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Evaluation of Buffalograss Germplasm for Resistance to *Blissus occiduus* (Hemiptera: Lygaeidae)

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ABSTRACT *Blissus occiduus* Barber has emerged as an important insect pest of buffalograss, *Buchloë dactyloides* (Nuttall) Engelm., in Nebraska. This research evaluated selected buffalograss germplasm for resistance to *B. occiduus*. Eleven buffalograss selections were screened for chinch bug resistance in three greenhouse studies and two field evaluations. Based on chinch bug damage, NE91–118, 'Tatanka', 'Bonnie Brae', and 'Cody' were rated highly to moderately resistant. These four buffalograsses exhibited minimal damage, even though all were heavily infested with chinch bugs. NE84-45-3 and '378' were highly susceptible to *B. occiduus*. Field evaluations confirmed chinch bug resistance ratings under field conditions. NE91–118 displayed high levels of resistance in the field screening evaluations, whereas Cody and Tatanka showed moderate levels of resistance, and 378 was highly susceptible.

KEY WORDS *Buchloë dactyloides*, *Blissus occiduus*, chinch bug, buffalograss, turf, plant resistance

BUFFALOGRASS, *Buchloë dactyloides* (Nuttall) Engelm., is a perennial, warm-season species native to the semiarid regions of the North American Great Plains (Wenger 1943, Beard 1973). The overall appearance of buffalograss is a fine textured, low growing, grayish-green turf that spreads vegetatively by stolons (Nuland et al. 1981, Falkenberg-Borland and Butler 1982, Riordan et al. 1996). In recent years, buffalograss has gained popularity as an alternative turfgrass species because of its exceptional drought tolerance and relative freedom from diseases and arthropod pests. Improved turf-type buffalograsses are now being used on home lawns, golf courses, around public establishments, and for erosion control along roadsides.

Relatively few insects are known to cause significant damage to buffalograss. Arthropods previously reported as pests of buffalograss include white grubs, *Phyllophaga crinita* (Burmesiter); grasshoppers; leafhoppers; mound-building prairie ants; buffalograss webworm, *Surattha indentella* (Kearfott); the rhodesgrass mealybug, *Antonina graminis* (Maskell); an eriophyid mite, *Eriophyes slykhuisi* (Hall); and two grass-feeding mealybugs, *Tridiscus sporoboli* (Cockerell) and *Trionymus* sp. (Reinhard 1940, Wenger 1943, Chada and Wood 1960, Sorenson and Thompson 1979, Crocker et al. 1984, Pfadt 1984, Baxendale et al. 1994). Several beneficial arthropods have also been collected

from buffalograss, including ants, big-eyed bugs, ground beetles, rove beetles, spiders, and numerous hymenopterous parasitoids (Heng-Moss et al. 1998).

Recently, a chinch bug, *Blissus occiduus* Barber, has emerged as an important insect pest of buffalograss in Nebraska (Baxendale et al. 1999). Currently, the reported distribution of *B. occiduus* includes California, Colorado, Montana, Nebraska, and New Mexico in the United States, and Alberta, British Columbia, Manitoba, and Saskatchewan in Canada (Bird and Mitchener 1950, Slater 1964, Baxendale et al. 1999). Reported hosts of *B. occiduus* include barley, *Hordeum* sp.; corn, *Zea mays* L.; oats, *Avena sativa* L.; sugarcane, *Saccharum officinarum* L.; wheat, *Triticum aestivum* L.; bromegrass, *Bromus* spp.; and various "native grasses" (Ferris 1920, Parker 1920, Bird and Mitchener 1950, Farstad et al. 1951). On-going research at the University of Nebraska has identified several additional turfgrass, crop, and weed species that serve as *B. occiduus* hosts (F.P.B., unpublished data).

Currently, other than insecticides, few effective management options are available for controlling chinch bugs and other arthropod infestations in buffalograss (Baxendale et al. 1999). Although most homeowners, golf course superintendents, and lawn care professionals still rely heavily on insecticides for controlling the arthropod pests affecting turfgrasses, interest in reducing pesticide inputs has underscored the need for developing more environmentally-responsible management alternatives. The development of insect-resistant buffalograsses offers an attractive approach for managing these pests because it is sus-

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tainable and fits well with buffalograss' low maintenance, reduced input philosophy.

The potential for identifying chinch bug resistant buffalograsses was suggested by well-documented differences in susceptibility to chinch bugs in several cool and warm-season turfgrasses (Baker et al. 1981, Ratcliffe 1982, Reinert 1982, Ahmad et al. 1984, Lynch et al. 1987, Busey 1990, Mathias et al. 1990). Further, Johnson-Cicalese et al. (1998) found dramatic differences among buffalograss selections in their resistance to the mealybugs, *T. sporoboli* and *Trionymus* sp. This research demonstrated extensive variation among buffalograss germplasm and suggested the potential for identifying buffalograsses with resistance to chinch bugs. Accordingly, the objective of this research was to evaluate selected buffalograss germplasm for resistance to the chinch bug, *B. occiduus*.

Materials and Methods

Greenhouse Screening. *Screening Study 1.* Eleven buffalograss cultivars/selections ('Texoka', 'Cody', 'Tatanka', '609', '315', '378', 'Bonnie Brae', NE84-45-3, NE91-118, NE86-61, and NE86-120) were screened for chinch bug resistance under greenhouse conditions. These buffalograsses were selected because they were either commercially available or were among the top performers in turfgrass quality evaluations (T.P.R., personal communication).

Six sod plugs of each cultivar/selection (10.6 cm diameter by 6 cm deep) were extracted from buffalograss evaluation plots at the John Seaton Anderson (JSA) Turfgrass and Ornamental Research Facility, University of Nebraska Agricultural Research and Development Center (ARDC), near Mead, NE, in July 1997. Plugs were planted in 15 cm pots containing a potting mixture of 0.66 sand/0.33 soil (Sharpsburg silty clay loam)/1 peat/1 perlite. Plants were placed under 400-watt high-intensity discharge lamps with a photoperiod of 16:8 (L:D) h, and temperatures were maintained at $24 \pm 3^\circ\text{C}$. Plants were fertilized biweekly with a soluble (20.0-4.4-16.6, N:P:K) fertilizer.

Blissus occiduus were collected from two infested Texoka buffalograss lawns at the University of Nebraska East Campus, Lincoln, NE, by vacuuming the soil surface with a DC insect vacuum (model #820B, BioQuip, Gardena, CA). Chinch bugs were sifted through a 2-mm mesh screen and were collected with an aspirator. A total of 50 fifth instar and adult chinch bugs was introduced onto each pot (described above) arranged in a randomized complete block design with six replications on 25 August 1997. Clear acetate tubes (12 cm in diameter by 30 cm high) were placed over the turf to confine chinch bugs. Cage tops were covered with organdy fabric and secured with a rubber band.

Unlike agronomic crops, plant aesthetics is the primary criterion for assessing turfgrass resistance to insects. Therefore, plants were rated for chinch bug damage on 25 August 1997 and thereafter every week using a 1-5 scale, where 1 = 10% or less of leaf area with reddish discoloration; 2 = 11-30% of leaf area

with reddish discoloration; 3 = 31-50% of leaf area with reddish discoloration; 4 = 51-70% of leaf area with reddish or yellowing discoloration; and 5 = 71% or more of leaf area with severe discoloration, thinned turf, or dead tissue. On 28 September, plants were placed in Berlese funnels (Southwood 1978) for chinch bug extraction.

Screening Studies 2 and 3. Additional studies were carried out to confirm results obtained in screening study 1. Plugs were collected from buffalograss evaluation plots, planted, and maintained as previously discussed. Based on the results obtained from screening study 1, NE84-45-3 and NE91-118 were included in each study as susceptible and resistant selections, respectively. Plants were evaluated for chinch bug damage at the start of the experiment and weekly thereafter using the rating scale described in screening study 1. Experiments were terminated when susceptible NE84-45-3 plants displayed a damage rating of four or higher. At the conclusion of experiments, plugs were individually placed in Berlese funnels to extract chinch bugs for counting.

In screening study 2, all of the selections from screening study 1 were further assessed for resistance to *B. occiduus*. Plugs were collected from buffalograss evaluation plots on 25 September 1997. A total of 50 fifth instar and adult chinch bugs was introduced onto pots on 25 October. Plants were placed in Berlese funnels to extract chinch bugs on 19 November. The experimental design was a randomized complete block design with six replications. Three cultivars/selections (Cody, Tatanka, and NE91-118) that had minimal damage in the first two screening studies were reevaluated in screening study 3 along with the susceptible NE84-45-3. Bonnie Brae was not included in this screening study because plant material was no longer available.

In screening study 3, plugs were collected from buffalograss evaluation plots on 15 September 1998, and 50, fifth instar and adult chinch bugs were placed on the plants on 15 October. The experimental design was a randomized complete block design with five replications. Plants were rated for chinch bug damage to provide baseline information at the start of the experiment and thereafter on a weekly basis. Plants were harvested on 20 November and placed in Berlese funnels. The total number of extracted chinch bugs was recorded for each pot.

Field Evaluations. In 1999 and 2000, *B. occiduus* infestations were detected in two buffalograss evaluation plots at the JSA Facility. These infestations provided an opportunity to evaluate several buffalograss cultivars/selections for resistance to *B. occiduus* under field conditions.

Field Study 1. In this study, five buffalograss selections (NE91-33, NE86-61, NE86-120, NE84-409, and NE91-118) were evaluated for chinch bug resistance. Although the buffalograss selections included in this previously established plot were not replicated, a naturally occurring chinch bug infestation provided the first opportunity to evaluate *B. occiduus* resistance under field conditions. Plot size was 3 by 5 m. Plot

Table 1. Susceptibility of buffalograsses to *Blissus occidius* under greenhouse conditions (studies 1, 2, and 3)

Buffalograss	Chinch bug damage rating ^a			Mean no. of chinch bugs ^b SEM		
	Study 1 ^c	Study 2 ^d	Study 3 ^d	Study 1 ^e	Study 2 ^f	Study 3 ^f
NE 84-45-3	4.3a	3.5bc	5.0a	17.3 ± 4.0c	14.2 ± 7.2d	93.3 ± 30.5a
Texoka	3.0b	2.6cd	—	19.3 ± 6.7c	62.3 ± 12.9abcd	—
378	3.0b	4.0ab	—	20.0 ± 5.8c	36.5 ± 7.5bcd	—
315	2.7bc	2.5cde	—	41.7 ± 5.6abc	81.8 ± 15.8ab	—
NE 86-120	2.4bcd	4.3ab	—	65.3 ± 21.9ab	30.5 ± 11.8bcd	—
NE 86-61	2.3cde	4.5a	—	34.2 ± 9.6bc	26.2 ± 6.8bcd	—
609	1.7def	2.6cd	—	42.0 ± 9.9abc	73.2 ± 23.6abc	—
Cody	1.5ef	1.8def	1.8c	44.5 ± 10.6abc	101.8 ± 22.4a	83.3 ± 22.2a
Bonnie Brae	1.5ef	1.4f	—	47.2 ± 8.6abc	115.8 ± 29.2a	—
Tatanka	1.3f	1.5ef	1.8c	39.3 ± 8.3abc	62.3 ± 14.5abcd	228.0 ± 36.0a
NE 91-118	1.0f	1.9def	2.4b	74.2 ± 14.8a	34.2 ± 4.1abc	201.8 ± 28.7a

Means followed by the same letter are not significantly different ($P > 0.05$, LSD test).

^a Chinch bug damage rating 1–5 scale, 1 = no damage.

^b Mean number of chinch bugs per 91.6 cm².

^c Mean damage rating at 34 d after chinch bug introduction.

^d Mean damage rating at 30 d after chinch bug introduction.

^e Mean number of chinch bugs at 34 d after chinch bug introduction.

^f Mean number of chinch bugs at 30 d after chinch bug introduction.

maintenance included two applications of 2.4 g N m⁻² (20-10-20, N:P:K), biweekly mowing at 6.25 cm, and after establishment preemergence herbicides were applied each year.

Buffalograsses were evaluated for chinch bug resistance based on the criterion (chinch bug damage) used in the greenhouse screening studies. Damage ratings were again based on the 1–5 rating scale described above. To obtain chinch bug population estimates, 10.6-cm-diameter soil plugs were extracted using a golf cup cutter. Five of these samples were randomly collected from each buffalograss selection and chinch bugs were extracted using Berlese funnels. Selections were evaluated for chinch bug numbers and damage on two September 1999 and 23 June 2000. These evaluation dates coincided with the presence of second and first generation fifth instar and adult chinch bugs, respectively.

Field Study 2. Seven additional buffalograsses (315, 378, Texoka, 'Bison', Tatanka, Cody, 609, and NE 91-118) from a replicated evaluation plot at the JSA Facility were evaluated for chinch bug resistance in 1999 and 2000. The buffalograsses in this plot were replicated three times in a randomized complete block design. Plot size was 1.5 by 1.5 m. Maintenance of the evaluation plot included two applications of 2.4 g N m⁻² (20-10-20, N:P:K), weekly mowing at 6.25 cm, and preemergence herbicides were applied each year after establishment. Buffalograsses were evaluated for chinch bug numbers and damage on 2 September 1999 and 23 June 2000 using the rating scale and chinch bug extraction methods discussed in field study 1.

Levels of Resistance. For each greenhouse and field study, buffalograsses were separated into four groups based on chinch bug damage ratings. Designated groups were HR = highly resistant (chinch bug damage rating = 1), MR = moderately resistant (chinch bug damage rating >1 but <3), MS = moderately susceptible (chinch bug damage rating ≥3 but <4), and HS = highly susceptible (chinch bug damage rating ≥4).

Statistical Analyses. Mixed model analyses (PROC MIXED, SAS Institute 1997) were conducted for each chinch bug damage rating to detect treatment differences (Littell et al. 1996). When appropriate, means were separated using Fisher least significant difference (LSD) procedure.

Results

Greenhouse Screening. Screening Study 1. Significant differences were detected in chinch bug damage among the buffalograsses evaluated ($F = 12.2$; $df = 10, 55$; $P < 0.0001$) (Table 1). NE91-118 exhibited a high level of resistance to *B. occidius* feeding; 609, Cody, Bonnie Brae, and Tatanka showed moderate levels of resistance; and NE86-61, NE86-120, 315, Texoka, 378, and NE84-45-3 were moderately to highly susceptible. NE91-118 had minimal chinch bug damage despite the large number of chinch bugs infesting this selection, suggesting tolerance to *B. occidius* feeding.

Screening Study 2. Significant differences ($F = 10.2$; $df = 10, 54$; $P < 0.0001$) in levels of chinch bug resistance were again observed among the evaluated buffalograsses (Table 1). The relative ranking of the cultivars/selections was similar to screening study 1; however, high chinch bug infestation levels associated with some cultivar/selection resulted in increased damage ratings. Mealybug (*Tridiscus sporoboli* Cockerell and *Trionymus* sp.) infestations on NE86-120 and NE86-61 also likely contributed to increased damage on these two selections. Cody, Bonnie Brae, Tatanka, and NE91-118 had high densities of chinch bugs, yet maintained low damage ratings of 1.8, 1.4, and 1.5, and 1.9, respectively. This study provided additional evidence that these four cultivars are resistant to *B. occidius*.

Screening Study 3. Chinch bug damage was significantly different ($F = 29.2$; $df = 3, 18$; $P < 0.0001$) among the buffalograsses evaluated (Table 1). Tatanka exhibited high levels of resistance despite the large number of chinch bugs infesting this cultivar.

Table 2. Susceptibility of selected buffalograsses to *Blissus occidius* under field conditions in a nonreplicated evaluation plot (field study 1)

Buffalograss	Chinch bug damage rating ^a		Mean no. of chinch bugs ^b ± SEM	
	2 Sept 1999	23 June 2000	2 Sept 1999	23 June 2000
	NE91-33	4.0	5.0	58.7 ± 7.6
NE86-61	4.0	4.0	57.3 ± 8.3	23.3 ± 7.6
NE86-120	3.0	4.0	20.0 ± 1.5	35.7 ± 3.9
NE84-409	1.0	2.0	23.7 ± 4.7	47.8 ± 15.8
NE91-118	1.0	1.5	3.0 ± 1.2	33.1 ± 9.8

^a Chinch bug damage rating 1–5 scale, 1 = no damage.

^b Mean number of chinch bugs per 91.6 cm².

NE91–118 and Tatanka both showed slightly higher levels of damage compared with previous studies. This likely resulted when chinch bug pressure exceeded the plant's ability to tolerate *B. occidius* feeding. Tatanka and Cody had similar levels of damage, even though Tatanka had approximately three times the number of chinch bugs. NE84-45-3 had significantly higher chinch bug damage ratings than the resistant buffalograsses. This research demonstrates that Cody, Tatanka, and NE91–118 exhibit moderate levels of resistance to chinch bugs even at high infestation levels.

Significant differences in chinch bug numbers were observed for screening studies 1 and 2 (study 1: $F = 1.9$; $df = 10, 55$; $P < 0.05$; study 2: $F = 2.9$; $df = 10, 54$; $P < 0.006$; study 3: $F = 2.6$; $df = 3, 18$; $P < 0.11$). In general, chinch bug numbers were lower on buffalograsses exhibiting the highest level of damage, whereas resistant plants supported the largest numbers of chinch bugs. This likely occurred because the susceptible plants did not provide a suitable host for chinch bug survival and as a result chinch bugs did not reproduce on these plants. The large numbers of chinch bugs on the moderately and highly resistant buffalograsses indicate that these buffalograsses were a suitable host for chinch bug development and reproduction, and suggest that antibiosis is not present in these resistant buffalograsses.

Field Evaluations. Field Study 1. Large numbers of chinch bugs were detected infesting this buffalograss evaluation plot (Table 2). NE86–120, NE86–61, and NE91–33 were heavily infested with chinch bugs and suffered considerable damage (3–5 damage rating) from chinch bug feeding. By contrast, NE91–118 and NE84–409 exhibited minimal damage with similar chinch bug infestation levels. NE91–118 displayed a high level of resistance during 2000, despite large numbers of chinch bugs infesting this plot. This study served to document NE91–118 resistance under field conditions.

Chinch bug numbers declined during the second evaluation year in the highly susceptible selections NE91–33 and NE86–61. This was likely due to the decline in turfgrass quality caused by chinch bug feeding during 1999. By contrast, chinch bug numbers increased in the NE84–409 and NE91–118 plots.

Field Study 2. Significant differences ($F = 16.9$; $df = 7, 23$; $P < 0.0001$) in chinch bug damage were observed among the buffalograsses for the two September 1999

Table 3. Susceptibility of selected buffalograsses to *Blissus occidius* under field conditions (field study 2)

Buffalograss	Chinch bug damage rating ^a		Mean no. of chinch bugs ± SEM ^b	
	2 Sept 1999	23 June 2000	2 Sept 1999	23 June 2000
	315	4.7a	1.0	4.1 ± 1.1
378	3.7b	1.0	5.2 ± 1.8	0.7 ± 0.2
Texoka	3.3bc	1.0	3.8 ± 0.7	0.0 ± 0.0
Bison	2.9cd	1.0	3.3 ± 1.2	0.0 ± 0.0
Tatanka	1.8de	1.0	2.7 ± 0.6	0.9 ± 0.3
Cody	1.7de	1.0	3.1 ± 1.4	0.4 ± 0.1
609	1.4e	1.0	1.4 ± 0.1	0.0 ± 0.0
NE91-118	1.3e	1.0	3.1 ± 0.9	1.2 ± 0.3

Means followed by the same letter are not significantly different ($P > 0.05$, LSD test).

^a Chinch bug damage rating 1–5 scale, 1 = no damage.

^b Mean number of chinch bugs per 91.6 cm².

evaluation (Table 3). NE91–118, 609, Cody, and Tatanka displayed high to moderate levels of resistance, while 315 and 378 were the most susceptible. Bison and Texoka showed moderate levels of susceptibility with damage ratings of 2.9 and 3.3, respectively.

Chinch bug numbers were lower during the second evaluation year (23 June 2000) which resulted in minimal chinch bug damage to all of the buffalograss cultivar/selections. In the absence of chinch bug pressure, the plots recovered from the chinch bug damage sustained during 1999. Traffic simulation experiments performed on this evaluation plot during the summer of 2000 may have contributed to the decline in chinch bug numbers.

Discussion

Based on turfgrass damage ratings, NE91–118, Tatanka, Bonnie Brae, and Cody were characterized as highly to moderately resistant to *B. occidius*. These four buffalograsses exhibited minimal chinch bug damage although all became heavily infested with chinch bugs. This suggests that tolerance may be responsible for their resistance. Conversely, NE84-45-3 and 378 were highly susceptible to chinch bug feeding.

Naturally occurring chinch bug infestations provided an opportunity to confirm NE91–118 resistance under field conditions. NE91–118 displayed high levels of chinch bug resistance in these field screening trials, whereas Cody and Tatanka showed only moderate levels of resistance. These results were consistent with greenhouse screening studies.

It is interesting to note that although Cody and Tatanka were among the most chinch bug-resistant buffalograsses, there was variability in their susceptibility to chinch bug feeding. Unlike vegetatively propagated buffalograsses (e.g., NE91–118 and 378) which are characterized by little genetic diversity, seeded buffalograsses such as Cody and Tatanka are developed from multiple parents which may vary in their level of resistance to *B. occidius*. Consequently, seeded buffalograss stands consist of numerous genotypes that often display substantial genetic diversity. This genetic diversity likely explains the observed

variability in susceptibility of Cody and Tatanka to *B. occiduus* in different studies.

Previous laboratory and field evaluations have identified several turfgrasses with resistance to *B. leucopterus hirtus* and *B. insularis* (Reinert 1972, Reinert et al. 1980, Baker et al. 1981, Ratcliffe 1982, Saha et al. 1987, Mathias et al. 1990). This research represents the first report of buffalograss resistance to *B. occiduus*. In addition, this research demonstrates useful variation to chinch bug feeding among buffalograss germplasm, and suggests the potential to improve the resistance of buffalograss to *B. occiduus*.

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References Cited

- Ahmad, T. R., K. P. Pruess, and S. D. Kindler. 1984. Non-crop grasses as hosts for the chinch bug, *Blissus leucopterus leucopterus* (Say) (Hemiptera: Lygaeidae). *J. Kans. Entomol. Soc.* 57: 17-20.
- Baker, P. B., R. H. Ratcliffe, and A. L. Steinhauer. 1981. Tolerance to hairy chinch bug (*Blissus leucopterus*) feeding in Kentucky bluegrass (*Poa pratensis*). *Environ. Entomol.* 10: 153-157.
- Baxendale, F. P., J. M. Johnson-Cicalese, and T. P. Riordan. 1994. *Tridiscus sporoboli* and *Trionymus* sp. (Homoptera: Pseudococcidae): potential new mealybug pests of buffalograss turf. *J. Kans. Entomol. Soc.* 67: 169-172.
- Baxendale, F. P., T. M. Heng-Moss, and T. P. Riordan. 1999. *Blissus occiduus* Barber (Hemiptera: Lygaeidae): a new chinch bug pest of buffalograss turf. *J. Econ. Entomol.* 92: 1172-1176.
- Beard, J. B. 1973. Turfgrass: science and culture. Prentice-Hall, Englewood Cliffs, NJ.
- Bird, R. D., and A. V. Mitchener. 1950. Insects of the season 1949 in Manitoba. *Can. Insect Pest Rev.* 28: 41.
- Busey, P. 1990. Polyploid *Stenotaphrum* germplasm: resistance to the polyploid damaging population southern chinch bug. *Crop Sci.* 30: 588-593.
- Chada, H. L., and E. A. Wood. 1960. Biology and control of the rhodesgrass scale. U.S. Dep. Agric. Tech. Bull. 1221.
- Crocker, R. L., V. G. Hickey, M. C. Engelke, H. L. Cromroy, and R. L. Toler. 1984. An eriophyid mite, *Eriophytes slykhuisi* infests buffalograss in Texas. *Tex. Agr. Exp. Stn. Prog. Rep.* 4287:128-131. *In Texas Turfgrass Research*. *Tex. Agric. Stn. Prog. Rep.* 1984: 4269-4289.
- Falkenberg-Borland, D. F., and J. D. Butler. 1982. Buffalograss-a new turfgrass for golf courses. *USGA Green Sect. Rec.* 20: 6-8.
- Farstad, C. W., and Staff. 1951. Insects of the season in Alberta, 1950. *Can. Insect Pest Rev.* 29: 18.
- Ferris, G. F. 1920. Insects of economic importance in the Cape Region of Lower California, Mexico. *J. Econ. Entomol.* 13: 463-467.
- Heng-Moss, T. M., F. P. Baxendale, and T. P. Riordan. 1998. Beneficial arthropods associated with buffalograss. *J. Econ. Entomol.* 91: 1167-1172.
- Johnson-Cicalese, J. M., F. P. Baxendale, T. P. Riordan, and T. M. Heng-Moss. 1998. Identification of mealybug-(Homoptera: Pseudococcidae) resistant turf-type buffalograss germplasm. *J. Econ. Entomol.* 91: 340-346.
- Littell, R. C., G. A. Milliken, W. W. Stroup, and R. D. Wolfinger. 1996. SAS system for mixed model. SAS Institute, Cary, NC.
- Lynch, R. E., S. Some, I. Dicko, H. D. Wells, and W. G. Monson. 1987. Chinch bug damage to Bermudagrass. *J. Entomol. Sci.* 22: 153-158.
- Mathias, J. K., R. H. Ratcliffe, and J. L. Hellman. 1990. Association of an endophytic fungus in perennial ryegrass and resistance to the hairy chinch bug (Hemiptera: Lygaeidae). *J. Econ. Entomol.* 83: 1640-1646.
- Nuland, D. S., P. E. Reece, and E. J. Kinbacher. 1981. Buffalograss: energy efficient turf for lawns. *Coop. Ext. Univ. Nebraska-Lincoln G81-564*.
- Parker, J. R. 1920. The chinch bug in Montana. *J. Econ. Entomol.* 13: 318-322.
- Pfadt, R. E. 1984. Species richness, density, and diversity of grasshoppers (Orthoptera: Acrididae) in a habitat of the mixed grass prairie. *Can. Entomol.* 116: 703-709.
- Ratcliffe, R. H. 1982. Evaluation of cool-season turfgrasses for resistance to the hairy chinch bug, pp. 13-18. *In H. D. Niemczyk and B.G. Joyner (eds.), Advances in turfgrass entomology*. Hammer Graphics, Piqua, OH.
- Reinert, J. A. 1972. Turf-grass insect research, pp. 79-84. *In Proceedings, Florida Turfgrass Management Conference, 16-19 October 1972, vol. 20. Florida Turf Grass Association, Gainesville, FL.*
- Reinert, J. A. 1982. A review of host resistance in turfgrasses to insects and Acarines with emphasis on the southern chinch bug, pp. 3-12. *In H. D. Niemczyk and B. G. Joyner (eds.), Advances in turfgrass entomology*. Hammer Graphics, Piqua, OH.
- Reinert, J. A., B. D. Burton, and R. W. Toler. 1980. Resistance of St. Augustinegrass to southern chinch bug and St. Augustine decline strain of *Panicum mosaic virus*. *J. Econ. Entomol.* 73: 602-604.
- Reinhard, H. J. 1940. The life history of *Phyllophaga lanceolata* (Say) and *Phyllophaga crinita* Burmeister. *J. Econ. Entomol.* 33: 572-578.
- Riordan, T. P., F. P. Baxendale, R. E. Gaussoin, and J. E. Watkins. 1996. Buffalograss: an alternative native grass for turf. *Coop. Ext. Univ. Nebraska-Lincoln, NE. G96-1297-A*.
- Saha, D. C., J. M. Johnson-Cicalese, P. M. Halisky, M. I. VanHeemstra, and C. R. Funk. 1987. Occurrence and significance of endophytic fungi in the fine fescues. *Plant Dis.* 71: 1021-1024.
- SAS Institute. 1997. SAS/STAT Software: changes and enhancements through release 6.12. SAS Institute, Cary, NC.
- Slater, J. A. 1964. A catalogue of the Lygaeidae of the World. University of Connecticut, Storrs.
- Sorenson, K. A., and H. E. Thompson. 1979. The life history of the buffalograss webworm, *Surattha indentella* Kearfott, in Kansas. *J. Kans. Entomol. Soc.* 52: 282-296.
- Southwood, T.R.E. 1978. Ecological methods. Halsted, New York.
- Wenger, L. E. 1943. Buffalo grass. *Kans. Agric. Exp. Stn. Bull.* 321.

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