Poa pratensis* (L.), Syn1 Texas bluegrass, *Poa arachnifera* Torr, Tifway bermudagrass, *Cynodon dactylon* (L.) Pers. X *C. transvaalensis* (Burtt-Davy), Common bermudagrass, *Cynodon dactylon* (L.) Pers., Raleigh St. Augustinegrass, *Stenotaphrum secundatum* (Walt.) Kuntze, Meyer zoysiagrass, *Zoysia japonica* Steud, Cavalier zoysiagrass, *Zoysia matrella* (L.) Merr., Buffalograss, *Buchloe dactyloides* (Nutt.) Engelm, Johnsongrass, *Sorgum halepense* (L.) Pers.) were evaluated for feeding preference or resistance to adult feeding by the differential grasshopper. Planting of each of these grasses were identified in the turf plots or in the landscape at the TAMU-Dallas Center. These grasses were tested in a no-choice feeding study using the laboratory procedures described above. Adequate plant material was placed in each feeding chamber with one adult differential grasshopper. Water was added sparingly to the filter paper as needed to maintain turgor of the grass cuttings. Grass was replaced every two to three days and feeding preference and consumption was evaluated. Not every grasshopper will feed daily, so a 2- to 3-day feeding period was necessary.

For this experiment, grasshoppers were field collected from wild plantings of Johnsongrass growing along roadsides. Individual grasshoppers were captured by sweeping across the planting with a butterfly net. The grasshoppers were held in the laboratory for 24 hr with only moistened paper towels and no food before the experiment was established. This delay allowed the grasshoppers to stabilize so each of them would all have a similar need for food during the experiment.

For this experiment, one grasshopper was randomly selected from the field collected specimens and placed on the respective grass (Table 6) in each feeding chamber and chambers were arranged in a randomized complete block design with eight replicates of three chambers (grasshoppers) each. Survivorship was recorded daily. For all surviving grasshoppers, the degree of feeding was ranked at 2-, 5- and at 8-days (rank = 0 - 5: 0 = no feeding during the test period, 5 = near complete consumption of ration). The number of fecal pellets produced during the feeding period and dry weight of the fecal pellets was also recorded as a measure of feeding activity.

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 –

Based upon ranked feeding and the number and weight of fecal pellets after 2-days of feeding, tall fescue was the most preferred host evaluated. 'Reveille' hybrid bluegrass, Tifway and Common bermudagrass, Syn1 Texas bluegrass and Meyer zoysiagrass were also highly preferred hosts based upon fecal pellet weights. 'Prairie' buffalograss and 'Cavalier' zoysiagrass were resistant to the grasshoppers and exhibited very low feeding damage, and fecal pellets. These trends held true throughout the 8-day feeding period of the test.

Publications:

Reinert, J. A., M. C. Engelke, J. C. Read, P. F. Colbaugh, S. J. Maranz & B. R. Wiseman. 1998. Fall armyworm, *Spodoptera frugiperda*, resistance in turfgrass. Inter. Sym. Crop Protection, Univ. Gent, Gent, Belgium 50: (in press).

Read, J. C., J. A. Reinert, P. F. Colbaugh & W. B. Knoop. 1998. Registration of 'Reveille' bluegrass. (Reg. No. CV-). Crop Sci. 26: (submitted to editor).

Reinert, J. A., M. C. Engelke, S. J. Maranz & B. R. Wiseman. 1998. Resistance to fall armyworm, *Spodoptera frugiperda,* in buffalograss, *Buchloe dactyloides*. TX Turfgrass Res. - 1997, Consolidated Prog. Rep. TURF-98- (in press).

Reinert, J. A., M. C. Engelke, S. J. Maranz and B. R. Wiseman. 1998. Zoysiagrass (*Zoysia* spp.) Resistance to the fall armyworm *Spodoptera frugiperda.* TX Turfgrass Res. - 1998, Consolidated Prog. Rep. TURF-98- (in press).

Reinert, J. A. & J. C. Read. 1998. Host resistance to white grubs among genotypes of *Poa arachnifera* X *P. pratensis* hybrids. TX Turfgrass Res. - 1998, Consolidated Prog. Rep. TURF-98- (in press).

Reinert, J. A., J. C. Read, S. J. Maranz & B.R. Wiseman. 1998. Resistance to fall armyworm, *Spodoptera frugiperda* in bluegrasses *Poa* spp. and *P. arachnifera* X *P. pratensis* hybrids. TX Turfgrass Res. - 1998, Consolidated Prog. Rep. TURF-98- (in press).

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	
Baby	
Midlawn	
Midiron	
Quicksand	
Texturf 10	
Tifway	
Tift 94	
Common	

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

Table 2. Mortality of life stages, weight of larvae and pupa, days-to-pupation and adult emergence for fall armyworms fed as 4-day-old larvae on clippings of bermudagrass cultivars in Spring 1998.

Bermudagrass	% Mortality[1,5]				Wt (mg)[2,3]		Days to[4]	
	7 d	10 d	Pupa	Adult	10 d larvae	Pupa	Pupa	Adult
3200W 70-18	20.83 abc[6]	29.17 ab	29.17 abc	37.50 a	91.58 fg	161.43 def	15.18 bcd	24.13 b-e
3200W 94-2	16.67 a-d	33.33 a	33.33 a	33.33 ab	102.34 efg	155.38 f	14.88 cde	24.38 bcd
4200W 38-2	12.50 a-d	25.00 abc	33.33 a	33.33 ab	146.39 ab	177.71 abc	14.06 gh	22.19 fgh
3200W 18-11	16.67 a-d	29.17 ab	33.33 a	33.33 ab	89.90 gh	175.14 abc	15.25 bc	25.00 bc
3200W 30-20	29.17 a	33.33 a	33.33 a	33.33 ab	99.58 efg	140.77 g	14.88 cde	24.13 b-e
4200W 25-1	8.33 bcd	12.50 bcd	25.00 a-d	29.17 abc	147.46 a	182.71 ab	14.33 e-h	23.18 d-h
4200W 19-18	16.67 a-d	29.17 ab	29.17 abc	29.17 abc	111.50 def	172.14 bcd	14.65 def	23.59 c-f
4200W 25-15	25.00 ab	29.17 ab	29.17 abc	29.17 abc	135.85 abc	185.29 a	14.00 h	22.41 fgh
4200W 20-6	12.50 a-d	25.00 abc	25.00 a-d	25.00 a-d	126.60 bcd	161.53 def	14.33 e-h	22.67 e-h
3200W 9-4	16.67 a-d	20.83 a-d	20.83 a-d	20.83 a-d	70.75 hi	155.77 f	15.63 b	25.17 b
4200W 22-13	4.17 cd	25.00 abc	25.00 abc	25.00 a-d	145.71 ab	170.49 cde	13.89 h	21.72 h
3200W 78-10	16.67 a-d	16.67 a-d	20.83 a-d	20.83 a-d	65.60 I	158.90 ef	16.26 a	27.00 a
4200W 22-10	8.33 bcd	16.67 a-d	16.67 a-d	20.83 a-d	126.78 bcd	171.65 bcd	14.15 fgh	22.11 gh
4200W 25-7	0 d	16.67 a-d	16.67 a-d	16.67 a-d	116.47 cde	178.50 abc	14.65 def	23.40 d-g
4200W 46-4	4.17 cd	8.33 cd	12.50 bcd	16.67 a-d	122.63 cd	179.63 abc	14.14 fgh	22.40 fgh
4200W 26-13	8.33 bcd	12.50 bcd	12.50 bcd	12.50 bcd	126.65 bcd	186.20 a	14.25 fgh	22.55 fgh
3200W 1-20	8.33 bcd	8.33 cd	12.50 bcd	12.50 bcd	118.99 cde	172.76 bcd	15.05 cd	24.29 bcd
3200W 6-12	4.17 cd	4.17 d	4.17 d	4.17 d	115.59 de	153.49 f	14.61 d-g	23.09 d-h

[1] Mean % of larvae alive at 7 and 10 days after egg hatch, % pupation and % that emerged as adults.
[2] Mean weight of surviving 10-day-old larvae after feeding on each genotype for 6 days.
[3] Mean pupa weight for only individuals that pupated (weight taken within 1 day after pupation).
[4] Mean number of days from egg hatch to pupation and to adult emergence for surviving insects.
[5] Analysis was made on arcsine transformation of the % mortality: % mortality is presented.
[6] 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). ns = not significant.

Table 3. Mortality of life stages, weight of larvae and pupa, days-to-pupation and adult emergence for fall armyworms fed as 4-day-old larvae on clippings of bermudagrass cultivars in Spring 1998.

Bermudagrass	% Mortality[1,5]				Wt (mg)[2,3]		Days to[4]	
	7 d	10 d	pupa	Adult	10 d larvae	Pupa	Pupa	Adult
4200W 74-3	0^{ns}	0^{ns}	18.18 abc[6]	27.27 bcd	25.53 abc	104.79 fgh	36.73 a	50.57 a
4200W 49-17	0	0	28.57 ab	52.38 a	28.92 bcd	109.93 e-h	35.33 ab	49.30 abc
Greg Norman-1	0	4.17	17.65 abc	23.53 bcd	20.24 a	108.24 e-h	35.21 abc	49.46 abc
CCB 10-8	0	0	4.55 c	9.09 d	31.45 cde	144.01 bc	34.42 bcd	49.25 abc
4200W 53-1	0	0	39.13 a	52.17 ab	22.63 ab	109.36 e-h	34.21 bcd	48.64 a-d
4200W 51-14	0	0	4.55 c	13.64 cd	34.15 d-g	120.54 def	33.81 cde	48.11 c-f
Midlawn	4.17	4.17	13.04 abc	21.74 bcd	38.52 fg	143.79 bc	33.55 de	48.28 bcd
4200W 47-7	0	0	0 c	0 d	30.72 cde	149.12 b	33.52 de	48.71 abc
Tifton 94	0	12.50	20.83 abc	25.00 bcd	40.46 g	155.73 b	32.95 def	48.22 cde
ERS-Turf	0	4.17	16.67 abc	16.67 cd	51.59 h	145.10 bc	32.63 ef	47.84 c-f
CCB 25-6	0	0	16.67 abc	16.67 cd	39.15 fg	138.55 bcd	32.40 efg	47.55 c-f
4200W 56-14	4.17	8.33	13.64 bc	22.73 cd	52.09 h	127.65 cde	31.74 fg	46.41 d-g
4200W 47-1	0	0	5.88 c	11.76 d	49.93 h	118.13 ef	31.06 g	46.00 efg
4200W 55-5	0	0	31.58 abc	42.05 abc	48.45 h	116.72 efg	31.00 g	45.91 fg
CCB 24-4	4.17	4.17	4.17 c	4.17 d	70.53 i	189.87 a	28.64 h	44.59 g

[1] Mean % of larvae alive at 7 and 10 days after egg hatch, % pupation and % that emerged as adults.
[2] Mean weight of surviving 10-day-old larvae after feeding on each genotype for 6 days.
[3] Mean pupa weight for only individuals that pupated (weight taken within 1 day after pupation).
[4] Mean number of days from egg hatch to pupation and to adult emergence for surviving insects.
[5] Analysis was made on arcsine transformation of the % mortality: % mortality is presented.
[6] 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). ns = not significant.

Table 4. Mortality of life stages, weight of larvae and pupa, days-to-pupation and adult emergence for fall armyworms fed as neonate larvae on clippings of bermudagrass cultivars in Spring 1998.

Bermudagrass	% Mortality[1,5]				Wt (mg)[2,3]		Days to[4]	
	7 d	10 d	Pupa	Adult	10 d larvae	Pupa	Pupa	Adult
3200W 9-4	4.17^{ns}	8.33^{ns}	12.50^{ns}	20.83^{ns}	40.37^{ns}	157.05 a[6]	22.05 a	31.28^{ns}
3200W 78-10	4.17	4.17	16.67	16.67	57.29	161.12 a	19.80 c-f	31.80
3200W 30-20	8.33	8.33	12.50	12.50	46.92	161.15 a	20.90 abc	32.57
3200W 1-20	4.17	8.33	12.50	20.83	65.60	161.53 ab	19.00 f-i	30.60
3200W 94-2	4.17	12.50	16.67	20.83	55.57	163.37 abc	19.47 e-h	30.05
3200W 18-11	4.17	8.33	12.50	12.50	35.48	164.84 abc	21.35 ab	32.50
3200W 6-12	4.17	4.17	4.17	4.17	184.1	166.73 abc	18.74 f-i	30.39
4200W 19-18	8.33	12.60	16.67	16.67	58.45	174.10 bcd	19.65 def	31.50
4200W 25-1	0	8.33	8.33	8.33	71.55	175.48 cd	18.68 f-i	30.55
3200W 70-18	8.33	12.50	12.50	12.50	49.26	175.81 cd	20.81 bcd	32.15
4200W 20-6	4.17	4.17	8.33	8.33	48.40	181.83 de	19.50 efg	31.55
4200W 22-13	4.17	4.17	4.17	4.17	51.14	185.80 def	19.83 c-f	31.70
4200W 46-4	4.17	12.50	12.50	16.67	74.93	192.46 efg	18.40 ghi	30.35
4200W 22-10	8.33	12.50	20.83	20.83	58.87	192.75 efg	19.11 f-i	31.58
4200W 25-15	0	4.17	4.17	4.17	75.97	193.05 efg	18.65 f-i	30.70
4200W 25-7	0	4.17	4.17	4.17	74.79	196.19 fgh	18.61 f-i	30.09
4200W 38-2	4.17	4.17	12.50	12.5	86.62	199.29 gh	18.05 i	30.29
4200W 26-13	0	0	0	4.17	86.06	199.75 gh	18.25 hi	30.43
Tifway	12.50	12.50	12.50	12.50	41.47	206.06 h	20.52 b-e	32.33

[1] Mean % of larvae alive at 7 and 10 days after egg hatch, % pupation and % that emerged as adults.
[2] Mean weight of surviving 10-day-old larvae after feeding on each genotype for 10 days.
[3] Mean pupa weight for only individuals that pupated (weight taken within 1 day after pupation).
[4] Mean number of days from egg hatch to pupation and to adult emergence for surviving insects.
[5] Analysis was made on arcsine transformation of the % mortality: % mortality is presented.
[6] 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). ns = not significant.

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Table 5. Mortality of life stages, weight of larvae and pupa, days-to pupation and adult emergence for fall armyworms fed as 4-day-old larvae on field grown clippings of bermudagrass cultivars in Summer 1998.

Bermudagrass	% Mortality[1,5]					Wt (mg)[2,3]		Days to[4]	
Cultivar	7 d	10 d	17 d	Pupa	Adult	10 d larvae	Pupa	Pupa	Adult
Texturf 10	0 a[6]	8.25 ns	8.25 ns	8.25 ns	16.50 bc	37.38 a	206.56 a	15.59 e	27.52 c
Baby	0 a	0	0	8.25	20.63 c	36.99 a	197.01 ab	15.73 e	27.60 c
Tifway	0 a	0	0	0	0 a	32.50 ab	201.55 ab	16.21 de	28.00 bc
Tifway	0 a	4.13	4.13	4.13	4.13 ab	31.12 ab	193.87 bc	16.57 cd	27.78 c
Tifton 10	0 a	0	0	4.13	4.13 ab	31.70 ab	185.44 cd	16.22 de	27.65 c
Tif 94	8.25 b	8.25	8.25	8.25	20.63 c	26.96 bc	184.46 de	16.27 cd	27.95 c
Quicksand	0 a	0	0	4.13	4.13 ab	32.10 ab	176.74 e	16.92 c	28.61 b
Midiron	4.13 a	4.13	4.13	4.13	8.25 abc	24.16 c	152.03 f	17.91 b	28.64 b
Common	4.13 a	4.13	4.13	8.25	8.25 abc	13.81 d	141.74 f	19.68 a	30.32 a

[1] Mean % of larvae alive at 7, 10 and 17 days after egg hatch, % pupation and % that emerged as adults.
[2] Mean weight of surviving 10-day-old larvae after feeding on each genotype for 6 days.
[3] Mean pupa weight for only individuals that pupated (weight taken within 1 day after pupation).
[4] Mean number of days from egg hatch to pupation and to adult emergence for surviving insects.
[5] Analysis was made on arcsine transformation of the % mortality: % mortality is presented.
[6] 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). ns = not significant.

Table 6. Foraging and survival response of differential grasshopper (*Melanoplus differentialis*) on turfgrass species in a no-choice feeding experiment (Autumn 1998) (8 replicates).

Grass species	2-day feeding evaluation[1] ranked[4] feeding	2-day feeding evaluation[1] no. of[5] pellets	2-day feeding evaluation[1] pellet[6] wt (mg)	(Adjusted 2-day evaluation)[2] pellets[5] /day	(Adjusted 2-day evaluation)[2] pellet[6] wt/day	mean days survival	8-day feeding period[3] pellets[5] /day	8-day feeding period[3] pellet wt[6] (mg)/day
Tall Fescue	4.62 a[7]	29.62 a	80.32 a	14.82 a	41.15 a	5.04 a	12.24 a	31.39 a
TXKY 16-1 Bluegrass	3.80 b	21.91 b	70.37 a	10.95 b	36.66 ab	5.38 a	7.04 cd	23.36 b
Tifway Bermuda	3.68 b	22.85 b	50.67 b	11.00 b	27.61 c	3.79 b	9.82 b	24.96 b
Common Bermuda	3.50 b	20.15 bc	55.11 b	10.08 bc	30.03 bc	4.70 ab	7.93 c	22.17 b
Syn1 TX Bluegrass	2.74 cd	17.78 c	54.31 b	8.89 cd	27.16 c	5.63 a	6.65 cde	20.04 bc
Johnsongrass	3.24 bc	11.96 de	29.94 c	6.15 ef	15.67 d	5.33 a	5.57 ef	13.72 d
Raleigh St. Augustine	2.48 de	13.83 d	27.33 c	7.20 de	14.22 d	5.38 a	5.78 def	12.05 d
Meyer Zoysiagrass	2.13 ef	13.22 de	50.76 b	7.24 de	25.38 c	4.75 ab	5.01 f	16.04 cd
Prairie Buffalograss	1.71 f	10.04 e	24.79 c	5.02 f	12.40 de	5.33 a	2.78 g	6.77 e
Cavalier Zoysiagrass	0.79 g	5.33 f	15.57 c	2.71 g	7.05 e	3.71 b	2.05 g	5.48 e

[1] Evaluations made after 2 days of feeding by grasshopper adults.
[2] Data adjusted for some mortality (feeding results per day during initial 2-day feeding evaluation).
[3] Response during the total 8-day feeding period.
[4] Feeding evaluation after 2 days of feeding. Rank = 0-5: 0 = no feeding during test period, 5 = near complete consumption of ration.
[5] Number of fecal pellets produced during feeding period.
[6] Weight of fecal pellets produced during feeding period.
[7] 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). ns = not significant.