Yield Comparison and Plant Character Correlations on 16 *Panicum* Accessions

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INTRODUCTION

Guineagrass, *Panicum maximum* Jacq., long has been recognized as excellent for grazing, green-soilage, hay, and silage in the Tropics. It is one of the most widely utilized grasses due to its excellent yields and adaptation to almost all soils and tropical climatic conditons. According to Vicente Chandler *et al.* (*4*),[2] Guineagrass is the highest yielding grass under grazing management in Puerto Rico, followed closely by, among others, Pangola, *Digitaria decumbens* Stent, and Napier, *Pennisetum purpureum* Schum.

Seed germination in Guineagrass is very poor, approximately in the 5-percent range (*4*). This important factor limits the utilization of this grass because its asexual propagation is very expensive. In addition, "Common" Guineagrass and "Gramalote" (another variety in the genus *Panicum*), are both susceptible to ergot caused by *Claviceps maximensis* Thesis. The incidence of this disease results in poor seed production in these grasses, especially during the rainy season. According to Theis (*3*), ergot infection on grasses is a potential threat to animals feeding on Guineagrass in Puerto Rico.

In Puerto Rico, research on the utilization of Guineagrass for grazing deals mostly with the "Common" or "Local" variety (*2,4*). Warmke (*5*) distinguished five strains of Guineagrass in Puerto Rico, differing significantly in size and in certain morphological characters. He designated them as "Local" or "Common", "Gramalote", "Borinquen", "Broadleaf", and "Fine Leaf". Of these, "Local" or "Common" is the most widely utilized, particularly because of its good yield, resistance to drought, and resistance to heavy grazing in drier areas of Puerto Rico.

Reproduction in Guineagrass is by apomixis, as reported by Warmke (*5*). Because of this condition, improvement through hybridization in this species is difficult. However, improvement most probably can best be obtained through selection amongst the available genetic populations.

This paper presents the evaluation of 16 *Panicum* accessions for total

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[2] Italic numbers in parentheses refer to Literature Cited, p. 183

yield (green forage,[3] dry matter, and protein) and a series of morphological plant characters (tillering ability, rooting at the nodes, forage volume, resistance to ergot, resistance to *Cercospora* leafspot, flowering percent, and greenness), during a period of 2 years at the Gurabo Substation, Gurabo, Puerto Rico.

Correlation coefficients were determined for total yield of green forage, dry matter and protein as dependent variables, and tillering ability, rooting at the nodes, forage volume (visual estimate of foliage produced), resistance to ergot attack caused by *Claviceps maximensis* Theis, resistance to attack by *Cercospora fusimaculans*, flowering percent, and greenness as independent variables.

MATERIALS AND METHODS

In 1964, a large number of *Panicum* accessions were space-planted in plots 3 feet by 3 feet at the Gurabo Substation for preliminary evaluation. This population consisted of local varieties, introductions, hybrids and promising selections from progenies of irradiated seed. Of these, 15 *Panicum* accessions representing various species were selected on the basis of agronomic characteristics after 1 year of study.

The 15 *Panicum* selections and "Common" Guineagrass included in this study are listed in table 1. They were planted at the Gurabo Substation on a Mabí clay soil with a pH ranging from 4.82 to 5.25. The design was a 4x4 balanced lattice square with five replications. Each plot was 9 feet by 10 feet and all grasses were planted vegetatively at a distance of 2 feet by 3 feet. A complete fertilizer, 14-4-10, was applied at the rate of 3,000 pounds per acre per year, distributed in six equal applications after each harvest, at 60-day intervals. Overhead irrigation was applied at the rate of ½ to 1 inch each time, whenever necessary during dry spells.

Prior to each harvest at 60-day intervals, all plots were evaluated on a visual rating basis as to: tillering ability, rooting at the nodes, forage volume, flowering percentage (within a period of 60 days), greenness, and resistance to diseases such as ergot (*Claviceps maximensis*) and leafspot caused by *Cercospora fusimaculans*. Ratings ranged from 1 to 9, number 1 representing the worst condition and 9 the best. The first 60-day harvest took place in December 1966, the last in October 1968.

GENERAL DESCRIPTION OF THE 16 *Panicum* SELECTIONS

Selections Nos. 1, 2, 4, 5, 6, 8, 9, and 16 may be considered as slender, having short, narrow, usually dark-green leaves, slender stems which tend to be more or less decumbent and have the ability to root at the nodes, and

[3] Forage means vegetative growth above ground.

usually the ability to flower profusely. Selections 5 and 8 are very similar in appearance although No. 5 is classified as *Panicum coloratum* and 8 as *P. deustum*. Both selections have very slender, rather long stems and short narrow leaves covered with large, widely spaced, hyaline, tubercle based deciduous hairs. Both have glaucous-colored leaves and stems, the latter very decumbent and which root freely at the nodes.

TABLE 1.—*Sixteen* Panicums *selected from a space-planted nursery at Gurabo, P.R., and their plant introduction* (P.I.)[1] *numbers*

Selection number	Species field identification	Plant introduction number		Other
		USDA P.I.	P.R. P.I.	
1	P. *coloratum*	208005	5958	—
2	P. *stapfianum*	208014	1991	—
3	P. *maximum*	—	—	Variety "Coarse"
4	do.	—	5857	"Capim Coloniao do Tangañika"
5	P. *coloratum*	208000	1965	—
6	P. *maximum*	202497	1982	—
7	P. *coloratum*	203520	1977	Variety "Makarikariense"
8	P. *deustum*	209195	1973	—
9	P. *maximum*	208399	1987	—
10	do.	—	—	Radiated progeny of "Common" Guinea
11	do.	259565	3634	—
12	do.	—	—	Selection "R-1", a hexaploid, 6n = 54
13	do.	—	—	Radiated progeny of selection "R-1"
14	do.	—	—	"Common" Guinea
15	do.	259553	3622	—
16	do.	259549	3619	Variety "Trichlogume"

[1] U.S. Department of Agriculture and Agricultural Experiment Station, University of Puerto Rico, plant introduction numbers.

Selection 7, classified as *P. coloratum* var. *Makarikariense*, is a very glaucous and glabrous plant; the stems are taller and the leaves wider and longer than those of the slender type. Anthers are bright orange-yellow in color. The stems, which are quite decumbent, are able to spread by rooting at the nodes and thus the original stool gradually disappears at an early stage of growth.

Selection 3 is a coarse velutinous plant with larger stems and leaves than those of the slender type; the stems are somewhat decumbent and produce a fair amount of roots at the nodes; the leaf margins are somewhat scabrid.

Selections 14 and 10 are very similar in appearance; 14 is the "Common" Guineagrass of Puerto Rico and 10, a selection originated from its radiated progeny. Stems are short, nondecumbent, while leaves are upright, long, moderately wide, yellowish-green in color, slightly scabrid and supple in texture. Both produce very good tillers but are seasonal in flowering at Gurabo; this usually occurs during the late autumn to early spring months. Selection 11 shows some resemblance to Common Guineagrass although it is coarser, taller and poorer in tillering; leaf margins are somewhat scabrid; the stems are somewhat longer and thicker and flowering seldom occurs. Selection 15 is an upright, fairly long-stemmed plant with yellowish-green, fairly long, wide, slightly scabrid-margined, supple-textured leaves. It also tillers fairly well, flowers the year round and is relatively free from disease. Leaf blades are conspicuously marked about one quarter way down from the tip by a constricted band or line across the blade, a distinguishing characteristic which separates selection 15 very easily from the other Panicums.

Selection 12 and 13 are very similar in appearance and may be considered as a group resembling "Gramalote", a coarse *P. maximum* which grows in the humid part of Puerto Rico. Selection 12 is supposedly a hybrid between "Common" Guinea × "Gramalote", developed by the Plant Breeding Department, Agricultural Experiment Station, Río Piedras. It has been determined to be a hexaploid ($2n = 54$)[4] and is known as Hybrid "R-1".

Selection 13 originated from its radiated seed progeny. Selections 12 and 13 produce good tillers but seldom flower and both are highly susceptible to rust, especially the former. They show much seasonal variation in their growth habits.

RESULTS AND DISCUSSION

During a period of 2 years, under irrigation as required, at the Gurabo Substation, selection 15 (*P. maximum*, USDA P.I. 259553), produced 95.60 tons of green forage per acre yearly. This selection outyielded the remaining 15 *Panicums* at the 5-percent level as presented in table 2. The second highest yielder in terms of green forage was selection 14, "Common" Guineagrass. This grass produced 83.72 tons of green forage per acre yearly. No statistical difference was observed between selection 14 or "Common" Guineagrass and 4, 11, 3, and 10. The lowest green-forage yielder was selection 8 (*Panicum deustum*, USDA P.I. 209195), an introduction which produced 55.54 tons.

Selection 5 (*P. coloratum*, USDA P.I. 208000) had the highest dry-matter content with 27.51 percent. Selection 15 and "Common" Guineagrass had 25.62 and 23.98 percent, respectively. Guinea selection 15 produced 23.84

[4] Plant Breeding Department Reports, Agricultural Experiment Station, Mayagüez Campus, University of Puerto Rico, Río Piedras, P.R., 1958–60

TABLE 2. *Comparison of the total green weight, dry matter and protein yields of 16* Panicum *selections during a 2-year period*

Selection	Annual green weight[1]	Selection	Dry matter content	Selection	Annual dry matter[1]	Selection	Crude protein content[1]	Selection	Annual crude protein yield[1]
Number	*Tons/Acre*	*Number*	*Percent*	*Number*	*Tons/Acre*	*Number*	*Percent*	*Number*	*Tons/Acre*
15	95.60 a[1]	5	27.51 a	15	23.84 a	13	8.26 a	15	1.57 a
14	83.72 b	8	27.50 a	11	21.12 b	14	7.85 a b	11	1.50 a b
4	83.24 b	16	26.44 a b	4	20.64 b c	10	7.77 a b	10	1.44 b
11	81.28 b c	2	26.33 a b	14	19.62 c d	12	7.66 a c	14	1.42 b c
3	80.08 b c	1	25.68 b c	12	18.80 d e	11	7.45 b d	12	1.40 b c
10	78.28 b d	6	25.64 b c	10	18.62 d e	5	7.19 b e	13	1.32 c d
12	76.52 c d	15	25.62 b c	2	18.00 e f	3	7.18 b e	7	1.24 d e
7	73.40 d f	11	25.58 b c	7	18.00 e f	8	7.16 b e	3	1.19 e f
9	73.10 d f	7	25.50 b c	3	17.56 e g	9	7.00 c f	4	1.17 e g
13	70.78 e f	12	25.16 b d	9	17.10 f h	7	6.91 d f	2	1.16 e h
2	69.72 e f	4	25.01 b d	1	16.83 f h	15	6.83 d f	9	1.12 e h
1	67.60 f g	10	24.90 b d	16	16.38 g h	1	6.71 d f	1	1.10 g h
16	62.94 g h	9	24.69 c d	13	16.15 g i	2	6.57 e f	5	1.08 f i
6	62.81 g h	14	23.98 d	6	15.97 h i	16	6.35 f g	8	1.05 g i
5	58.38 h i	13	23.73 d	5	15.75 h i	6	6.30 f g	16	1.04 h i
8	55.54 i	3	21.96 e	8	14.90 i	4	5.81 g	6	0.96 i

[1] Means followed by the same letter are not significantly different (0.05-level of probability) by Duncan's multiple range test.

tons of dry matter per acre yearly and it outyielded the remaining 15 grass selections at the 5-percent level, as presented in table 2. The second highest dry-matter yielder was selection 11 (*P. maximum*, USDA P.I. 259565). It produced 21.12 tons of dry matter per acre yearly. The third highest yielder was selection 4 (introduction *P. maximum*, P.R. P.I. 5857), which produced 20.64 tons of dry matter. No statistical difference was observed between selections 11 and 4. "Common" Guineagrass, or selection 14, ranked fourth, yielding 19.62 tons of dry matter per acre yearly, which is very similar to that obtained by Little *et al.* (*2*) on "Common" Guineagrass at Santa Isabel. No statistical difference was observed between "Common" Guineagrass and selections 10 and 12. The lowest dry-matter yielder was selection 8, which produced 14.90 tons.

Table 2 shows that the protein content of the 16 grasses varied from 5.81 to 8.26 percent. The top four selections in terms of crude protein content (no significant difference between them) were 13, 14, 10 and 12. These four selections are genetically related to each other. The top protein yielders were selections 15 and 11, which produced 1.57 and 1.50 tons per acre yearly, respectively as shown in table 2. "Common" Guineagrass selection 14 produced 1.42 tons of protein per acre yearly, while its radiated progeny, selection 10 produced 1.44 tons; however, no statistical difference was observed between them. The lowest yielder was selection 6, which produced 0.96 tons of protein per acre yearly.

During the course of the experiment, selection 15 showed no indication of attack by ergot or leafspots. This characteristic, plus its high-yielding capacity, makes this introduction one of the best *Panicum* selections included in this experiment.

CORRELATIONS

The three dependent variables investigated during the experiment were total green forage (Y_1), total dry matter (Y_2) and total protein (Y_3) per acre per year, while the independent variables were tillering ability (X_1), rooting at nodes (X_2), forage volume (X_3), resistance to ergot (X_4), resistance to a leafspot disease caused by *Cercospora fusimaculans* (X_5), flowering percentage (X_6) and greenness (X_7).

The interrelationship among total yields and the seven independent variables are shown in table 3. Highly significant although small correlations, ranging from 0.37 to 0.46, were obtained between tillering ability and total yield. Slightly higher correlations, ranging from 0.59 to 0.67, were obtained between forage volume and total yield. These values indicate that selecting for these two characters may enable breeders to obtain still higher forage-yielding *Panicums*.

Negative significant correlations although low, ranging from −0.20 to

TABLE 3.—*Correlation coefficients of seven plant characters and yield characters (Y) for 16* Panicum *selections during a 2-year period*

Plant characters	Tillering ability (X_1)	Rooting at the nodes (X_2)	Forage volume (X_3)	Resistance to ergot (X_4)	Resistance to *Cercospora* (X_5)	Flowering percentage (X_6)	Greenness (X_7)
Total green weight	0.458**[1]	−0.220**	0.664**	0.021	−0.090**	−0.027	0.192**
Total dry matter (Y_2)	0.367**	−0.195**	0.674**	0.024	−0.027	−0.046	0.110**
Total protein yield (Y_3)	0.429**	−0.240**	0.591**	−0.078*[2]	−0.145**	−0.159**	0.167**
Tillering ability (X_1)		−0.253**	0.391**	0.052	−0.196**	−0.137**	0.353**
Rooting at the nodes (X_2)			−0.379**	−0.208**	0.322**	0.389**	−0.180**
Forage volume (X_3)				0.036	−0.039	0.042	0.161**
Resistance to ergot (X_4)					0.027	−0.273**	0.035
Resistance to Cercospora (X_5)						0.335**	−0.317**
Flowering percentage (X_6)							0.127**

[1] * Significant at the 5-percent level.

[2] ** Significant at the 1-percent level.

−0.24, were obtained between rooting at the nodes and total yield measurements.

The ratings on resistance to ergot attack and to *Cercospora fusimaculans* indicate the relatively healthy condition of these grasses. In general, most plants were very healthy. This could account for the low correlation values obtained between these two characters and total yield.

Flowering was not related with total green forage and total dry matter although it showed a high significant negative correlation ($r = -0.16$) with total protein yield.

Greenness is an indication of heat and drought resistance (*1*). Because the grasses were irrigated, very little variation in greenness was detected. This may explain in part the low correlations obtained between this character and total yield.

Based on the results obtained from the study of the various plant characters, it appears that rooting at the nodes is of little value in a selection program in the genus *Panicum*. Also, the ratings on resistance to ergot and *Cercospora fusimaculans*, flowering and greenness did not provide conclusive evidence as to their possible potential in a selection program. Tillering ability and forage volume appear to be of more importance than the other characters studied in the selection of high-yielding *Panicums*.

SUMMARY

The annual total yields of green forage, dry matter and protein per acre were determined for 16 *Panicums* under irrigation at the Gurabo Substation, Gurabo, Puerto Rico, for a period of 2 years.

The grasses were harvested at 60-day intervals. Selection 15, USDA P.I. 259553 (USDA Plant Introduction Number) was the highest yielder. It produced 95.60 tons of green forage and 23.84 tons of dry matter, per acre yearly. This selection outyielded the remaining 15 *Panicums* at the 5-percent level. The second highest dry-matter yielder was selection 11, USDA P.I. 259565 which produced 21.12 tons of dry matter per acre yearly.

Prior to each 60-day cutting all forage plots were evaluated as to the following plant characters: tillering ability, rooting at the nodes, forage volume, resistance to ergot, resistance to a leafspot caused by *Cercospora fusimaculans*, flowering percentage and greenness; these character values were correlated with yields of total green forage, total dry matter and total protein. The ratings were from 1 to 9, 9 representing the best condition. The best correlations obtained were those of tillering ability and forage volume with total yield. Other significant correlations, with yield, although low, were greenness (positive) and rooting at the nodes (negative).

It is concluded that the plant characters of forage volume and tillering ability can be of potential value in a selection program in the genus *Pani-*

cum. On the other hand, the characters of rooting at the nodes, resistance to ergot, resistance to leafspot attacks, flowering and greenness apparently are of little value as compared to forage volume and tillering ability.

The excellent yielding ability, resistance to disease attack and many other desirable morphological plant characteristics of selection 15 are indications that a Guineagrass superior to the present type is available in Puerto Rico. It warrants further testing under managed grazing conditions for a final-type evaluation.

RESUMEN

En la Subestación Experimental de Gurabo de la Estación Experimental Agrícola, se determinó el peso verde, peso seco y proteína total producidos por 16 *Panicums* durante un período de 2 años, a los cuales se les proveyó riego en la época de sequía.

Las yerbas se cosecharon a intérvalos de 60 días. La selección 15 (USDA P.I. 259553) fue la que produjo el mejor rendimiento, con 95.60 toneladas de forraje verde y 23.84 toneladas de materia seca, por acre por año. Esta selección superó estadísticamente al nivel del 5 por ciento de probabilidad, a los demás *Panicums*, incluyendo la Guinea Común (Puerto Rico).

Antes de cada corte se evaluaron visualmente todas las parcelas, asignándoseles valores del 1 al 9, representando el 9 la mejor en cuanto a los siguientes caracteres: habilidad para producir cepas (*tillers*) (X_1), habilidad para desarrollar raíces en los nudos, (X_2), volumen de forraje (X_3), resistencia al ataque del ergotismo (X_4), resistencia a la mancha de la hoja causada por *Cercospora fusimaculans* (X_5), porciento de la florecida (X_6) e intensidad del verdor de las hojas (*greenness*) (X_7). Se calculó el coeficiente de correlación de estos valores con el del peso verde total (Y_1), peso seco total (Y_2) y proteína total, expresado en libras (Y_3). Las mejores correlaciones que se obtuvieron fueron la habilidad para producir cepas y el volumen de forraje con el rendimiento total.

Esto permite concluir que caracteres tales como el volumen de forraje y la habilidad para producir cepas pueden ser potencialmente valiosos en un programa de selección con el género *Panicum*. Por otro lado, caracteres tales como la habilidad para producir raíces en los nudos, resistencia al ataque del ergotismo, resistencia a la mancha de la hoja causada por *Cercospora fusimaculans*, porciento de la florecida e intensidad del verdor de las hojas son aparentemente de escasa importancia en dicho programa de selección, en comparación con el volumen de forraje y la habilidad para producir cepas.

La excelente capacidad productiva de la selección 15, expresada en términos de forraje verde, peso seco y proteína, su resistencia al ataque de ciertas enfermedades y muchos otros caracteres deseables indican que se

cuenta con una yerba de Guinea superior al tipo que comúnmente se siembra en Puerto Rico. Desde luego, para evaluarla mejor es necesario hacer pruebas de pastoreo en pastos adecuadamente manejados.

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