EVALUATION OF GRASSES FOR RESISTANCE TO SPITTLEBUGS[1]

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ABSTRACT - The grasses that had consistently fewer spittlebug nymphs in field plots over a three-year period were *Andropogon gayanus* Kunth cv. Planaltina, *Brachiaria brizantha* (Hochst. ex A. Rich.) Stapf cv. Marandu, *Panicum maximum* Jacq. cv. Colonião and Coloninho, *Paspalum guenoarum* Archevaleta and *Paspalum plicatulum* Michx. When given a choice, the spittlebug nymphs preferred plants of *Brachiaria* sp. over those of *A. gayanus* cv. Planaltina and *P. plicatulum*. Studies conducted in a screenhouse showed that grasses with high levels of antibiosis were *B. brizantha* cv. Marandu, *P. maximum* cv. Colonião, *P. guenoarum* and *P. plicatulum;* the grass *A. gayanus* cv. Planaltina was intermediante in this respect. Grasses *A. gayanus* cv. Planaltina, *B. brizantha* cv. Marandu, *Brachiaria humidicola* (Rendle) Schweickt cv. IRI 409, *P. guenoarum* and *P. plicatulum* showed good levels of tolerance. Grasses were evaluated for the feeding and ovipositional preference also. Three grasses, namely, *Brachiaria decumbens* Staf cv. Basilisk, *Bachiaria ruziziensis* Germain & Evrard, and *Cenchrus ciliaris* L. did not show any mechanisms of resistance. These three grasses and *B. humidicola* cv. IRI 409 favored spittlebug multiplication. Generally, the degree of resistance of a given grass species was the same for different spittlebug species.

Index terms: *Zulia entreriana, Deois flavopicta, Mahanarva fimbriolata, Andropogon gayanus, Brachiaria decumbens* Cercopidae, antibiosis, tolerance, nonpreference.

AVALIAÇÃO DA RESISTÊNCIA DE GRAMINEAS ÀS CIGARRINHAS-DAS-PASTAGENS

RESUMO - As gramíneas que apresentaram menor número de ninfas de cigarrinhas em parcelas de campo durante um período de três anos foram *Andropogon gayanus* Kunth. cv. Planaltina, *Brachiaria brizantha* (Hochst. ex A. Rich.) Stapf cv. Marandu, *Panicum maximum* Jacq. cv. Coloninho, *Paspalum guenoarum* Archevaleta e *Paspalum plicatulum* Michx. Nos ensaios de livre escolha, as ninfas preferiram as plantas de *Brachiaria* sp. quando comparadas com *A. gayanus* cv. Planaltina e *P. plicatulum*. Os estudos feitos em casa telada, mostraram que as gramíneas com altos níveis de antibiose froam *B. brizantha* cv. Marandu, *P. maximum* cv. Colonião, *P. guenoarum* e *P. plicatulum;* neste aspecto, o comportamento de *A. gayanus* cv. Planaltina foi intermediário. As gramíneas *A. gayanus* cv. Planaltina, *B. brizantha* cv. Marandu, *B. humidicola* cv. IRI 409, *P. guenoarum* and *P. plicatulum* apresentaram bons níveis de tolerância. Foram avaliados os capins quanto à preferência alimentar e postura. Os três capins, *B. decumbens* cv. Basilisk, *B. ruziziensis* e *Cenchrus ciliaris* L. não apresentaram nenhum mecanismo de resistência. Estas três gramíneas e *B. humidicola* cv. IRI 409 favoreceram a multiplicação das cigarrinhas. De modo geral, o grau de resistência de uma dada gramínea foi o mesmo para as diferentes espécies de cigarrinhas.

Termos para indexação: *Zulia entreriana, Deois flavopicta, Mahanarva fimbriolata, Andropogon gayanus, Brachiaria decumbens,* antibiose, tolerância, não-preferência.

INTRODUCTION

Spittlebugs (Genera *Zulia, Deois* and *Mahanarva*) are one of the more important limiting factors that prevent Brazil from reaching its full potential in beef production. The insects suck sap and inject toxins in grass plants. This reduces plant growth and in turn the carrying capacity of pastures. By one estimate, spittlebugs reduced green matter content of Brazilian pastures by about 15% (Empresa Brasileira de Pesquisa Agropecuária 1984). Furthermore, control of spittlebugs has an added importance since they develop in pastures and may fly to rice causing damage in that crop (Nilakhe 1985).

Mainly because of the low value of pasture per unit area, the cost of insecticides to control these insects is prohibitive. It is doubtful that any one single control method will eliminate the spittlebug problem. One approach then is to integrate various control tactics. Grasses resistant to spittlebugs would form one of the most important tactics of such an integrated control package.

With the objective of finding grasses resistant to spittlebugs, the studies done in Brazil include counting spittlebug populations in field plots (Botelho et al. 1980, Cosenza 1982, Lima & Gondim

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1982, Valério & Koller 1982, Oliveira & Gonçalves 1984), determining mechanisms of resistance (Menezes & Ruiz 1981, Cosenza 1982, Silva 1982, Nilakhe et al. s.n.t.), and studying the effect of nitrogenous fertilization on population of the insects in different grasses (Gaeiras et al. 1980). Outside Brazil, Calderón (1983) counted spittle masses in field plots in Colombia, and Stimmann & Taliaferro (1969), and Taliaferro et al. (1969) evaluated mecahisms of resistance in the USA. Because different spittlebug species damage pastures in different regions of the country where the climate, soil conditions and management practices are different, it becomes imperative that the host plant resistance studies be conducted in different regions. Herein are reported results of studies in the state of Mato Grosso do Sul, on the evaluation of grasses for resistance to spittlebugs under field conditions and a series of tests to determine probable mechanisms of resistance.

MATERIALS AND METHODS

Evaluation of grasses for resistance in field plots

Twenty two grasses were planted at a cooperator's field located about 15 km from Dourados and at the CNPGC, EMBRAPA in Campo Grande in November, 81. The grasses used are listed in Tables 1 and 2. The grass species were selected in consultation with grass breeders and seed production specialists of CNPGC. Along with grass cultivars that had some promise for the region, locally grown grasses were also included for testing. Grasses were established by seeding in plots of 3 x 6 m spaced 3 m apart. The grass plots were arranged in a randomized block design with five replications. For better establishment of grasses, NPK at the rate of 50, 50, 100/ha was applied prior to seeding. Once the grasses were well established, cattle were allowed to graze inside the experimental area two to three times during a rainy season (October to May). Normally 30-40 cattle grazed for three to four days. The cattle was removed when most of the grasses were reduced to 20-25 cm height. A few grasses received only light grazing and these were clipped manually. Periodic collection of spittlebug adults at these locations showed that at Dourados the insect species in diminishing abundance were *Zulia entreriana* (Berg.), *Deois flavopicta* (Stal) and at Campo Grande they were *D. flavopicta*, *M. fimbriolata* and *Z. entreriana.*

At Dourados, spittlebug nymphs were counted two times during the 1981-82 rainy season (March 5, 82, and April 1, 82) four times during 82-83 (December 7, 82; January 24, 83; February 25, 83; April 18, 83), and three times during 83-84 (October 31, 83; December 15, 83; January 18, 84). At Campo Grande, no spittlebugs appeared during the 81-82 rainy season. The insects were counted five times during 82-83 (January 8, 82; January 17, 83; February 2, 83; February 28, 83; April 6, 83) and three times during 83-84 rainy season (October 25, 83; Jnuary 11, 84; March 23, 84). Initially, nymphs were counted at about two-week intervals but later counts were made only at the higher infestation levels. The dates indicate when the nymphal counting was initiated; however, completing the count in all grass plots took an average of three days. At each count, a metal frame of 25 x 25 cm was thrown at random four times in a plot, and nymphs present inside the square were counted by classifying them into three groups: small (1st and 2nd instar), medium (3rd and 4th instar) and large (5th instar). A sample size of 25 x 25 cm was chosen because it was shown to be more efficient than larger sample sizes(Nilakhe 1982). A damage rating for grass plants in each plot was given by three persons independently at the end of a rainy season. A scale of 0 to 10 was used, where 0 = no damage; 1 = 10% leaf area with damage symptoms; up to 10 = 100% leaf area dry and leaves apparently dead. For analysis of variance means of the nymphal counts in each plot were averaged over a rainy season. The data for each location were analyzed as a two-factor experiment where the two factors were grass species/cultivar, and rainy seasons. Prior to analysis the data were transformed as $\sqrt{x + 0.5}$, where x = observed count, however, in tables the data are presented on original scale.

Five grasses (Table 3) planted in November 80 in 8 x 8 m plots by grass seed scientists at "CNPGC Introduction Garden" were also used for nymphal counts. The grasses were planted in a completely randomized design with three plots per grass. No cattle were used in these plots and grass plants were cut to 25 cm height after the seeds were harvested. The plots were fertilized every year at the beginning of the rainy seasons. The procedures for nymphal counts, damage rating and analysis of variance were the same as given in the preceeding paragraph. During 81-82 rainy season, the nymphal counts were made five times (January 14, 82 and January 29, February 16, March 5 and April 1, 82) and five times during 82-83 (November 11, 82; January 6, 83; March 2 and March 30, 83). Spittlebug adults in decreasing abundance were *M. fimbriolata*, *D. flavopicta* and *Z. entreriana.*

Survival of nymphs on different grasses in screenhouse

Grasses were planted in 20 cm diameter 2 kg earthen pots (Table 4). Usually one grass plant per pot was allowed to grow. When plants were 50 cm tall they were clipped to 20 cm. About six-month old plants were used for the tests mentioned in this section, and if not otherwise mentioned, for all the studies reported in this paper. After each clipping, the soil was fertilized at rate of 4.4 g of N, 15 g of P and 10.2 g of K per 100 kg of soil in the pots. A grass plant in a port was infested with ten *Z. entreriana* eggs (ready to hatch) by placing the eggs close to the tillers. A total of five pots per grass species were used. All eggs hatched in about two days – this was confirmed by periodical removal of empty egg shells. Thereafter the number of nymphs present in each pot were counted at about weekly intervals. The grass plants were held in a screenhouse, where the temperature was similar to the outdoors, and fluctuated between 18 and 36°C.

In one test, plants were infested with 6 medium size *Z. entreriana* nymphs per pot using six pots per grass species listed in Table 5. The number of nymphs present on each plant were counted one day after infestation. In other tests, plants were infested similarly, but nymphs were counted one week after the infestation. In all tests reported here, no insectcides were used and plants were never exposed to spittlebugs prior to the test infestations. In most cases the grass *B. decúmbens* Stapf, cv. Basilisk was used as a "check".

Survival of nymphs on different grasses under field conditions

One m^2 grass areas in field plots of four of the 22 grasses mentioned in Table 2 were caged with 1 m^3 saran covered cages. The four grass species used are listed in Table 6. All spittlebug nymphs and other insects present in the 1 m^2 areas were removed prior to placing cages. Similarly any additional nymphs appearing in the cages were removed every two weeks over a period of about six weeks. After a month period of insect-free cages the caged areas were considered to be free of any viable spittlebug eggs. On March 3-4, 1983 plants in each cage were infested with 20 (less than one-day old) *Z. entreriana* nymphs. Procedures for obtaining nymphs and infesting plants were the same as those of Nilakhe et al. (s.n.t.).

The number of nymphs present inside the cages were counted seven and 19 days after infestation. Similarly, in another test the same four grasses were infested with 40 newly hatched nymphs/m^2 from 26-28 of October, 83. The grass plants were caged during the previous rainy season to avoid insect oviposition in the test area.

Feeding preference of nymphs when given choice of different grasses

Three plants of two grass species (Table 7) were grown in 28 cm diameter earthen pots of 5 kg capacity. Plants inside the pot were arranged in a triangular design. Distance between the plants was 10 cm and the plants were equidistant from the center of the pot. Four pots were used for each combination of two plants of species 1 + one plant of species 2, and vice versa. When plants were about six months old, five small (newly emerged first instars), medium or large *Z. entreriana* nymphs were placed on the soil surface at the center of the pot. Nymphs present on each plant in the pot were counted one day after infestation. The number of repetitions used for small, medium, and large nymphs were four, twelve and twelve, respectively. As more experience was gained, the methodology for the small nymphs was modified – two nymphs were placed on each plant at the soil level, and the nymphs were counted the following day.

By calculating x^2, the observed nymphal count was tested against the theoretical ratio of 2:1 using the formula given by Leclerg et al. (1962). Chi square values significant at 5% level of probability were considered to indicate no fit for the tested ratio.

Adult emergence from eggs deposited in different grass plants

Thirty spittlebug adults were caged for 2-3 days on the potted grass plants, and the number of pots per grass species varied from 6-8, although the infestation period and the number of pots per grass were consistent within each of the five tests (Table 8). During the infestation period the dead adults were replaced with live ones on a daily basis. After the infestation, the plants were clipped to a 20 cm height and the pots were held in dishes. Water was added to the dishes to prevent complete drying of the soil. Since none of the eggs hatched, they were presumed to be in a diapause stage (Tests 1, 2 and 4). Hatching began from the 3rd week of August to the middle of October (small nymphs were found during this period). When large nymphs appeared, a cage made of a metal frame and nylon cloth of 15 mesh was placed over the grass plants. Initially, emerging adults were removed daily but, later large nymphs were removed from the cages twice a week. Experience has shown that almost all large nymphs reach the adult stage, therefore nymphs that reached the 5th instar were considered successful in reaching adult stage. Adult emergence occurred from the third week of September to the first week of December. The length of the adult was measured from the anterior most part of the head to the posterior most part of the wings.

The grass plants in Tests 3 and 5 were infested in November and October, respectively. In these two tests, the majority of the nymphs appeared about two weeks after infestation. In all tests, plants were watered by placing water only in the dishes holding pots.

Grass tolerance to adult feeding

A total of five tests were conducted by infesting six to eight potted grass plants per grass species with 25-30 field-collected spittlebug adults for two or three days (Table 9). The number of pots, adults, and duration of infestation were consistent within a given test. The plants used were

45-50 cm tall. During the infestation period, dead adults were replaced with live ones on a daily basis. Eight days after infestation, plants were rated for damage by three people using the scale described in the first section.

Adult preference for feeding and oviposition

Four grass species were used in Tests 1-4, three in Test 5 and two in Test 6. The grasses used are listed in Table 10. A potted grass plant of each of the grass species to be tested was placed at equidistance and well separated from one another in a 1 m^3 cage. The cage was made of a wooden frame with wooden bottom and was covered with a ten-mesh screen and had a door for placing plants, insects, etc. For each test, eight cages were used and they were placed either in a screenhouse or in open shady outdoor areas. The number of spittlebug adults released per cage were equal to the number of grass plants inside the cage x 15. The first observation on the number of adults present on each plant was made two hours after the insects were introduced. Thereafter three to four observations were recorded per day at intervals of about two hours so as to obtain a total of 13 observations. After each observation, the dead insects were replaced with live ones

Presence of a spittlebug on a particular grass plant was considered as its feeding preference. During test duration, pots were held in dishes containing water. Following the observations, the clipped plant portion up to a height of about 10 cm from the soil level, and soil from the pot to a depth of 2.5 cm, were washed through a series of sieves allowed to dry, and were examined for the insect eggs as described by Nilakhe et al. (1984a).

Survival and fecundity of adults reared on different grasses

In four of the seven tests both survival and fecundity were measured, whereas in three tests only survival was determined (Table 11). In Test 1, single grass plants (three grass species) were grown in 10 cm diameter x 9 cm tall plastic cups. When four to five-month old, the plants were caged witn a pair of adults and the pair moved to a fresh plant every four days: To obtain adults, last instar nymphs were collected from *B. decumbens* pastures and were caged on potted grass plants. Emerging one-day old adults were col'ected daily. Cages containing paired spittlebugs were checked daily, until all the insects were dead. Thereafter the soil was examined for eggs as described in the preceeding section. In Tests 2, 5 and 6 the methodology was modified somewhat. Four pairs of one-day old adults were held along with four plants of a grass species grown in cups in 35 x 35 x 60 cm tall saran covered cage. The other details were the same as in Test 1. In Tests 3, 4 and 7, ten newly emerged adults (5♂ + 5♀) were caged on grass plants in pots by using six pots per grass species, and the adult survival was checked daily.

Summarizing data into three categories of mechanisms of resistance

Informations presented in this paper and those of Nilakhe et al. (s.n.t.) were summarized. Based on Painter's classification of mechanisms of resistance (Painter 1951), the adverse effect of a grass on survival, development, and reproduction of spittlebugs was arbitrarily classified as "Antibiosis". Considering the damage ratings, the degree of "Tolerance" was suggested. For the category "Nonpreference", both ovipositional and the feeding preference were considered. For each of three categories (antibiosis, nonpreference and tolerance), the degree of plant resistance was arbitrarily classified into four categories: 0 = below average, x = average, xx = good, and xxx = very good.

RESULTS AND DISCUSSION

Evaluation of grasses for resistance in field plots

The mean number of spittlebug nymphs counted in field plots at Dourados are given in Table 1 and those at CNPGC, Campo Grande, are given in Table 2. Because the interaction of grass species x collection period (rainy season of 81-82, 82-83, etc.) was significant ($P < .05$) for counts at both locations, the means for different collection periods were not averaged. Good levels of infestations occurred at both locations to permit discrimination among grass species.

At Dourados, consistently higher number of nymphs were found in the grass *Cenchrus ciliaris* L. in all the three rainy seasons. The nymphal counts were higher in 1981-82 (grass plants were less than five months old) than in 82-83 in the grasses *B. decumbens* cv. Basilisk, IRI 562 and IRI 700; *Brachiaria* sp. (BRA 000060), *B. mutica* (Forsk) Stapf, *B. ruziziensis* Germain & Evrard and *Chloris gayana* Kunth. However, in the case of *Cynodon dactylon* (L.) Persoon, and *Setaria sphacelata* Stapf ex. Massey cv. Kazungula more nymphs were found in 82-83 than in 81-82. In four grasses the nymphal counts decreased significantly from 82-83 to 83-84 (*C. ciliaris, C. dactylon, Panicum maximum* Jacq. cv. Green Panic and *S. sphacelata* cv. Kazungula).

No data on *Brachiaria humidicola* (Rendle) Schweickt cv. IRI 409 could be recorded in 1981-

TABLE 1. Mean number of spittlebug nymphs in field plots of different grasses, Dourados, MS, 1981-84.

Grass	x no. of nymphs/m² during year[1]		
	1981-82	82-83	83-84
Cynodon dactylon	0.0 a	27.7 f-i	4.5 a-d
Hyparrhenia rufa	0.0 a	3.8 a-d	8.3 a-e
Paspalum guenoarum	0.0 a	4.8 a-d	1.9 a-c
Panicum maximum cv. Coloninho	0.0 a	0.8 ab	0.0 a
Paspalum plicatulum	2.4 a-c	1.1 ab	0.5 a
Panicum maximum cv. Colonião	3.2 a-c	2.6 ab	0.5 a
Panicum maximum cv. Tobiatã	4.0 a-d	17.0 c-q	15.5 b-g
Panicum maximum cv. Makueni	10.9 a-e	17.0 d-g	7.2 a-e
Andropogon gayanus cv. Planaltina	12.2 a-g	1.6 ab	4.3 a-d
Brachiaria brizantha cv. Marandu	13.6 a-g	0.8 ab	0.2 a
Setaria sphacelata cv. Kazungula	20.8 d-g	54.7 jk	7.7 a-e
Brachiaria mutica	27.2 g-1	8.3 a-f	2.7 a-c
Panicum maximum cv. Green Panic	28.8 g-i	26.4 g-i	2.9 a-d
Chloris gayana	48.0 h-j	8.3 a-f	10.9 a-g
Brachiaria sp.	54.3 j	7.2 a-e	8.8 a-g
Brachiaria ruziziensis	57.3 jk	20.3 e-g	25.6 e-h
Brachiaria decumbens cv. IRI-700	67.7 j-l	14.1 a-g	7.2 a-e
Brachiaria decumbens cv. IRI-562	90.7 l	11.8 a-g	8.8 a-f
Brachiaria decumbens cv. Basilisk	92.5 l	13.4 a-g	10.1 a-g
Cenchrus ciliaris	95.2 kl	99.7 l	50.4 i-j

[1] Means not followed by the same letter(s) differ significantly at 5% level of probability by Duncan's multiple range test.

-82 because the establishment of the grass plants was delayed. Nymphal density on this grass was 11.4/m² in 82-83 and 14.4/m² in 83-84. The grass plants *Melinis minutiflora* Beau. disappeared during the third rainy season (83-84). This might have happened because the cattle preferred this grass and this might have resulted in too much tramping. Nymphal density in grass plots of *M. minutiflora* was 134.4/m² in 81-82 and 59.4/m² in 82-83. Generally the damage ratings ranged between 0 to 1. Only on two occasions the damage rating exceeded 1: in the case of *C. ciliaris* 1.7 in 81-82, and 1.4 in 82-83.

At Campo Grande, nymphal density was similar in both rainy seasons in all but six of the 22 grasses: In five of these six grasses: *B. decumbens* cv. Basilisk, IRI 562, IRI 700, *Brachiaria* sp. and *Hyparrhenia rufa* (Ness) Stapf, significantly higher numver of nymphs were found in 83-84 than 82-83, and it was vice versa in the case of *M. minutiflora*. Despite the lower spittlubug numbers in 82-83, *C. dactylon* showed a high degree of damage (damage rating of 8.6). On the other hand, *B. humidicola* cv. IRI 409 (rating of 0.9) and *S. sphacelata* cv. Kazungula (rating of 0.3) received low damage ratings, despite high infestations. Two years after planting, *C. ciliaris* was deteriorating rapidly and perhaps this might have contributed to its high damage rating.

The grasses that had consistently low spittlebug populations at both locations were *Andropogon gayanus* Kunth. cv. Planaltina, *Brachiaria brizantha* (Hochst, ex. A. Rich.) Stapf cv. Marandu, *P. maximum* cv. Colonião and Coloninho, *Paspalum guenoarum* Archevaleta and *Paspalum plicatulum* Michx.

At CNPGC Introduction Garden, grass plots of one species labeled *Brachiaria* sp. had far greater number of nymphs than the other four grasses (Table 3). Counts made on January 14, 82 showed 678 nymphs/m². The plants in *Brachiaria* sp. plots received damage rating of 10, whereas other grass species had rating of 1 or less. The above ground portions of the *Brachiaria* sp. appeared to be

TABLE 2. Mean number of spittlebug nymphs in field plots of different grasses and the damage estimations, Campo Grande, MS, 1982-84.

Grass	x̄ no. of nymphs/m² during[1]		Damage note[2]
	1982-83	83-84	
Paspalum plicatulum	0.3 a	0.5 a	0.9 ab
Paspalum guenoarum	2.6 ab	3.2 ab	1.3 ab
Andropogon gayanus cv Planaltina	2.6 ab	4.3 ab	2.4 b-d
Brachiaria brizantha cv. Marandu	3.2 ab	0.8 a	2.0 bc
Panicum maximum cv. Coloninho	3.7 ab	16.8 a-f	4.6 ef
Panicum maximum cv. Colonião	4.8 a-c	6.7 a-c	3.5 de
Hyparrhenia rufa	8.3 a-d	33.6 e-h	1.6 a-c
Brachiaria decumbens cv. IRI-700	12.3 a-e	82.9 k	4.9 f
Chloris gayana	13.8 a-f	18.4 a-f	5.9 fg
Brachiaria decumbens cv. Basilisk	14.4 a-f	98.1 k	5.4 fg
Cynodon dactylon	17.9 a-f	2.2 ab	8.6 i
Brachiaria mutica	18.9 b-g	11.2 a-d	2.3 bc
Brachiaria decumbens cv. IRI-562	20.0 b-g	109.8 k	5.3 f
Panicum maximum cv. Green Panic	25.4 c-g	28.2 d-g	4.8 f
Cenchrus ciliaris	25.6 c-g	38.4 f-i	7.3 hi
Brachiaria sp	27.8 d-h	74.4 i-k	6.7 gh
Brachiaria ruziziensis	30.2 e-h	52.0 h-i	3.0 cd
Panicum maximum cv. Tobiatã	34.6 f-h	26.4 d-g	2.7 cd
Panicum maximum cv. Makueni	35.4 e-h	34.9 e-h	3.3 de
Brachiaria humidicola cv. IRI-409	41.0 gh	76.5 j-k	0.9 ab
Setaria sphacelata cv. Kazungula	53.0 h-j	55.5 h-j	0.3 a
Melinis minutiflora	54.1 h-j	23.5 c-g	1.0 ab

[1] Means not followed by the same letter(s) differ significantly at 5% level of probability by Duncan's multiple range test.

[2] A scale of 0-10 was used, where 0 = no damage; 1 = 10% leaf area with damage symptoms; up to 10 = 100% leaf area dry and leaves apparently dead.

TABLE 3. Mean number of spittlebug nymphs in field plots of different grasses at the CNPGC Introduction Garden, Campo Grande, 1981-83.

Grass	x no. of nymphs/m²[1]
Paspalum plicatulum	0.8 a
Andropogon gayanus cv. Planaltina	20.1 ab
Brachiaria humidicola cv. IRI-409	45.8 bc
Brachiaria ruziziensis	92.0 c
Brachiaria sp.	189.4 d

[1] Interactions, grass species x collection period (rainy seasons of 1981-82, and 82-83) were not significant ($P > 0.05$). Means not followed by the same letter(s) differ significantly at 5% level of probability by Duncan's multiple range test.

completely dry. The following rainy season some new growth appeared, but there were many empty spaces between plants.

Counting spittlebug numbers in field plots of different grasses should be considered as an initial step in evaluating grasses for resistance to these insects. If possible, one should avoid making recommendations to growers based only on field counts. Absence of spittlebug nymphs in a particular grass may be because the adults did not prefer the grass for oviposition, the grass was preferred only for feeding, eggs were deposited but emerging nymphs had difficulty in surviving, etc. Spittlebug adults may show a feeding preference when two or more pastures of different grass species border one another. However, when a single grass species is grown over a large area (several square kilometers), then the insects are left without any choice and are sort of "forced" to survivel on this grass. Therefore it becomes necessary to obtain some sort of measure so as to whether the grass will cause a decrease or an increase in spittlebug populations. Therefore, studies about mechanism of resistance become necessary. A grass that escaped the infestation (in field plots along with other grasses), for whatever reasons, may turn out to be the one that favors increase of spittlebug population. For example, in the present study, nymphal counts in plots of the grass *C. dactylon* were generally low. Thus, based only on these data one may suggest the grass to be resistant, however, the newly hatched spittlebug nymphs reached adulthood in larger numbers on this grass compared to some other grasses (Nilakhe et al. s.n.t.). Other than serving as a first step in evaluation for resistance to the insects, the field plots also help determine adaptability and response of these grasses to other agronomic characteristics in a given region.

No systematic sampling was done for spittlebug adult densities in field plots of differen grasses. Grass areas (3 x 6 m) were small to take sweep samples with a sweep-net, and the degree of variation in counts that may be caused because of differences in growing habits of grasses is not yet known. To avoid the latter problem, one may consider taking absolute adult counts by means of a cage (Nilakhe et al. 1984b). However, because of the efforts involved, the sampling could be done on only a few grasses. Nevertheless, measuring adult densities should be useful.

It is known that spittlebug adults cause far greater damage than the nymphs (Silva 1982, Nilakhe 1983). Thus spittlebug adults definitely were responsible for a great deal of damage and since the adults are mobile, it would not be very accurate to associate degree of damage (damage rating) with the nymphal counts alone. In general the soil at Dourados being far more fertile than at Campo Grande, the grass plants at Dourados were more vigorous and this may have contributed to the lower damage rating at Dourados.

Why the nymphal counts in some grasses varied considerably from one year to another was not clear. Yearly differences in spittlebug densities and differential grass growth habits might have contributed to such differences.

The nymphs were classified as small, medium and large with the objective that some grasses may be found in which nymphs had died before reaching later instars. However, this was not the case. All grasses had some large nymphs and the number of nymphs among grasses varied so greatly that no attempt to interprete these data were made.

Survival of nymphs on different grasses in screenhouse

Table 4 gives the mean number of nymphs found on each grass species on various days after infestation of grass plants with ready to hatch eggs. Significantly fewer nymphs were found on *B. brizantha* cv. Marandu than on *P. maximum* cv. Tobiatã and *B. decumbens* cv. Basilisk ($P < .05$). In the test where grass plants were infested with six medium-size nymphs, the mean number of nymphs found one day after infestation on plants of *P. guenoarum* was 3.6, on plants of *B. brizantha* cv. Marandu 3.8, and 4.2 on plants of *B. decumbens* cv. Basilisk; none of these counts differed significantly ($P < .05$). However, the results were different in the two similarly conducted tests in which the number of nymphs per pot were counted one week from infestation (Table 5). No nymphs were found on plants of *P. plicatulum* and

TABLE 4. Survival of *Z. entreriana* nymphs on different grasses, when a grass plant in a pot was infested with 10 eggs ready to hatch.

Grass	$\bar{x}$ no. of nymphs/pot on days after infestation[1]		
	6	12	26
Brachiaria brizantha cv. Marandu	1.0 a	0,6 a	0.6 a
Panicum maximum cv. Tobiatã	4.2 b	4.0 b	4.0 b
Brachiaria decumbens cv. Basilisk	5.6 b	5.0 b	4.6 b

[1] Means not followed by the same letter differ significantly at 5% level of probability by means of Duncan's multiple range test.

the number of nymphs found on *B. brizantha* cv. Marandu (1.5) was fewer than on *B. decumbens* cv. Basilisk (4.5) ($P < .05$).

TABLE 5. Survival of medium size *Zulia entreriana* nymphs on different grasses[1].

Grass	x̄ no. of nymphs remaining per pot 1 wk after infestation	
	Test 1	Test 2
Paspalum plicatulum	0.0 a	0.0 a
Brachiaria brizantha cv. Marandu	1.5 b	1.5 b
Brachiaria decumbens cv. Basilisk	4.5 c	4.5 c

[1] Six nymphs were placed per grass plant in a pot and 6 pots per grass were used. Means not followed by the same letter within a test differ significantly at 5% level of probability by Duncan's multiple range test.

In an early study to determine the number of nymphs reaching adulthood on different grasses, the plants were infested with newly hatched nymphs (Nilakhe et al. s.n.t.). Prior to placing these nymphs on the test plants, they had fed for a few hours on young *B. decumbens* seedlings. It was not known how critical this might be for the nymphal survival, i.e., if nymphs had fed on test plants right from the start, would the results be any different? Thus, to get away from this doubt and also to allow nymphs to search their own food and to avoid handling of nymphs manually, a test was conducted by infesting plants with ready to hatch eggs. The results obtained either by infesting with newly emerged nymphs or by the ready to hatch eggs were the same. Thus, one may use either method. When one infests with nymphs, the infestation rate can be kept constant; however, eggs may fail to hatch and the number of nymphs would be different. In the present study, empty egg shells were removed by periodic observations; however, in routine tests this may be cumbersome.

Both newly hatched nymphs, and medium size nymphs had difficulty surviving on plants of *B. brizantha* cv. Marandu. When infestation were done using medium size nymphs, the insects readily formed spittle and were found on the plants one day after infestation. However, thereafter the nymphs died or left the plants in search of other food. Experience has shown that on plants of *P. guenoarum* and *P. plicatulum* the newly hatched nymphs generally form spittle on the day of infestation, but on the following day the spittles disappear.

Survival of nymphs on different grasses under field conditions

Table 6 shows that the percent of nymphs alive one week after infestation tended to be higher in *B. decumbens* cv. Basilisk than in *A. gayanus* cv. Planaltina, *B. brizantha* cv. Marandu and *P. plicatulum*. Nineteen days after infestation no nymphs were found in *B. brizantha* cv. Marandu and *P. plicatulum* but *B. decumbens* cv. Basilisk still had the highest percentage of nymphs.

TABLE 6. Survival of freshly hatched *Z. entreriana* nymphs on different grasses under field conditions[1].

Grass	% nymphs alive days after infestation	
	7	19
Paspalum plicatulum	1.3	0.0
Brachiaria brizantha cv. Marandu	2.5	0.0
Andropogon gayanus cv. Planaltina	13.8	3.8
Brachiaria decumbens cv. Basilisk	25.0	11.3

[1] Four 1 m^2 areas per grass were protected from natural spittlebug infestations. Then the grass plants were infested with 20 freshly hatched nymphs/m^2.

In a test in which plants were infested with 40 nymphs/m^2, the percent nymphs alive one week after infestation was five in *B. decumbens* cv. Basilisk and zero in *A. gayanus* cv. Planaltina, *B. brizantha* cv. Marandu and *P. plicatulum*.

In a test in which the plants were infested with 20 newly hatched nymphs/m^2 (Table 6), the overall survival was generally lower than the one obtained in a screenhouse (data reported in this paper and Nilakhe et al. s.n.t.). However, the influence of a particular grass host on nymphal survival tended to be the same in a screenhouse and under field conditions. This is good because it increases credibility of screenhouse data. In another test where 40 nymphs/m^2 were used the survival was lower than expected even in *B. decumbens* cv. Basilisk. It was suspected that some predators were taking the nymphs away. Observations revealed that within two or three hours from infestation the majority of nymphs were carried away by ants. In future, such tests should be conducted in areas free of ants.

Feeding preference of nymphs when given choice of different grasses

In most cases, the χ^2 values were significant indicating no fit for the expected 2:1 ratio (Table 7). This also suggested that in most cases the nymphs showed definite plant preference. Generally, nymphs of all sizes preferred plants of *Brachiaria* sp. over those of *A. gayanus* cv. Planaltina and *P. plicatulum*. Cosenza (1982) also found that *D. flavopicta* nymphs (2nd instars) preferred plants of *B. decumbens* over those of *A. gayanus* cv. Planaltina.

Most of the medium and large nymphs placed in the pots were recovered the next day. However, of all the small nymphs released in the center of the pots, 57.5% were lost; they had either died or left the pots. Greater success was obtained by placing two nymphs on each of the three plants in a pot – only 43.5% were lost. On eight occasions, nymphs were observed to leave plants of *P. plicatulum* and establish on *Brachiaria* sp. On two occasions nymphs were observed to move from *A. gayanus* to *Brachiaria* sp., and vice versa on one occasion.

Apparently, the nymphs chose plants randomly. Also, as soon as the nymphs reached plants of *Brachiaria* sp. they started to feed and form spittle, and were not attracted to other plants. In the case of *P. plicatulum*, the nymphs walked on stems for five or six minutes without feeding and then left the plants probably in search of others. In a pasture of this grass the nymphs may move several times from one plant to another in search of a more suitable one. Thus, the nymphs are likely to be exposed to predators and parasites for longer periods of time and this also may increase the chances for contact with spores of fungal diseases.

Adult emergence from eggs deposited in different grass plants

The data given in Table 8 show that, generally more *D. flavopicta* developed on the grasses *B. decumbens* cv. Basilisk, *B. humidicola* cv. IRI 409, *B. ruziziensis* and *C. ciliaris* than on the other test grasses. The fewest number of nymphs reached the adult stage on *P. maximum* cv. Colonião and Makueni, whereas an intermediate response was

TABLE 7. Feeding preference of *Zulia entreriana* nymphs when given choice of different grasses.

Nymphal size	Combination of three plants of two grass species in a pot and the number of nymphs found on the grasses 24 hours after infestation[1]							
	2 *Brachiaria* sp.	+ 1 *Paspalum plicatulum*	1 *Brachiaria* sp.	+ 2 *Paspalum plicatulum*	2 *Andropogon gayanus*	+ 1 *Brachiaria* sp.	1 *Andropogon gayanus*	+ 2 *Brachiaria* sp.
Small	6	0	7	2	1	8	2	8
χ^2 values[2]	3.0		8.0*		12.5*		0.8	
Small (A)	10	0	22	2	12	10	6	33
χ^2 values	5.0*		36.8*		1.5		46.2*	
Medium	47	2	30	23	24	27	8	42
χ^2 values	18.9*		12.9*		18.8*		6.8*	
Large	45	6	39	10	22	28	17	38
χ^2 values	10.7*		47.2*		11.6*		0.2	

[1] Distance between plants in a pot was about 10 cm. Five nymphs were released on soil surface at the center of a pot in the case of small, medium and large nymphs. The number of pots used in each of these nymphal categories were 4, 12 and 12, respectively. In the case of nymphs "Small (A)", 2 nymphs were placed on each of the three plants in a pot, and a total of seven pots were used for each of the four grass plant combinations.

[2] Significant χ^2 values (* means significant at 5% level of probability) indicate disagreement with the expected 2:1 ratio for the number of nymphs found on two grass species.

TABLE 8. Mean number of spittlebug adults developed from eggs deposited by 30 adults caged for two or three days on grass plants in pots, MS, 1982.

Grass	Number of spittlebug adults obtained/pot[1]	Length of adults emerged (mm)
Test 1, *D. flavopicta*, infestation from April 30 to May 1, Campo Grande		
Panicum maximum cv. Colonião	1.33 a	9.26 b
Milinis minutiflora	1.33 a	8.60 a
Panicum maximum cv. Makueni	2.33 ab	8.70 ab
Hyparrhenia rufa	2.67 ab	9.05 ab
Andropogon gayanus cv. Planaltina	5.00 abc	8.85 ab
Brachiaria ruziziensis	5.17 abc	9.27 b
Brachiaria decumbens cv. Basilisk	5.67 bc	9.05 ab
Setaria sphacelata cv. Kazungula	6.17 bc	8.60 a
Brachiaria humidicola cv. IRI 409	7.00 c	9.12 ab
Test 2, *D. flavopicta*, infestation from April 6 to 8, Dourados		
Panicum maximum cv. Colonião	0.20 a	–
Andropogon gayanus cv. Planaltina	3.00 ab	7.85 a
Panicum maximum cv. Makueni	3.20 ab	8.21 ab
Melinis minutiflora	4.00 ab	7.89 a
Setaria sphacelata cv. Kazungula	4.50 ab	9.41 c
Hyparrhenia rufa	8.50 b	9.05 bc
Brachiaria decumbens cv. Basilisk	9.30 b	9.15 c
Brachiaria humidicola cv. IRI 409	9.80 b	9.56 c
Cenchrus ciliaris	18.20 c	8.67 abc
Brachiaria ruziziensis	18.80 c	9.32 c
Test 3, *D. Flavopicta*, infestation from November 1 to 3, Campo Grande		
Andropogon gayanus cv. Planaltina	4.17 a	–
Melinis minutiflora	7.16 a	–
Brachiaria decumbens cv. Basilisk	8.83 a	–
Test 4, *Z. entreriana*, infestation from April 15 to 17, Campo Grande		
Paspalum plicatulum	0.00 a	–
Paspalum guenoarum	0.63 a	–
Brachiaria decumbens cv. Basilisk	5.63 b	–
Test 5, *Z. entreriana*, infestation from October 14 to 16, Dourados		
Andropogon gayanus cv. Planaltina	0.33 a	–
Panicum maximum cv. Colonião	0.50 a	–
Hyparrhenia rufa	0.83 a	–
Setaria sphacelata cv. Kazungula	2.00 ab	–
Brachiaria ruziziensis	2.33 ab	–
Brachiaria humidicola cv. IRI 409	2.33 ab	–
Melinis minutiflora	3.33 ab	–
Panicum maximum cv. Makueni	4.17 b	–
Brachiaria decumbens cv. Basilisk	4.83 b	–
Cenchrus ciliaris	8.33 c	–

1 Means within a test are based on 6-8 pots/grass species, although number of pots were consistent within a given test. As nymphs became adults, they were removed from caged pots. Within a column and a given test, means not followed by the same latter(s) differ significantly at 5% level of probability by Duncan's multiple range test. In Test 1, growth of *M. minutiflora* and *B. ruziziensis* was drastically reduced after the infestation. This may have helped reduce the number of adults obtained.

observed for grasses *A. gayanus* cv. Planlatina, *H. rufa, M. minutiflora* and *S. sphacelata* cv. Kazungula. In Test 1 the adults emerging from nymphs reared on *M. minutiflora* and *S. sphacelata* cv. Kazungula were smaller (shorter body length) than those from *B. ruziziensis* and *P. maximum* cv. Colonião. In Test 2, adults from pots of *A. gayanus* and *M. minutiflora* were smaller than those from *B. decumbens* cv. Basilisk, *B. humidicola* cv. IRI 409, *B. ruziziensis* and *S. sphacelata* cv. Kazungula.

A higher number of *Z. entreriana* adults were recovered from pots of *B. decumbens* cv. Basilisk, *C. ciliaris* and *P. maximum* cv. Makueni than from *A. gayanus,* cv. Planaltina, *H. rufa, P. maximum* cv. Colonião, *P. guenoarum* and *P. plicatulum.*

Generally at the time of hatching about the same number of nymphs were observed in each pot, but the initial survival (the first two or three days) was poor on grasses such as *P. guenoarum, P. plicatulum,* and *P. maximum* cv. Colonião.

The gross estimates indicated that overall the number of spittlebug adults obtained in *A. gayanus* and *P. maximum* cv. Colonião were two or three times, and three of four times fewer, respectively, than in *B. decumbens* Basilisk and *B. humidicola* cv. IRI 409. Such differences have occurred obviously because of the differential nymphal mortality. Clearly, it is not known if the same degree of survival will be observed in pastures of these grasses or not; however, it is hoped that the trends will be the same. The insects reared on some grasses produced bigger adults than on others. It is likely that bigger spittlebug adults may cause more damage and produce more eggs than the smaller ones. Allowing adults to deposit eggs in the potted grass plants eliminated handling of eggs and nymphs – a situation much more natural. Within a given test, the sex ratio of the adults and the number of eggs deposited per pot were considered equal. No estimates were made of eggs present in these pots. In another study, 30 adults (15♂ + 15♀) caged in April 85 for three days over potted *B. decumbens* deposited an average of 140 eggs, and about 40% of such eggs survived through the dry period; thus there were 56 viable eggs at the beginning of the rainy season. Although, not definite, these egg counts could be considered somewhat similar as the tests reported in this paper where the adults were caged in April-May. Because of the different physiological status of females and because of the varying proportions of sex ratios (mostly in favor of males), the number of eggs might have varied considerably from one test to another. Determining sex ratios of the caged adults and obtaining some measure about the egg number should be useful in future tests.

Grass tolerance to adult feeding

Damage ratings for several grass species are shown in Table 9. Although the ratings of some grasses were different between the tests, the following grasses showed a high degree of tolerance: *A. gayanus* cv. Planaltina, *B. humidicola* cv. IRI 409, *B. brizantha* cv. Marandu, *P. guenoarum* and *P. plicatulum.* The grasses that showed the least tolerance were *B. ruziziensis, C. ciliaris, M. minutiflora* and *P. maximum* cv. Colonião. The grasses *B. decumbens* cv. Basilisk, *H. rufa, P. maximum* cv. Makueni and *S. sphacelata* cv.Kazungula were considered intermediate.

In the present study, the grass *B. humidicola* cv. IRI 409 showed good levels of tolerance to damage by the spittlebug, *Z. entreriana.* This findings is in agreement with that of Cosenza (1982) on *D. flavopicta* in the Distrito Federal and that of Silva (1982) for *D. incompleta* Walker, in the state of Pará. Cosenza (1982) reported the grass *M. minutiflora* was one of the most tolerant among the ten grasses evaluated. However, in the present study this grass was found to be one of the least tolerant. Also in this study, the performance of *B. decumbens* cv. Basilisk was not as poor as the one found in the evaluations of Cosenza (1982). Apparently, some grass species react differently to the feeding of different spittlebug species. Under field conditions, if the grass grows poorly one may expect it to be less tolerant also.

Adult preference for feeding and oviposition

Only a few differences were found between the feeding and ovipositional preference for the various grasses (Table 10). *P. maximum* cv. Colonião was preferred for feeding over *B. ruziziensis* and *C. ciliaris* and *P. maximum* cv. Makueni were preferred

TABLE 9. Tolerance level of different grasses to attack of spittlebug adults in screenhouse, 1982.

Grass	$\bar{x}$ damage rating 8 days after infestation[1]
Test 1, *Z. entreriana*, March, Campo Grande	
Andropogon gayanus cv. Planaltina	2.70 a
Panicum maximum cv. Makueni	3.47 a
Brachiaria decumbens cv. Basilisk	3.83 ab
Brachiaria humidicola cv. IRI 409	3.90 ab
Setaria sphacelata cv. Kazungula	4.37 ab
Panicum maximum cv. Colonião	5.03 bc
Brachiaria ruziziensis	5.30 bc
Hyparrhenia rufa	5.67 bc
Melinis minutiflora	6.87 c
Test 2, *Z. entreriana*, April, Campo Grande	
Paspalum plicatulum	2.63 a
Paspalum guenoarum	3.50 a
Brachiaria sp.	7.23 b
Test 3, *Z. entreriana*, October, Dourados	
Brachiaria humidicola cv. IRI 409	3.40 a
Andropogon gayanus cv. Planaltina	3.70 ab
Brachiaria decumbens cv. Basilisk	4.45 a-c
Setaria sphacelata cv. Kazungula	4.85 a-c
Hyparrhenia rufa	4.90 a-c
Panicum maximum cv. Makueni	5.35 bc
Cenchrus ciliaris	5.60 bc
Panicum maximum cv. Colonião	5.65 c
Brachiaria ruziziensis	6.00 cd
Melinis minutiflora	7.75 d
Test 4, *Z. entreriana*, November, Dourados	
Brachiaria brizantha cv. Marandu	1.50 a
Brachiaria decumbens cv. Basilisk	4.20 b
Melinis minutiflora	4.93 b
Test 5, *D. flavopicta*, November, Campo Grande	
Andropogon gayanus cv. Planaltina	1.50 a
Brachiaria decumbens cv. Basilisk	5.00 b
Melinis minutiflora	6.17 b

[1] Means within a test are based on six to eight pots/grass species. The grass plants in a pot were infested with 25 or 30 spittlebug adults for two or three days, although both were consistent within a given test. A scale of 0-10 was used for damage rating, where no damage; 1 = 10% leaf area with damage symptoms, up to 10 = 100% leaf area dry and leaves apparently dead. Means not followed by the same letter(s) within a test differ significantly at 5% level of probability by Duncan's multiple range test.

over *B. decumbens* cv. Basilisk and *B. humidicola* cv. IRI 409. In one test more eggs were deposited in pots of *B. decumbens* cv. Basilisk, *B. ruziziensis* and *M. minutiflora* than in pots of *P. maximum* cv. Colonião. In another test, more eggs were deposited in pots of *B. decumbens* cv. Basilisk than in pots of *B. brizantha* cv. Marandu. Overall, no apparent relationship was seen between the grasses chosen for feeding and those chosen for oviposition.

The adults of *Z. entreriana* preferred feeding on *P. maximum* cv. Makueni over *B. humidicola* cv. IRI 409. This was also reported for *Z. entreriana* in the state of Bahia by Menezes & Ruiz (1981). Cosenza (1982) showed apparent association between the number of adults found on grass species (feeding preference) and the number of eggs deposited in the respective grass species. Under field conditions it is very likely that the spittlebug females oviposit in the same pasture that was preferred for feeding. Almost nothing is known about the within and between pasture movement of spittlebug adults. Studies are needed to determine what kind of pasture (grass species and grass height) the insects prefer and when the insects move from one pasture to other (assuming that it occurs) and in what numbers. In the present study the number of eggs in Tests 1 to 4 (Table 10) were lower than expected; it is not clear why it was so. Probably there was a preponderance of males. The spittlebugs used in the tests were collected by sweeping, and in such collections males quite often outnumber females.

Survival and fecundity of adults reared on different grasses

The adults of *D. flavopicta* survived longer when reared on *B. decumbens* cv. Basilisk than on *P. plicatulum* ($P < .05$) (Table 11). Also, adults survived longer on *B. decumbens* than on *P. guenoarum* in two of the three tests and on *A. gayanus* cv. Planaltina in one of the two tests. The survival of adults reared on *B. decumbens* cv. Basilisk and *P. maximum* cv. Colonião was the same ($P > .05$). On the other hand, adults of *M. fimbriolata* survived longer on *B. brizantha* cv. Marandu than on *B. decumbens* cv. Basilisk in one of the two tests. No difference was seen for adult survival between *B. decumbens* cv. Basilisk and *P. maxi-*

TABLE 10. Feeding and ovipositional preference of spittlebug adults to various grasses in a screenhouse, 1982-84[1].

Grass	x̄ no. of adults/plant	x̄ no. of eggs deposited/pot
	Test 1. *Z. entreriana*	
Brachiaria decumbens cv. Basilisk	7.5 a	11.3 a
Andropogon gayanus cv. Planaltina	7.8 a	9.4 a
Hyparrhenia rufa	8.2 a	5.8 a
Setaria sphacelata cv. Kazungula	9.9 a	9.2 a
	Test 2. *Z. entreriana*	
Panicum maximum cv. Colonião	5.6 a	7.0 a
Brachiaria decumbens cv. Basilisk	7.6 ab	24.7 bc
Melinis minutiflora	8.1 ab	18.5 b
Brachiaria ruziziensis	9.8 b	25.0 c
	Test 3. *Z. entreriana*	
Brachiaria humidicola cv. IRI 409	3.8 a	8.8 a
Brachiaria decumbens cv. Basilisk	5.2 a	4.6 a
Cenchrus ciliaris	8.8 b	9.9 a
Panicum maximum cv. Makueni	9.3 b	12.5 a
	Test 4. *Z. entreriana*	
Paspalum plicatulum	3.1 a	5.1 a
Brachiaria humidicola cv. IRI 409	4.0 a	13.4 a
Brachiaria sp.	6.4 a	9.4 a
Andropogon gayanus cv. Planaltina	6.6 a	13.7 a
	Test 5. *Z. entreriana*	
Paspalum plicatulum	4.9 a	11.3 a
Brachiaria brizantha cv. Marandu	5.6 a	39.7 ab
Brachiaria decumbens cv. Basilisk	9.1 a	67.1 b
	Test 6. *D. flavopicta*	
Brachiaria brizantha cv. Marandu	5.7 a	–
Brachiaria decumbens cv. Basilisk	6.2 a	–

[1] For a test, a potted grass plant of a grass species used was placed in 1 m^3 cage and number of spittlebug adults released inside the cage were the number of grass species x 15. Eight cages were used per test and adults present on each plant were counted 13 times over a 4-day test period. Thereafter the soil in the pot was examined for eggs. Mean separation within a column and within a test was done using Duncan's multiple range test.

mum cv. Tobiatã. *M. fimbriolata* adults also lived shorter on *P. plicatulum* than on *B. decumbens* cv. Basilisk.

Females of *D. flavopicta* reared on *A. gayanus* cv. Planaltina produced fewer eggs than when reared on *B. decumbens* cv. Basilisk. Also, fewer eggs were obtained when reared on *P. guenoarum* than on *B. decumbens* cv. Basilisk in one of the two tests. The fecundity of *M. fimbriolata* did not differ significantly among grasses tested ($P > .05$).

Differences in survival and fecundity of adults developing on the various grass species were small. However, such small differences could be important; for example, reduced adult survival would probably mean lesser damage and a shorter ovipositional period. Likewise, reduced fecundity would help reduce spittlebug populations and such an effect would probably be cumulative.

Summarizing data into three categories of mechanisms of resistance

The grasses that showed better levels of antibiosis were *B. brizantha* cv. Marandu, *P. maximum* cv.

TABLE 11. Survival and fecundity of spittlebug adults reared on different grasses, 1983-85[1].

Grass	Adult survival in days	Fecundity/female
	Test 1. *D. flavopicta*, January-February 85	
Andropogon gayanus cv. Planaltina	7.5 a	29.2 a
Paspalum guenoarum	6.1 a	36.2 a
Brachiaria decumbens cv. Basilisk	10.3 b	61.9 b
	Test 2. *D. flavopicta*, February 85	
Paspalum guenoarum	7.3 a	23.6 a
Panicum maximum cv. Colonião	9.2 b	24.1 a
Brachiaria decumbens cv. Basilisk	9.5 b	28.3 a
	Test 3. *D. flavopicta*, January 84	
Paspalum plicatulum	6.0 a	–
Andropogon gayanus cv. Planaltina	6.4 ab	–
Brachiaria brizantha	6.5 ab	–
Panicum maximum cv. Colonião	7.7 ab	–
Brachiaria decumbens cv. Basilisk	7.9 b	–
	Test 4. *D. flavopicta*, January 83	
Paspalum plicatulum	5.6 a	–
Paspalum guenoarum	7.7 ab	–
Brachiaria decumbens cv. Basilisk	8.9 b	–
	Test 5. *M. fimbriolata*, January-February 85	
Panicum maximum cv. Tobiatã	8.2 a	54.0 a
Brachiaria brizantha cv. Marandu	8.3 a	61.5 a
Brachiaria humidicola cv. IRI 409	8.6 a	64.8 a
Brachiaria decumbens cv. Basilisk	8.7 a	51.6 a
	Test 6. *M. fimbriolata*, March-April 85	
Panicum maximum cv. Tobiatã	7.4 a	48.1 a
Brachiaria decumbens cv. Basilisk	7.4 a	46.5 a
Brachiaria brizantha cv. Marandu	8.2 b	38.0 a
	Test 7. *M. fimbriolata*, April 83	
Paspalum plicatulum	5.1 a	–
Paspalum guenoarum	6.2 ab	–
Brachiaria decumbens cv. Basilisk	7.0 b	–

[1] In Test 1, a pair of newly emerged adults was caged on a grass plant. The adult survival means are based on 40 adults. In Test 2, 5 and 6, four pairs were caged per plant and 4 repetitions were used per grass species. In Test 3, 4 and 7, ten adults were caged on grass plants in a pot and 6 pots per grass species were used. Within a column and within a Test, mean separation is by Duncan's multiple range test at 5% level of probability.

Colonião, *P. guenoarum* and *P. plicatulum* (Table 12). Also three of these four grasses (excluding "Colonião") and *A. gayanus* cv. Planaltina showed good levels of tolerance also. Very few grasses were not preferred for oviposition or feeding. The grasses *B. decumbens* cv. Basilisk, *B. ruziziensis* and *C. ciliaris* were classified as highly susceptible. These three grasses and *B. humidicola* cv. IRI 409 did not show any antibiosis, and therefore one may expect spittlebugs to multiply faster on these grasses. In general grasses that have the most "x" in all columns are most resistant (Table 12). However, the category "antibiosis" is probably more important than the other two, and therefore the number of "x" in this category would have more weight than the ones in the other two categories. The factors that were considered as antibiosis (difficulty of nymphs in establishing on plants, re-

TABLE 12. Estimates of resistance levels of different grasses to spittlebug attack grouped into 3 categories of mechanisms of resistance[1].

	Mechanisms of resistance[2]		
	Antibiosis	Tolerance	Nonpreference
Paspalum plicatulum	xxx	xx	x
Paspalum guenoarum	xxx	xx	.
Brachiaria brizantha cv. Marandu	xxx	xx	x
Panicum maximum cv. Colonião	xx	0	x
Andropogon gayanus cv. Planaltina	x	xx	0
Panicum maximum cv. Makueni	x	x	0
Setaria sphacelata cv. Kazungula	x	x	0
Hyparrhenia rufa	x	x	0
Melinis minutiflora	x	0	0
Brachiaria humidicola cv. IRI 409	0	xx	x
Brachiaria decumbens cv. Basilisk	0	x	0
Brachiaria ruziziensis	0	0	0
Cenchrus ciliaris	.0	0	0

[1] Information presented in this paper and that of Nilakhe et al. (s.n.t.) was used in preparing this table.
[2] 0 = below average, x = average, xx = good, xxx = very good

duced nymphal survival, shorter adult stage, smaller adults, reduced fecundity and all of these independently or in combinations) may help reduce spittlebug populations. A grass having more than one form of resistance may be better than a grass with just one. Grasses *B. brizantha* cv. Marandu, *P. guenoarum* and *P. plicatulum* had higher levels of resistance in two or more categories and therefore chances of these grasses becoming "susceptible" are much less than for the other grasses listed in Table 12.

The degree of resistance of *P. guenoarum* and *P. plicatulum* was among the best obtained in this study. These grasses should be evaluated first for adaptability and then evaluated under grazing conditions in various parts of Brazil. Although the nutritional value of these two grasses was somewhat lower than *B. humidicola* (Lima & Gondim 1982), they should be considered as part of the grazing plan on a farm. The grass *P. maximum* cv. Colonião showed good level of antibiosis, but in this and other studies it was found to be quite susceptible to adult damage. In the state of Mato Grosso do Sul, observations have shown that many spittlebug adults are found in "Colonião", but the pastures always have fewer nymphs than those of *B. decumbens*. It is likely that some of the adults developing in *B. decumbens* fly to Colonião. Field observation have shown that pastures of *B. humidicola* have excellent tolerance level to spittlebug damage. However, this grass favors spittlebug multiplication. Thus one may expect the spittlebug populations to increase on this grass to levels at which the plants may not tolerate the damage any more. Such a situation is sometimes referred as "Breakdown of resistance". In the present study, *A. gayanus* cv. Planaltina showed less degree of resistance than the one reported by Calderón (1983) in Colombia and by Cosenza (1982) in the Distrito Federal. Nevertheless, this grass is definitely better than those that do not have any antibiosis.

Generally, grasses resistant to one spittlebug species (for example, *Z. entreriana*) were resistant to other species such as *D. flavopicta*. This is desirable because both species are economically important and occur together in the state of Mato Grosso do Sul.

Although the grasses, *B. decumbens*, *B. humidicola*, *B. ruziziensis* and *C. ciliaris*, are susceptible to spittlebugs, they form a major part of the cultivated pasture grasses grown in Brazil because they have certain economic advantages. It is very important that the grasses resistant to spittlebugs (especially those to be recommended to growers) should possess agronomic qualities equal to those grasses in current use. It would be economically unsound to suggest to growers to remove pastures of these susceptible grasses and plant resistant grasses in their place. However, growers should consider planting resistant grasses in areas newly cleared for planting, in deteriorated pastures that have to be replaced, and in areas where spittlebugs cause problems year after year. Planting resistant grasses, especially those that have high levels of "antibiosis" would be a step in the right direction to render spittlebugs economically unimportant.

CONCLUSIONS

1. Generally, the grasses showing resistance under field conditions showed resistance in the screenhouse studies.

2. Spittlebug nymphal mortality was higher on grasses *B. brizantha* cv. Marandu, *A. gayanus* cv. Planaltina, *P. suenoarum* and *P. plicatulum* in comparison to *B. decumbens* cv. Basilisk, *B. humidicola* cv. IRI 409, *B. ruziziensis* and *C. ciliaris*.

3. The results obtained by infesting grass plants with freshly hatched nymphs were the same as those obtained by infesting with ready to hatch eggs.

4. The influence of a grass on nymphal survival tended to be same in screenhouse and in field conditions.

5. Nymphs of different developmental stages preferred to feed on plants of *Brachiaria* sp. over those of *A. gayanus* cv. Planaltina and *P. plicatulum*.

6. Grasses *A. gayanus* cv. Planaltina, *B. brizantha* cv. Marandu, *B. humidicola* cv. IRI 409, *P. guenoarum* and *P. plicatulum* showed good levels of tolerance.

7. Relative estimates of resistance of various grasses were grouped into three categories of mechanisms of resistance. Among the grasses tested, the most resistant were *B. brizantha* cv. Marandu, *P. guenoarum* and *P. plicatulum*. The most susceptible were *B. decumbens* cv. Basilisk, *B. ruziziensis* and *C. ciliaris*.

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