EFFECTS OF SPACING ON DRY MATTER YIELDS OF F¹PENNISETUM HYBRIDS AND ELEPHANT GRASS (*PENNISETUM PURPUREUM* SCHUM)

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SUMMARY

Crown splits of three bulrush millet (*Pennisetum americanum* (L) K. Schum) x elephant grass F¹ hybrid genotypes and an improved local strain of elephant grass were set every 30, 45, 60 and 90 cm in rows 90 cm apart to ascertain the effects of spacing on forage dry matter (DM) yield. Plants were harvested by cutting 30 cm above ground level every 5 weeks during the late rainy season of the first year (4 harvests) and the rainy session of the second year (7 harvests).

There were significant differences in DM yields between spacing treatments, as well as between genotypes. When averaged over genotypes, total DM yield in the two years of study at 90 x 30, 90 x 45, 90 x 60 and 90 x 90 cm were 31.16, 27.27, 25.75 and 23.13 t/ha, respectively. Genotype x spacing interaction for DM yield was not significant.

Spacing, in general, had no appreciable effects on forage quality so that linear regression analysis revealed no relationship between spacing on one hand and DM content, percent leaf, crude protein (CP) content, and *in vitro* organic matter digestibility (IVOMD), on the other.

The results indicated that close spacing can be utilized to increase DM yields of F¹ *Pennisetum* hybrids and elephant grass without detriment to quality.

INTRODUCTION

Consequent to the identification of promising genotypes of elephant grass (*Pennisetum purpureum* Schum) and of the F¹ hybrids between 'maiwa' bulrush millet (*Pennisetum americanum* (L) K. Schum) and elephant grass for forage (Schheda, Aken'Ova and Growder, 1973), studies were initiated to ascertain agronomic and management practices that would assure optimum forage dry matter yields and quality.

The productivity of clump-forming vegetatively propagated forage is influenced considerably by planting density as determined by plant spacing. In summarizing the effects of plant spacing, Whyte, Moir and Cooper (1959) noted

that the spacing adopted depended on factors such as establishment costs, environmental or climatic conditions as well as the intended use and management of the forage. Genotypic differences in response to spacing, especially as they relate to growth habit, are also of importance so that the response to spacing may be used as one of various selection criteria in forage improvement (Lazenby, 1962; Lazenby and Rogers, 1965; McIlroy, 1972).

Elephant grass exhibits a relatively stronger rhizomatous habit than the F¹ *Pennisetum* hybrids and it therefore tends to spread faster at its base, forming dense clumps. Although information on the role and effects of plant spacing on DM yield and quality of elephant grass in various parts of the tropics is available (Addison, 1956; Akinola, 1976; Growder, 1974; Kennan, 1952; Oakes, 1967; Takahashi, Moomaw and Ripperton, 1966), such information is lacking with respect to the F¹ *Pennisetum* hybrids particularly in the low-altitude humid tropics. Spacings tested for elephant grass range from 0.50 x 0.50 m (Crowder, 1974) to 3.66 x 0.91 m (Kennan, 1952). Closer spacings appeared to be satisfactory in humid areas while wider spacings appeared better suited for drier areas (McIlroy, 1972; Whyte *et al.*, 1959). Paired rows have also been utilized (Takahashi *et al.*, 1966).

This study reports the effects of spacing on the dry matter (DM) yields as well as quality as measured by DM content, proportion of leaf in the cut herbage, crude protein (CP) content and *in vitro* organic matter digestibility (IVOMD) of selected F¹ *Pennisetum* hybrid and elephant grass genotypes in an environment of the low

altitude humid tropics.

MATERIALS AND METHODS

A promising local elephant grass selection, S.13, was utilized together with three *F¹ Pennisetum* hybrid genotypes, 13, 15 and 20. The *F¹* hybrid genotypes represented the diversity of growth habit found in the hybrid population.

At land preparation farmyard manure was applied at the rate of 5 t/ha to the experimental site which was on the Teaching and Research Farm of the University of Ibadan, Ibadan. A split-plot layout with three replications was adopted with elephant grass and the *F¹ Pennisetum* hybrids as the main plots. Subplots were the following four spacing treatments: crown splits set at every 30 cm, 45 cm, 60 cm and 90 cm in 1.80m long rows which were 90 cm apart. Each subplot consisted of four rows. These relatively close spacings were tested to ensure rapid ground in order to check weed growth.

In May, 1975 crown splits were set in the plots at the appropriate spacing. Eleven weeks later when plants were well established, all treatments were cut at 30 cm above ground level and the herbage discarded. Yield data were taken at subsequent five-weekly harvests with cuts made 30 cm above ground level. Fresh herbage yield estimations were made by cutting and weighing herbage from the two middle rows of each subplot. At each harvest, about 500g of fresh sample was taken from each plot and oven-dried to determine DM content. Four harvests were taken during the rainy season. Plants were not cut during the dry season; but at the end of it, in April of the following year, plants were cut 30 cm above ground level but no yield estimates were made because plants had been grazed a number of times by stray livestock during the dry season. Yield data were recorded at every five-weekly harvest thereafter, up to December and there was a total of seven harvests in the second year of the study. During the second year, in addition to

DM yield estimates CP content was estimated according to A.O.A.C. (1970) procedures while IVOMD was determined using Tilley and Terry's (1963) two-stage technique as modified by Alexander (1969). However, owing to a shortage of reagents for various analyses, only samples from the second and fifth harvests representing early and late rainy season, respectively were utilized for CP determination, while fifth harvest samples were utilized for IVOMD estimates. Results from another experiment reported by Aken'Ova (1975) indicated close correlations among IVOMD values of these genotypes at different harvests. Estimates of the proportion of leaves in cut forage at each harvest were obtained by determining the proportion by weight of leaf blades in 2g of fresh samples.

Plots were fertilized at the annual rate of 224 kg N/ha as urea applied in equal split doses following a harvest; three doses in the first year and six in the second. Plots were weeded when necessary.

RESULTS AND DISCUSSION

Data for forage DM yields in each of the two years of study are shown in Table 1. The total yields for both years are given in Table 2. DM yields tended to increase with closer spacing and the highest yields were recorded at the 90 x 30 cm spacing. While Paterson (1938) and Oakes (1967) found no appreciable effects of spacing on DM yields in the Caribbean the trend towards increased yields with closer spacing has also been recorded in other parts of the tropics such as Rhodesia (Addison, 1956; Kennan, 1952), Colombia (Crowder, 1974) and Northern Nigerian (Akinola, 1976). However, in Rhodesia, the initial advantage of closer spacing tended to be lost with time (Addison, 1956; Kennan, 1952).

In the first year, elephant grass DM yield at 90 x 30 cm was not significantly greater than those of *F¹ Pennisetum* hybrids 13 and 15 at the same spacing (Table 1). However, its yield in the second

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TABLE 1

EFFECT OF SPACING ON DRY MATTER YIELDS (t/ha) OF F¹PENNISETUM HYBRIDS AND ELEPHANT GRASS WHEN CUT EVERY FIVE WEEKS IN THE RAINY SEASON OF TWO YEARS

		Spacing (cm)*									
		90 x 30		90 x 45		90 x 60		90 x 90		Genotype means	
Genotypes		1975 ^a	1976 ^b	1975	1976	1975	1976	1975	1976	1975	1976
Elephant grass:											
	S.13	14.70	25.68	12.50	21.49	12.36	22.27	10.12	20.61	12.41	22.51
F ¹ hybrids:											
	13	13.50	20.53	11.86	16.63	11.46	17.81	9.73	15.57	11.64	17.63
	15	12.70	18.46	12.20	17.53	9.20	14.24	9.29	12.80	10.80	15.71
	20	7.83	11.26	6.03	11.04	6.18	9.48	4.89	9.69	6.23	10.37
Spacing means		12.18	18.98	10.60	16.67	9.80	15.95	8.51	14.62		

a 4 harvests b 7 harvests

* 5% LSD:	(i) genotypes means	1975	1976
	(ii) spacing means	0.87	2.66
	(iii) between spacings for the same genotype	1.05	1.28
	(iv) between spacings for different genotypes	2.10	2.57
		2.01	3.45

TABLE 2

EFFECT OF SPACING ON TOTAL DRY MATTER YIELD (t/ha) OF F¹PENNISETUM HYBRIDS AND ELEPHANT GRASS IN TWO YEARS

Genotype	Spacing (cm)*				Genotype
	90 x 30	90 x 45	90 x 60	90 x 90	
Elephant grass:					
S.13	40.38a	33.99b	34.63b	30.73bc	34.93a
F ¹ hybrids:					
13	34.02b	28.49cd	29.27cd	25.30de	29.27b
15	31.16bc	29.55bcd	23.44ef	21.89ef	26.51b
20	19.09fg	17.07g	15.66g	14.58g	16.60c
Spacing means	31.16a	27.27b	25.75b	23.13c	

* Value in rows and columns with one letter or more in common are not significantly different at the 5% level — Duncan's Multible Range (DMR) test.
Means in a row or a column with one letter or more in common are not significantly different at the 5% level — DMR test.

year at that spacing was significantly greater than those of the F¹ *Pennisetum* hybrids, a result that was repeated when the yields were summed over the two years (Table 2). These results confirm findings in another study (Aken'Ova, 1975) which indicated a relative superiority in DM productivity of the elephant grass strain over time.

Genotype x spacing interactions were not significant in either year, indicating that the patterns of response of all genotypes to spacing were essentially similar.

Table 3 shows the effects of spacing on forage quality as measured by the DM content, percent leaf, CP content and IVOMD, along with the linear relation-

TABLE 3

EFFECT OF SPACING ON SOME QUALITY CHARACTERISTICS OF
F¹ PENNISETUM HYBRIDS AND ELEPHANT GRASS IN 1976

Genotype	Spacing (cm)	DM ^a (%)	Leaf ^a (%)	CP ^b (% DM)	IVOMD ^c (%)
Elephant grass S.13	90 x 30	16.7	42	11.8	54.1
	90 x 45	17.7	37	10.0	52.5
	90 x 60	17.1	44	11.7	54.3
	90 x 90	16.5	37	11.4.	50.8
linearity		ns	ns	ns	ns
F ¹ hybrid 13	90 x 30	16.6	45	11.8	50.8
	90 x 45	16.3	46	12.1	45.1
	90 x 60	16.8	43	10.4	53.1
	90 x 90	17.5	43	10.4	52.2
linearity		ns	ns	ns	ns
F ¹ hybrid 15	90 x 30	16.7	48	12.6	54.5
	90 x 45	16.8	47	12.5	52.8
	90 x 60	16.2	46	10.7	54.9
	90 x 90	16.0	45	10.3	53.0
linearity		ns	-0.049*	ns	ns
F ¹ hybrid 20	90 x 30	16.9	57	11.6	45.3
	90 x 45	16.3	59	12.1	52.8
	90 x 60	16.2	53	12.7	55.5
	90 x 90	17.1	60	13.1	54.2
linearity		ns	ns	0.025*	ns

a average of seven harvests; b average of two harvest; c one harvest

* Significant linear relationship with spacing at the 5% level; figure preceding asterisk is the linear regression coefficient (b).

ns Non-significant linear relationship with spacing.

ships between these quality characteristics and spacing. The data indicated that in most cases the spacings employed had no adverse or consistent effects on quality. Significant linear relationships were only found between spacing and percent leaf and CP in F¹ hybrid 15 and 20, respectively. CP levels at all treatment combinations were well above the dietary minimum of 7% recommended for tropical forages (Elliot and Topps, 1963).

Although the amount of weeds under each spacing treatment was not estimated, 90 x 60 cm and 90 x 90 cm plots required weeding more frequently than the other

two closer spacings. This is an indication of greater weed growth under wider spacing and indicative of the smothering effect on weeds of plant canopies in denser plantings.

Since the choice of spacings tested in this study was influenced by the need for rapid canopy cover in a sole cropped pasture, spacing adopted in practice must take into consideration the availability of propagating material, more being required at the closer spacing at which the genotypes studied produced their highest DM yields. Addison (1956) suggested that elephant grass may be established at

closer spacing with relatively higher levels of nitrogen fertilization on limited acreages for DM production while wider spacings with lower nitrogen levels might be more suitable if the objective is soil improvement in a crop rotation.

As the F¹ hybrids do not form dense spreading crowns like elephant grass, it might be worthwhile to try even closer spacings to maximize DM yields.

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REFERENCES

- ADDISON, K.B. 1956. The effect of various cultural and manutrial treatments on Napier fodder. Part II. The effect of nitrogen and spacing on the production of Napier fodder. *Rhod. Agric. J.* 53: 567—666.
- AKEN'OVA, M.E. 1975. Improvement of *Pennisetum purpureum* Schum. for forage in the low-altitude Humid Tropics. Ph.D. Thesis University of Ibadan, Ibadan.
- AKINOLA, J.O. 1976. Influence of spacing on performance of elephant grass (*Pennisetum purpureum* Schum) during the year of establishment in the northern guinea savanna of Nigeria. *Nig. J. Anim. Prod.* 3: 172—180.
- ALEXANDER, R.H. 1969. The establishment of a laboratory procedure for the *in vitro* determination of digestibility. *West Scotland Agric. College Res. Bull.* No.42.
- A.O.A.C. 1970. Official Methods of Analysis of the Association of Official Analytical Chemists (11th Edition). Association of Official Analytical Chemists. Washington D.C.
- CHHEDA, H.R., AKEN'OVA, M.E. and CROWDER, L.V. 1973. Forage crops research at Ibadan. 2 *Pennisetum purpureum*. In J.K. Loosli, V.A. Oyenuga and G.M. Babatunde (eds.) *Animal Production in the Tropics*. Heinemann Educational Books (Nigeria) Limited, Ibadan. pp.95—101.
- CROWDER, L.V. 1974. Pasture and Forage Research in Tropical America. *Cornell Agric. Bull.* No.28.
- ELLIOTT, R.C. and TOPPS, J.H. 1963. Voluntary intake of low protein diets by sheep. *Anim. Prod.* 5: 269—376.
- KENNAN, T.C.D. 1952. The improved West African Napier fodders. *Rhod. Agric. J.* 49: 221—228.
- LAZENBY, A. 1962. Selection criteria in grass breeding. *I.J. Agric. Sci.* 59: 51—62.
- LAZENBY, A. and ROGERS, H.H. 1965. Selection criteria in grass breeding. V. Performance of *Lolium perenne* genotypes grown at different nitrogen levels and spacings. *J.Agric. Sci.* 65: 79—89.
- MILLROY, R.J. 1972. An introduction to Tropical Grassland Husbandry. Oxford University Press, London.
- OAKES, A.J. 1967. Effect of nitrogen fertilization and spacing on yield and composition of Napier grass in the dry tropics. *Trop Agric. (Trinidad)* 44:77—82.
- PATERSON, D.D. 1948. Further experiments with cultivated tropical fodder crops. *Emp. J. Exp. Agric.* 6: 323—340.
- TAKAHASHI, M., MOOMAW, J.C. and RIPPERTON, J.C. 1966. Studies of Napier grass III Grazing management. *Hawaii Agric. Expt. Sta. Univ. of Hawaii. Bull.* 128.
- WHYTE, R.O., MOIR, T.R.G. and COOPER, J.P. 1959 *Grasses in Agriculture*, FAO Agric. Series No. 42. FAO. Rome.