TESTING NEW ACCESSIONS OF GUINEA GRASS (*PANICUM MAXIMUM*) FOR ACID SOILS AND RESISTANCE TO SPITTLEBUG (*AENEOLAMIA REDUCTA*)

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ABSTRACT

Adaptation of new accessions of *Panicum maximum* to an acid Oxisol (pH 4.8, 90% Al saturation) was assessed over 3 years on 2 sites of contrasting soil texture at the Carimagua Research Station, in the Eastern Plains of Colombia. Twenty-seven lines, selected originally from a collection of 436 accessions, were evaluated along with 2 commercial cultivars as controls. Concurrently, a pot trial was established in the glasshouse at CIAT, Palmira, Colombia to test the accessions for resistance to spittlebug (*Aeneolamia reducta*).

At the 2 sites, 6 accessions produced significantly more green leaf dry matter than the controls. Accessions CIAT 6799, 6944, 16019 and 16042 were amongst the highest yielding lines at both sites, despite wide variation in soil texture. *In vitro* digestibility values did not vary significantly from those of the controls. The incidence of plant diseases and spittlebug in the field trial was low. In the glasshouse, emergence of spittlebug adults (a measure of antibiosis) reared on 10 of the accessions (including CIAT 6799 and 16042) was less than that of spittlebugs reared on a resistant control. Foliar damage was correlated significantly with adult emergence. Practical implications of the results are discussed.

RESUMEN

*En un Oxisol (pH = 4.8, saturación de AL = 90%) del Centro Nacional de investigaciones Carimagua, llanos orientales de Colombia, se evaluaron 27 lineas de Panicum maximum, seleccionadas originalmente de una coleccion de 436 accesiones; como testigos se utilizaron dos cultivares comerciales de la especie. Simultaneamente, un ensayo fue establecido en el inverandero de CIAT, Palmira, Colombia para evaluar la resistencia de las accesiones al salivazo (*Aeneolamia reducta).

En ambos sitios, 6 accesiones significativamente produjeron mas hoja verde y MS que los testigos. Las acceciones CIAT 6799, 6944, 16019, y 16042 fueron las lineas mas productivas en ambos sitios, a pesar de la amplia variación en la textura del suelo. Los valores de la digestibilidad in vitro *no varió significativamente en comparación con los testigos. La incidencia de enfermedades en la planta y de salivazo en el experimento de campo fue baja. En el invernadero, la aparición de adultos de salivazo (una medida de antibiosis) en 10 de las accesiones (incluyendo CIAT 6799 y 16042) fue menor que la población de salivazo desarrollada sobre el testigo resistente. Se encontró una correlación significativa entre el daño foliar y la emergencia de adultos de salivazo. Se discuten en el trabajo las implicaciones prácticas de estos resultados.*

INTRODUCTION

Panicum maximum is an extremely variable, tufted, perennial grass of pan-African origin that is used widely in tropical regions for grassland improvement and increasing livestock production. Unlike many other tropical grasses, a range of cultivars is available commercially which reflects the morphological variation present in the species (McCosker and Teitzel 1975). Although Motta (1953) reported adaptation to a wide range of soils, production is poor in commercial cultivars grown in infertile situations, and marked responses to fertilizer occur. On an Oxisol in Brazil, with a high P fixation capacity and more than 80 per cent Al saturation, Couto *et al.* (1985) found that cv. Makueni only performed well on limed plots at high levels of applied P (175 kg/ha). The response of cv. Petrie green panic was similar but levels of production were lower.

Another major problem for grasses in the tropics of South America is the incidence of spittlebugs (*Cercopidae: Homoptera*) of the genera *Aeneolamia, Deois* and *Zulia* (Calderón 1982). Although biological control has been tried with insect predators, nematodes and the fungus *Metarhizium anisopliae* (de Menezes *et al.* 1983), genetic resistance remains the most economical and practical control measure for spittlebugs. Commercial cvv. of *P. maximum* (e.g. Colonião and Petrie green panic) are highly susceptible to spittlebugs (Cosenza 1982, de Menezes *et al.* 1983). Therefore, there is a need to identify edaphically adapted lines of the species that are also not susceptible to these insect pests.

This paper describes the preliminary field evaluation at 2 sites from 1986 to 1988 of 27 new accessions of *P. maximum,* selected from a much larger collection, for adaptation to acid low fertility soils in the savannas of the Eastern Plains of Colombia. In addition, the results of a glasshouse trial are reported in which these same accessions were tested for resistance to *Aeneolamia reducta,* the most common spittlebug species found in the Colombian savannas.

MATERIALS AND METHODS

Experimental sites

The field trial was conducted at 2 sites on the Carimagua Research Station, Meta, Colombia, South America at latitude 4° 30'N, longitude 71° 19'W and altitude 150 masl. Rainfall during the three years was 2872 mm (1986), 2743 mm (1987) and 2033 mm (1988) distributed from April to December inclusive. Mean maximum and mean minimum temperatures during the experimental period were 32°C and 23°C, respectively. The soil type was an Oxisol (Sánchez and Isbell 1979) and the characteristics for both sites are shown in Table 1. The Al saturation, defined as Ex. Al/Ex(Ca + Mg + K), in both soils was approx. 90%. The "Yopare" site had an appreciably higher sand content but lower organic-matter content than the "La Alcancia" site, although differences in available nutrients were small. The sites were representative of the type of variation found in soil texture in the Eastern Plains.

TABLE 1
Soil characteristics for the 2 evaluation sites at Carimagua, Colombia

Soil parameter	"La Alcancía" site	"Yopare" site
pH	4.7	4.9
Al (me/100 g)	3.2	1.5
Ca (me/100 g)	0.12	0.09
Mg (me/100 g)	0.08	0.05
K (me/100 g)	0.06	0.04
P (ppm)	1.2	1.3
S (ppm)	9.6	10.3
Cu (ppm)	0.78	0.58
Fe (ppm)	37	42
Mn (ppm)	2.2	1.8
Zn (ppm)	0.09	0.06
OM (%)	3.2	1.7
Clay (%)	45.95	32.12
Silt (%)	46.68	35.31
Sand (%)	7.37	32.57

P analysed by Bray II method (0.03 N NH_4F + 0.1 N HCl).

The glasshouse trial was carried out at CIAT Headquarters, Palmira, Valle, Colombia, South America at latitude 3° 33'N, longitude 76° 18'W and altitude 1000 masl.

Field evaluation trial

Originally, 436 accessions from the CIAT collection (Schultze–Kraft *et al.* 1987) were sown at both sides in a randomized complete block design with 3 replications. These included the commercial cultivars common Guinea, Hamil, Makueni and Petrie green panic as controls. The collection represented a wide range of morphological variation including differences in plant height, leafiness and leaf size. During the first year (1986), the collection was classified into groups representing some of the commercial cultivars. Approximately 32% was morphologically similar to cv. Hamil a giant, robust plant with large leaves and rather thick stems; 41% was similar to the common Guinea (botanical var. *typica*) a stemmy, medium-sized type with narrow, predominantly basal leaves and 27% was similar to cv. Petrie green panic (botanical var. *trichoglume*) a plant with numerous fine leaves and stems. Since the main interest was to select low to medium height grazing types, accessions morphologically related to cv. Hamil were discarded from the evaluation. The poor vigour of many other accessions also enabled the collection to be reduced further to 90 lines by the end of 1986 and, eventually, to 27 accessions by the end of 1987. Data are presented for these 27 lines together with two controls (common Guinea and cv. Petrie green panic).

The origins of accessions CIAT 696 to CIAT 6827 are not known, but accessions CIAT 6899 to CIAT 16065 were collected in either Kenya or Tanzania. Most accessions were obtained from France (ORSTOM), with other donations from Australia (CSIRO), Cuba (Ministry of Agriculture) and Kenya (FAO).

The trial was established in May 1986 with vegetative material obtained from existing nursery plots. Each treatment (accession) consisted of a single row of 10 plants, 50cm apart, with 2m between plots. The inter-plot areas, consisting of native grasses, were not cultivated during the trial to try to increase pressure from the native spittlebug population. The presence of vegetation also provided some plant competition, reduced the erosion hazard and the labour required for maintenance of the trial. Periodically, the native pasture was cut with a mower.

Fertilizer was broadcast in the rows at establishment in May 1986 at rates to provide 5, 5, 3 and 3 kg/ha of P, K, Mg and S respectively. The sources of fertilizer were triple superphosphate, potassium chloride, magnesium sulphate and elemental sulphur. In addition, 40 kg/ha N was broadcast as urea. The same level of N was applied in May in subsequent years, with other nutrients given at 50% of establishment rates.

A standardization cut was made in April 1987 at the start of the wet season. Cuts for yield were made in August and December 1987. This sequence of defoliation was repeated during 1988. Using a pair of hand-shears 4 plants were cut to 10cm above ground level in each plot and green leaf was separated from stem and senescent material. Samples were oven-dried for 48 h at 60° C and the dry weight of green leaf recorded. Sub-samples were then ground in a Wiley mill using a 1 mm screen, and subjected to a two-stage *in vitro* DM digestibility devised by Tilley and Terry (1963) and modified by Moore and Mott (1974). Accessions were periodically monitored for pest and disease symptoms during the course of the trial.

Data were subjected to conventional analysis of variance and least significant differences between means are reported.

Glasshouse trial

Despite the presence of native vegetation between plots in the field trial, the natural spittlebug population was extremely low and none of the plants suffered damage. Therefore, to obtain some information on spittlebug resistance in the selected accessions it was necessary to establish a trial in the glasshouse. Accordingly, 10 plants each of 29 accessions were propagated vegetatively in 10 cm plastic pots and prepared for infestation in November, 1988 according to the method described by Lapointe *et al.* (1989). Plants were kept in a glasshouse under natural light at CIAT, Palmira. Temperature in the glasshouse fluctuated between 20° and 35°C in synchrony with photoperiod, and relative humidity ranged between 40 and 90%. Individual pots were fitted with aluminium covers with a central hole (4 cm diameter) for the grass stems. The cover reduced solar radiation and increased relative humidity inside the pots thereby favouring superficial rooting and survival of the spittlebug nymphs. Surface roots are the preferred feeding site of nymphs.

One month after propagation, pots were infested with 10 fully developed eggs of the spittlebug *Aeneolamia reducta*. This number had been shown to be adequate to achieve infestation (Lapointe *et al.* 1989). Eggs were previously incubated in the laboratory and sorted to ensure viability and synchronized development. Since this method had not previously been used to evaluate *P. maximum*, *Brachiaria decumbens* cv. Basilisk. and *B. brizantha* cv. Marandú were included as susceptible and resistant controls, respectively (Ferrufino and Lapointe 1989). Antibiosis was measured by the mean percent survival of nymphs to the adult stage (adult emergence). Nymphs or adults were not able to move from one pot to another. Each pot was treated as a replication. An index of adult emergence was calculated as follows: $(E_x-E_r)/(E_s-E_r)$ where E_x, E_r and E_s are mean percent emergence on the test accession, resistant control, and susceptible control, respectively. Accessions were judged to be resistant (antibiotic) if the index on that accession was less than the mean emergence plus one standard deviation on the antibiotic check, *B. brizantha* cv. Marandú.

Foliar damage was evaluated 30 days after infestation on a visual scale of 1 (no damage) to 5 (total death of leaf lamina). To examine the relationship between adult emergence and foliar damage, a least-squares regression line was calculated (Anon. 1985).

RESULTS

Field evaluation trial

Although there was some variation in leaf dry weight and digestibility between years, differences were not statistically significant. Accordingly, results for the 2 seasons have been combined and means presented.

At both sites 6 accessions produced markedly more green leaf dry matter than the two commercial cvv. Petrie green panic and common (Table 2). Accessions CIAT 6799, 6944, 16019 and 16042 were superior to the controls and were amongst the highest yielding lines at both "La Alcancia" and "Yopare", despite wide differences in soil texture. Across accessions, dry matter yield was significantly higher at the sandier "Yopare" site (mean 104 g DM/plant) than at "La Alcancia" (mean 60 g DM/plant). This was probably due to observed periodic waterlogging at the latter site, particularly in the first 2 years when rainfall was 27 to 33% above the 12-year average for Carimagua.

In vitro digestibility values are presented in Table 3. These ranged from 39.3 to 50.1% and were relatively low for leaf material, reflecting the rather long interval of 16 weeks between cuts and low N application. Despite marked increases in leaf dry weight, differences in digestibility between the new accessions and commercial controls were not statistically significant at either site. Across accessions there were no differences between sites in digesibility values ("La Alcancia" mean 44.5%; "Yopare" mean 44.4%).

Although a number of plant diseases were observed at both sides during the trial, the attacks were light. The most common disease on the selected accessions was a leaf spot caused by the fungus *Cercospora fusimaculans*, which has been recorded in the species in Central and South America by Lenné (1982). Another widely distributed fungal disease in tropical America is smut (*Tilletia ayersii*) which attacks the inflorescences in *P. maximum*. Although widespread in non-selected accessions, only line CIAT 6799 amongst the final 27 selections was attacked by the fungus. Rust (*Uromyces setariae-italicae*), which has recently been destructive on *Brachiaria* species in Colombia and Ecuador (J. Lenné, pers. comm.), was found only on common *P. maximum* in the trial.

TABLE 2

Dry weight of green leaf[1] *in the wet season in accessions of* Panicum maximum *growing at 2 sites at Carimagua, Colombia.*

CIAT accession number	"La Alcancia" site	"Yopare" site	Mean
		(g/plant)	
6799	133	257	195
6944	128	161	145
16042	119	183	151
6177	83	89	86
16019	82	152	117
6973	77	131	104
6629	75	67	77
16065	71	158	115
16021	70	133	102
16024	64	134	99
6506	64	92	78
16032	61	103	82
698	57	93	75
6798	54	90	72
6899	53	124	89
6904	53	85	69
6951	49	68	59
6589	48	67	58
6172	47	83	65
6971	46	97	87
696	45	95	70
6949	44	66	55
6988	39	68	54
6536	33	86	60
6908	32	96	64
6837	30	55	43
6171	23	75	49
cv. Petrie	21	53	37
common	20	42	31
LSD[2]	54	80	68

[1] Mean of two years data (1987 and 1988). Two cuts each year.
[2] Least significant difference (P = 0.05).

Glasshouse trial

Emergence of spittlebug adults reared on 10 of the 29 accessions tested was less than that of spittlebugs reared on the resistant control, *B. brizantha* cv. Marandú (Fig. 1). Adult emergence ranged from 1.0 ± 3% on the highly resistant *P. maximum* CIAT 16042 to 51.0 ± 20% on the susceptible *P. maximum* CIAT 6988. Damage caused by nymphal feeding ranged from slight (1.2) on *P. maximum* CIAT 16042 to moderate (3.4) on *P. maximum* CIAT 6988.

Foliar damage was characterized by initial chlorosis and subsequent necrosis of the apical margins of the leaves. Foliar damage was correlated significantly with adult emergence (P = 0.001) (Fig. 2).

DISCUSSION

Commercial cultivars of *P. maximum* do not perform well in the Oxisols and Ultisols of tropical America unless significant quantities of fertilizer and lime to neutralize aluminium are applied (Couto *et al.* 1985). In this preliminary trial a number of new accessions have been identified which show much better edaphic adaptation than the commercial cultivars at modest levels of fertilizer input. No lime was applied in the trial

TABLE 3
In vitro *dry matter digestibility*[1] *of green leaf in the wet season in accessions of* Panucum maximum *growing at 2 sites at Carimagua, Colombia*

CIAT accession number	"La Alcancia" site	"Yopare" site	Mean
		%	
6629	49.6	48.6	49.1
698	48.1	45.4	46.8
6973	48.0	50.1	49.1
6988	47.6	47.5	47.5
6908	47.1	46.3	46.7
6899	47.0	43.0	45.0
6177	46.7	44.9	45.8
6172	45.7	45.4	45.6
696	45.1	39.8	42.4
6944	45.1	45.7	45.4
6589	45.0	47.2	46.1
6799	44.8	44.9	44.8
6798	44.7	43.2	43.9
6171	44.6	43.0	43.8
16019	44.2	45.6	44.9
6949	44.2	46.9	45.6
16024	43.5	45.0	44.3
16032	43.0	42.5	42.7
6837	43.0	42.1	42.6
16021	42.6	41.5	42.0
6904	42.5	46.1	44.3
6951	42.4	45.9	44.1
16042	40.7	40.0	40.4
6971	40.7	41.2	40.9
6536	40.4	39.3	39.9
6506	40.3	42.8	41.6
16065	39.5	42.1	40.8
cv. Petrie	49.4	47.5	48.5
common	45.0	43.1	44.1
LSD[2]	11.8	10.3	7.5

[1] Mean of two years data (1987 and 1988). Two cuts each year. 16 week regrowth.
[2] Least significant difference (P = 0.05).

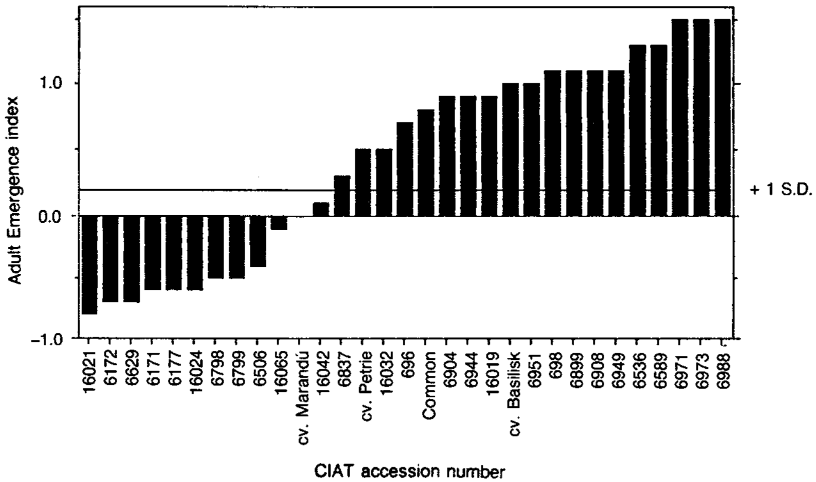

FIGURE 1
Index of adult spittlebug emergence from uniformly infested pots of 29 accessions of *P. maximum* in the glasshouse. Emergence from the resistant control (*B. brizantha* cv. Marandú) is defined as 0 and that of the susceptible control (*B. decumbens* cv. Basilisk) as 1. The solid line is the mean of the resistant control plus 1 standard deviation.

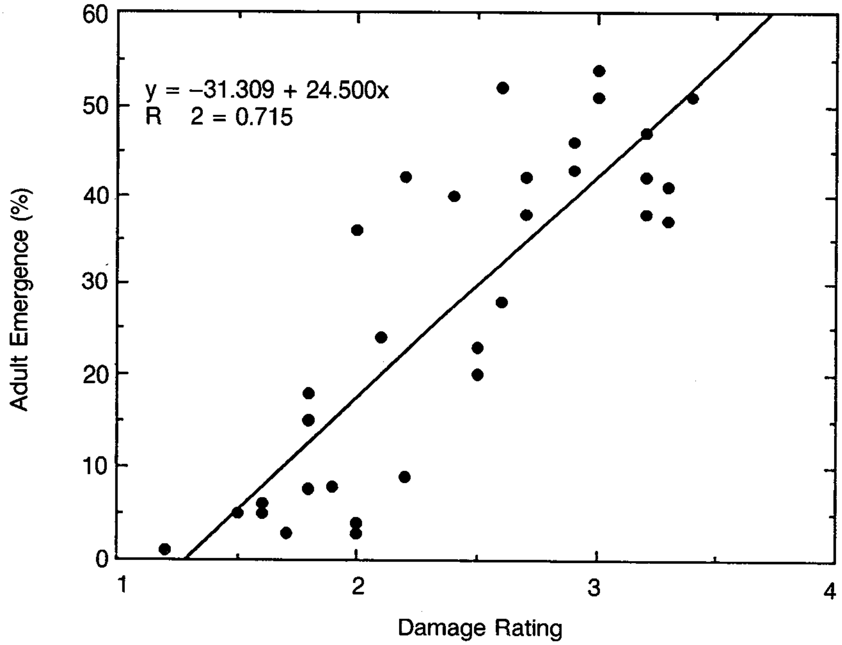

FIGURE 2

Correlation of damage caused by nymphal feeding and adult emergence on 29 accessions of *P. maximum.*

and aluminium saturation values at both sites were approximately 90%; a toxic level for many crop plants. In addition, 4 of the accessions (CIAT 6799, 6944, 16019 and 16042) performed well across the two sites with sand contents of 7 and 33%. Adaptation in a cultivar to such variation in soil texture would be highly desirable in the Eastern Plains of Colombia where edaphic conditions are not uniform.

As previously mentioned, it was not possible to test for spittlebug resistance in the field in this trial because of the low natural population of the insect. Nevertheless, glasshouse testing was able to identify resistance in 10 of the accessions, including CIAT 6799 and 16042 which also show wide edaphic adaptation. Expression of resistance in the glasshouse is probably a good indicator of resistance in the field. However, it should be emphasized that susceptibility in the glasshouse does not necessarily imply susceptibility in the field since some resistance factors such as growth habit may be masked under glasshouse conditions. For example, *A. gayanus* cv. Carimagua I is highly resistant in the field due to its erect, tufted growth habit. On the other hand, when infested with spittlebugs in the glasshouse, using the technique described previously, nymphal survival and adult emergence on cv. Carimagua I is high (Ferrufino and Lapointe 1989). Recently, considerable success was achieved in field evaluation of spittlebug resistance in a large collection of *Brachiaria* species at Carimagua by surrounding plots with the highly susceptible *B. decumbens* cv. Basilisk. As a consequence natural populations increased dramatically and a high pest pressure was maintained on the collection during evaluation, obviating the need for artificial infestation.

The correlation between damage and emergence was expected due to the differential in survival (antibiosis) between resistant and susceptible accessions. Thus, antibiotic accessions suffered less damage due to the smaller number of nymphs surviving to feed on those accessions compared with the susceptible accessions. An ideal screen for tolerance to insect feeding damage maintains a constant insect population over a period of time until a predetermined level of damage is achieved (Ferrufino and Lapointe 1989). In general, however, it could be expected that those accessions that fall above the regression line in Fig. 2 would be tolerant since they experienced less damage per spittlebug surviving to adult compared with accessions below the regression line.

At the present time, the most widely grown grasses on the Oxisols and Ultisols of tropical America are *Brachiaria decumbens* and *B. humidicola,* neither of which is resistant to spittlebugs, although the resistant *A. gayanus* is increasing in importance. The identification of edaphically adapted accessions in *P. maximum* which also show resistance to spittlebug, offers the possibility of a further option for the future. Selected accessions are now under seed increase and will be evaluated under grazing in combination with suitable legumes in the near future.

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