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FORAGE YIELD, QUALITY AND PERSISTENCE OF INTERSPECIFIC *PENNISETUM* HYBRIDS IN THE CARIBBEAN

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ABSTRACT

The species *Pennisetum purpureum* includes perennial, high yielding and good quality forage types. However, the need for vegetative propagation has limited its commercial use. In two 2-year experiments, forage yield and quality, and stand persistence of 'Mott' dwarf elephantgrass (*P. purpureum*) were compared with either those of other pure lines of elephantgrass (N43, N114, N127 and N128) or their interspecific hybrids with pearlmillet (*P. glaucum*) grown in mixture with glycine (*Neonotonia wightii*). Grasses were harvested every 60 to 100 days, based on rainfall. In neither year was there a genotype x harvest date interaction for dry matter yield. Annual forage yield of tall pure lines or their triploid hybrid with pearl millet was 21-29 t/ha compared with 9-23 t/ha from Mott and its seeded hexaploid derivatives. Forage in vitro organic matter digestion (IVOMD) for Mott (65%) at 60-day regrowth was similar to the hexaploids, but superior to the tall lines (60%). Minimum crude protein (CP) content and IVOMD of *Pennisetum* forage stockpiled for 90 days were 7% and 54% for dwarf types and 6% and 54%,for tall types, respectively. Mott cultivar maintained higher plant and tiller numbers than the hybrids. Legume content of dry forage at the final harvest was 40-48% for the hybrids and 28% for Mott. Seed propagated *Pennisetum* hybrids have a potential for stockpiled forage in the Caribbean if their persistence is improved.

INTRODUCTION

The livestock industry in the Caribbean Basin is based on grazing native pastures. Forage quantity and, particularly, forage quality become serious obstacles to livestock productivity in the dry season. *Pennisetum* is a very diverse genus and the species *P. purpureum* is one of the highest dry matter producing grasses in the tropics (Vincente-Chandler et al. 1959, 1974, Velez-Santiago and Arroyo-Aguilu 1981, Wan Hassan et al. 1990). Mott, a very digestible dwarf elephantgrass (Mott and Ocumpaugh 1984), has produced average cattle daily gains of 0.97 kg (Sollenberger et al. 1988) which is unusually high for a tropical grass. However, all pure selections or varieties of elephantgrass have very low natural seed production with low seed viability and have to be vegetatively propagated. The high labour requirement and cost of establishment have limited the adoption of elephantgrass as a forage crop.

Pearlmillet hybridizes readily with elephantgrass and some hybrids have been released in India (Krishnaswamy and Raman 1954), parts of Africa (Aken'ova and Chheda 1981) and other tropical countries (Muldoon and Pearson, 1979). The F_1 hybrids between pearlmillet (diploid) and elephantgrass (tetraploid) are triploids which are completely sterile due to unbalanced chromosome distribution during meiosis (Khan and Rahman 1963, Hanna 1981, Schank et al. 1989). Hence, the triploids must be multiplied vegetatively unless there is a specialized production and supply of certified seed. However, when the chromosome number of the triploid is doubled to form a hexaploid, either by using colchicine (Hanna 1981, Hanna et al. 1984) or tissue culture (Rajasekaran et al. 1986, Diz and Schank 1991), fertility is restored and large viable seed can be produced. Rapid progress is being made in obtaining seeded-type pearlmillet-elephantgrass hybrids that are similar in yield and quality performance to pure elephantgrass (Schank et al. 1993, Schank et al. 1989, Boddorff and Ocumpaugh 1986, Hanna and Monson 1980), and there is considerable interest in the tropics in this development.

The objective of this study was to compare, in the Caribbean environment, yield and quality performance of selected genotypes of *Pennisetum* at three ploidy levels.

MATERIALS AND METHODS

Two separate trials were conducted at the University of the Virgin Islands' Agricultural Experiment Station, on St. Croix (Latitude 17° 43' N, and Longitude 64° 48 ' W). The soil was a mildly alkaline (pH 7.8) Fredensborg clay (Fine carbonatic, isohyperthermic, Typic Rendolls Mollisols). Mean monthly temperatures range from 24 to 27 °C. Annual rainfall averages between 1000 mm with 50 % of rain falling during the months of September to December. Open pan evapotranspiration exceeds 1800 mm per year.

Experiment 1

Germplasm for this trial included five tetraploid elephantgrass lines — N43, N114, N127, N128 and cv. Mott. Varieties N43 and N114 were tall types whereas the remaining were dwarf types (Figure 1). Stem cuttings with three nodes (N43 and N114) and cuttings approximately 0.4 m in length which included four to five nodes (N127, N128 and Mott) were planted 0.625 m apart in rows 6.25 m long in July, 1990. Rows were spaced 1.25 m apart and each row represented a plot. Depending on the quantity of planting material received, between two and four replications of each line were established under rainfed conditions, in a randomized block design. Established plots were cut back to a 15-cm stubble in mid December, 1990. Plots were given 75 kg/ha of N, yearly, in two split applications. Beginning from late February, 1991, varieties were repeatedly harvested every 60 to 100 days, based on amount of rainfall (Table 1), through January, 1993. Prior to each harvest, height measurements were taken of three randomly selected plants in a plot and averaged. Subsamples of harvested forage were dried at 60 °C to constant weight and ground to a 1 mm size. Dried subsamples of selected harvests (60 and 90 day regrowth) were analyzed for CP (Gallaher et al., 1975) and IVOMD (Moore and Mott, 1974).

Experiment 2

Germplasm for this study consisted of four seed producing hexaploids (2n=42) HX2, HX3, HD105, HD237 developed by Dr. S. C. Schank, University of Florida, Gainesville; a tall triploid (2n=21) selection (MEF1) which was a cross between tall pearl millet (*P. glaucum*) (2n=14) (Tift 23A) and three tall *P. purpureum* (2n=28) lines (N14, N23. N74), developed by Dr. W. W. Hanna, USDA-ARS, Tifton Georgia; and a dwarf tetraploid (2n=28), Mott elephantgrass.

The procedure for the development of the hexaploids is well documented (Diz and Schank 1991). Briefly, the cytoplasmic male-sterile inbred 'Tift 23DA' (dwarf) pearlmillet was crossed to 'Mott' and triploid offsprings were obtained. Selected hybrids were subjected to tissue culture (Rajasekaran et al. 1986) to obtain two hexaploid plants, one of which was designated P3. The hexaploid P3 was then crossed back to two different tall hexaploid phenotypes, namely MN3 and MN33, which were developed by Dr. W. W. Hanna, in order to improve male fertility in the progeny. Mass selection for two years resulted in a population from which entries for this study were selected. At the tetraploid level, hexaploid cross number 2 (HX2) originated from a cross of MN33 x 434 {P3 x MN3}, and the hexaploid cross number 3 (HX3) came from a different cross MN33 x 493 {P3 x MN3}. HD105 and HD237 are different composite seed samples from mass selection within the crosses. The hexaploid entries were therefore very heterozygous in genotype.

The study, a randomized complete block design with four replicates, was planted during the rainy season of September, 1991. Based on an initial observation of a possible shading effect of tall genotypes on dwarf types in Experiment 1, hybrids were seeded in rows 2 m apart instead of the previous 1.25 m row spacing. Four grams of seed were planted per 6.25 m row (3.2 kg/ha). Seedlings were thinned to 0.625 m intra-row spacing when they were approximately 15 cm in height. Mott was vegetatively propagated as described in Experiment 1 with a 0.625 m intra-row and 2 m inter-row spacing. Planted rows were side-dressed with 40-10-20 kg/ha of N-P_2O_5-K_2O to promote establishment. Alleys between rows were rototilled as needed and 2,4-D herbicide was broadcast over rows at 2.37 L/ha, using a backpack sprayer, to control weeds during the seedling stage. From January, 1992 through December, 1993, established plots were repeatedly harvested every 60 to 100 days for forage. There were four harvests each in 1992 and 1993. Heights were measured for three randomly selected plants in a row prior to each harvest. Harvested subsamples were dried and analyzed as described in experiment 1. A total of 75 kg/ha of N was applied in 1992. However, following the second (April) harvest in 1992, the 2-m alleys between rows were tilled and interseeded with three rows each of glycine (*Neonotonia wightii*) at a seeding rate of 6 kg/ha. Glycine seed was scarified in 80 °C water for 3 minutes before planting to improve germination and establishment. Nitrogen fertilizer was withheld from the study in 1993 and harvested forage for that year included legume biomass. However, component grass/legume biomass was separated only at the final (eighth) harvest. Twenty eight days after the fourth and eighth harvests, *Pennisetum* clumps in a row that had initiated regrowth were counted as live plants. Tiller numbers in 2-m section of each grass row were also counted at the same time to monitor persistence. Data on yield, quality and persistence were statistically analyzed using the GLM procedure for SAS system (SAS Institute Inc. 1988). Mean separation was performed using the Duncan's Multiple Range Test.

RESULTS

Mean plant heights ranged from 0.89 m for N128 to 1.8 m for N114 (Figure 1). Heights were affected by harvest date ($P<0.001$) and genotype ($P<0.0001$). A greater standard deviation in height was obtained for hybrids than for pure lines (Figure 1) as a result of the heterogenous genotype of the hybrids.

Experiment 1

Forage dry matter harvested of the tetraploid *Pennisetums* ranged from 18 to 21 t/ha in 1991 and 6 to 29 t/ha in 1992 (Table 2). Yield was generally higher for the tall lines (N114 and N43) than for the dwarf types. The extremely low yields for Mott and N127 in 1992 was partly due to shading effects from the well established, adjacent tall lines. This resulted in a significant year x variety interaction on yield ($P<0.05$). Variety N127 was the line with the lowest yield in both years.

With the exception of the tall genotype, N43, the nutritive value of tetraploid *Pennisetums* was not different from each other. However, there was a tendency for Mott elephantgrass to have the highest CP and IVOMD concentrations (Table 3). Crude protein content and IVOMD of N43 for the 60-day regrowth were lower than those for Mott. This was due to the earlier development of more stem material in N43.

Experiment 2

Forage yield of *Pennisetums* in the second experiment ranged between 17 and 27 t/ha/yr over the

2-year period (Table 4) and there were no genotype x harvest date (P>0.91) or genotype x year (P>0.75) interactions. The tall triploid hybrid (MEF1) was the highest yielding cultivar each year, although its yield was not significantly different from Mott. The yields of the hexaploids tested were similar to the yield of Mott. At the end of the initial year of harvest (fourth harvest), plant numbers within rows were similar for the various entries with the exception of HD237 which had a higher number of plants (Table 5). Although shorter (Figure 1), Mott elephantgrass produced more tillers and maintained a higher plant population, (Table 5) to sustain over 22 t/ha DM production, yearly, in Experiment 2. Also, as a result of Mott's vigour, legume competition was significantly reduced. Thus, legume DM in harvested forage increased to only 28% in plots planted to Mott compared to over 40% in plots planted to the seeded hybrids (Table 5). This indicates that Mott was more productive than the other seeded elephantgrasses in the second year although component grass/legume forage was not measured throughout 1993.

When compared to the hexaploid hybrids, the nutritive value of Mott was always the highest, however, CP and IVOMD of Mott was not significantly different from the hexaploids (Table 6). Averaged over Mott and the hexaploid genotypes, CP and IVOMD values were 14.84% and 62.71% for 60-day regrowth and 12.31% and 54.54% for 90-day regrowth (Table 6). The nutritive value of the tall stemmy triploid hybrid (MEF1) was much lower than Mott. Comparative CP and IVOMD values at 60 days of regrowth for the MEF1 were 13.33% and 60.98% and at 90 days, 9.31% and 52.38%, respectively (Table 6).

DISCUSSION

Forage yields of elephantgrasses obtained on St. Croix in this study agree with data reported by Vincente-Chandler et al. (1974) on Puerto Rico, which has a similar tropical climate. Except in cases where yields were suppressed by shading, our yields were higher than those reported for elephantgrass forage crops in Florida (Sollenberger et al. 1988, Chaparro and Sollenberger 1991) probably because of the longer, frost-free growing season in the Caribbean. Besides being productive, the elephantgrasses generally exhibited outstanding forage quality as previously reported (Sollenberger et al. 1988) and maintained good quality even when stockpiled over the 90-day interval. The quality superiority of Mott and its semi-dwarf hexaploid derivatives over tall genotypes has been attributed to the maintenance of a much higher leaf/stem ratio over a wide range of maturities for the dwarf types (Schank and Dunavin 1988, Boddorff and Ocumpaugh 1986). Elephantgrasses provided trellis for the legume glycine to climb. This association with a native legume if maintained in the proper balance would further improve the CP value of an elephantgrass forage bank for dry season feeding as observed in Experiment 2. Whereas the stand of Mott was uniform and proliferated with many tillers, those of the hybrids consisted of heterogeneous plants with some dieback. Thus, legume competition was kept in check by cv. Mott, whereas legume content within the hexaploids increased over time probably due to the loss in their stand and reduced tiller numbers.

CONCLUSIONS

The forage production potential of *Pennisetum* tetraploids, their triploid and seeded hexaploid derivatives with pearl millet (diploid) were compared to Mott (tetraploid) dwarf elephantgrass. The tall tetraploids out-yielded Mott in forage production but tended to be inferior in nutritive value. Forage yield of the triploid and hexaploids was similar to Mott in the first year but lower in the subsequent year due to legume competition and loss of grass stand. Nutritive value of the tall triploid was also lower than Mott. The hexaploids were not different from Mott in CP and IVOMD. Despite the advantage of being propagated from seed, we cannot at this stage recommend the hexaploids over Mott in the Caribbean until their persistence is improved through on-going recurrent restricted phenotypic selection.

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Table 1. Monthly and yearly rainfall at the experimental site on St. Croix for 1991 - 1993.

Month	1991	1992	1993
	------------- mm -------------		
January	35	54	50
February	66	24	43
March	45	72	33
April	26	65	86
May	44	273	180
June	28	27	67
July	77	61	151
August	36	58	51
September	52	127	90
October	87	157	59
November	80	259	182
December	39	106	61
Total	615	1283	1053

Table 2. Dry matter yield of tetraploid elephantgrasses on St. Croix.

Pennisetum variety	DM Yield 1991	DM Yield 1992	DM Yield 2 yr. avg.
	--------- t/ha ---------		
Mott	18.2b*	9.0b	13.6
N127	15.0c	6.0c	10.5
N128	16.9bc	12.6b	14.8
N114	21.4a	10.6b	16.0
N43	19.9ab	29.1a	24.5

*Values for each year not followed by the same letter are significantly different at P=0.05. Year x variety interaction was significant (P<0.05).

Table 3. Crude protein content and in vitro organic matter digestion (IVOMD) of tetraploid *Pennisetum*) forage for a sixty- and a ninety-day regrowth.

Pennisetum variety	Crude protein 60 d	Crude protein 90 d	IVOMD 60 d	IVOMD 90 d
	%			
Mott	8.73a*	6.85a	63.10a	57.70ab
N127	7.34ab	7.02a	60.02b	54.60b
N128	7.35ab	7.68a	59.90b	60.60a
N43	6.05b	7.82a	58.70b	60.00a
N114	8.17a	6.59a	61.19ab	54.40b

*Values for each column not followed by the same letter are significantly different at P=0.05.

Table 4. Dry matter yield of seeded interspecific *Pennisetum* hybrids and cv. Mott on St. Croix.

Pennisetum variety	DM yield 1992	DM yield 1993[1]	DM yield 2 yr. avg.
	t/ha		
Mott	22.9	22.7	22.8ab*
HX2	19.0	17.4	18.2b
HX3	18.0	20.9	19.5b
HD105	18.5	22.6	20.6b
HD237	18.1	22.8	20.5b
MEF1	27.3	25.9	26.6a

*Values for the 2-year average not followed by the same letter are significantly different at P=0.05.
[1]The 1993 yields include legume DM.

Table 5. Plant and tiller numbers of seeded interspecific *Pennisetum* hybrids and cv. Mott following the fourth and eighth repeated harvests; and legume content of dry forage at the final harvest on St. Croix.

Pennisetum variety	Number of plants		Number of tillers		Legume content
	Sept '92	Nov '93	Sept '92	Nov '93	
	#/m				%
Mott	1.60b*	2.05a	138.8a	115.3a	28.3a
HX2	1.85b	1.03b	134.5ab	50.0b	48.3b
HX3	1.75b	1.32b	105.8bc	57.7b	42.7b
HD105	2.33a	1.24b	110.8abc	38.8b	45.6b
HD237	2.1ab	1.28b	110.3abc	52.5b	42.5b
MEF1	1.63b	1.11b	95.3c	55.2b	41.0b

*Values in each column not followed by the same letter are significantly different at P=0.05.

Table 6. Crude protein content and in vitro organic matter digestion (IVOMD) of interspecific *Pennisetum* hybrids and cv. Mott for a sixty- and a ninety-day regrowth.

Pennisetum variety	Crude protein		IVOMD	
	60 d	90 d	60 d	90 d
	%			
Mott	15.40a*	13.06a	64.51a	56.40ab
HX2	14.89a	12.63ab	61.68ab	53.10a
HX3	14.56a	12.55ab	62.28ab	52.85a
HD105	14.97a	11.79b	62.15ab	55.75a
HD237	14.36ab	11.52b	62.91ab	54.58a
MEF1	13.33b	9.31c	60.08b	52.38a

*Values for each column not followed by the same letter are significantly different at P=0.05.

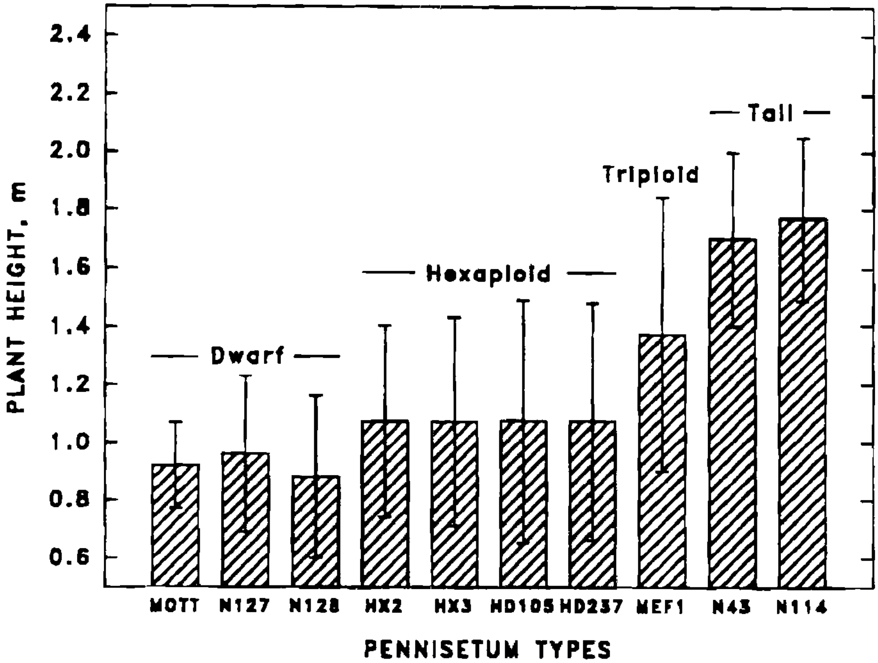

Figure 1. Average plant height of *Pennisetum* genotypesmeasured at harvest (1991-1993) on Croix.