Influence of Spacing on Performance of Elephant Grass (*Pennisetum Purpureum Schum*) during the Year of Establishment in the Northern Guinea Savanna of Nigeria

By

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SUMMARY

A STUDY was conducted using a split-plot design to determine the effect of within-row spacings of 90, 60 and 30 cm at a constant 60 cm inter-row distance on the forage yield and growth components of two elephant grass varieties, "Shika" and "Ngala", during establishment, at Shika in the northern guinea savanna of Nigeria.

With closer spacing, dry matter (DM) yield increased from 11300 kg to 16700 kg/ha and 12300 kg to 15300 kg/ha whilst crude protein (CP) yield increased from 517 kg to 644 kg/ha and 600 kg to 698 kg/ha, for "Shika" and "Ngala", respectively, during the wet season when most of the annual growth occurred. The data suggest that "Shika" was more sensitive to denser planting than "Ngala".

The stem and the green leaf made the greatest contribution to forage yield during the growing season. However, the green leaf accounted for a greater proportion of yield during the dry season when DM production fell drastically and crude protein content attained a peak.

Considerable stand mortality occasioned early July-planted "Ngala" and this provides evidence that it would not be beneficial to establish this more succulent variety at Shika until ample rainfall has been received during the growing season. The low DM content of 18 per cent in 2.6 m tall "Ngala" suggests that successful ensilage of this crop would necessitate pre-wilting.

Wider spacing resulted in lower herbage yield and significantly greater weed competition.

INTRODUCTION

The distribution, and the vegetative as well as reproductive morphology of elephant grass (*Pennisetum purpureum* Schum) have been described (Whyte, Moir and Cooper,

1959; Grof, 1969; Stanfield, 1970). The forage yield potential of elephant grass is tremendous, (Cooper, 1970), and compares very favourably with that recorded for any of the most highly productive tropical grasses. Elephant grass has been put to various agricultural uses including green soiling particularly in dairying, conservation as silage or hay, grazing and ley for soil improvement.

Among the major constraints to the continued high yield and persistence needed to justify the enormous costs of vegetative establishment is weed competition. In Kenya (Anon, 1955) and Cuba (Casamayor, 1970) weeds caused 50 and nearly 46 per cent yield reduction, respectively, in planted pastures of elephant grass. At Shika in the northern guinea savanna of Nigeria (Akinola, unpublished) annual forage yield declined as the pasture aged and by the fourth season, over 70 per cent of stands had succumbed to weed infestation while the living stands revealed varying degrees of depletion and chlorosis. Although varieties differ in aggressiveness and competitive ability, factors such as the frequency and intensity of defoliation (Wilsie, Akamine and Takahashi, 1940) and spacing, incorrectly applied, may induce suppression by weeds and an untimely eradication of the pasture.

Variations from no spacing effect (Loterio, Bernal and Herrera, 1967; Oakes, 1967; Zyl van, 1970) to significant increases in the yields of DM (Fernandez de Paredes and Muro C. Del, 1961; Chillar and Tomer, 1970) and protein (Diaz,

1968) with increasing planting density have been reported. Addison (1956) observed that the initial advantage of the higher forage yield produced as a result of closer spacing was progressively lost with time. Wider spacing has been credited with lower costs (Oakes, 1967) and ease of inter-row cultivation and furrow irrigation (Crespo and Guzman, 1973). Thus it would appear that the spacing to adopt would be greatly influenced by environmental factors, cultural practices and the intended use of the pasture (Takahashi, Moomaw and Ripperton, 1966).

In the guinea savanna the zero grazing system is commonly practised but far greater importance is attached to elephant grass ensilage in view of its highly nutritious and supplementary role in ruminant livestock feeding in the long dry season. However no adequate management systems have been evolved in this environment for maintenance of stands in a relatively highly productive state and for a sufficiently long time to make its cultivation worthwhile. The regime here lies within the requisite range described for the species (Grof, 1969). This paper reports the effect of three plant spacings on various attributes of yield of two elephant grass varieties evaluated during establishment.

MATERIALS AND METHODS

The experiment was conducted between July, 1974 and May, 1975 at Shika Agricultural Research Station on a grey, cracking sandy clay soil. Major climate parameters of the environment during the investigation are provided in Table 1. The site was used in the previous season for maize and maiwa (*Pennisetum americanum*) production. Prior to establishing the trial, compound fertiliser (N:P₂O₅:K₂O=20:10:10) was applied at 377 kg/ha.

A split-plot design, replicated four times, with spacing as mainplot and variety as subplot was used. The spacings consisted of a constant 60 cm between rows and three within-row distances of 90, 60 and 30 cm, thus providing populations of 18518, 27778 and 55555 stands per hectare, respectively. The elephant grass varieties

were the "Shika" or local, and the "Ngala" from the Chad Republic.

Rooted nature stem pieces with three complete internodes were stuck into the ground almost erect and about 15 cm deep, showing one or two nodes above ground on 10 July, 1974. Dead stands were counted and replaced with fresh material on 31 July, 1974 (day 21). The only weeding of the experiment, using hand and hoe, was done on the same date. Stand mortality was recorded again at the first harvest on 26 October, 1974 (day 108).

The plots were harvested on 26 October 1974, 24 February and 21 May 1975. On each occasion, sampling involved cutting the inner, bordered plants 20 cm above ground. The October 1974 forage yield was separated into green leaf, green leaf sheath, dry leaf, dry leaf sheath and stem components. Subsamples of each plant organ, including the succulent stems which had to be sliced open, were weighed fresh before oven-drying at about 80°C to obtain dry matter content. Per cent crude protein was determined (A.O.A.C., 1970) on the dry, milled material.

RESULTS

Dry Matter Yield

About 90 per cent of the total DM yield of elephant grass grown between the initial planting date, 10 July 1974, and the third and final harvest on 21 May 1975, was obtained from the 1974 rainy season growth (Table 2). Both the yield at first harvest and the total yield revealed significant spacing effects with production increasing as within-row distances decreased. Statistical significance was recorded for the spacing x variety interaction but not for varietal yield responses. The "Shika" variety yielded lower at the widest spacing and higher at the closest spacing, than the "Ngala" variety.

The lowest DM yield was observed in the second harvest, following a 121-day regrowth. No marked varietal differences in yield were found during this period of low night temperature and complete dryness (Table 1) but spacing exerted considerable influence on yield. The fact that the yield

TABLE 1
Summary of climate at Samaru + (Rainfall at Shika + +)

	Total rainfall (mm)	Mean max. temp. (°C)	Mean min. temp. (°C)	Mean relative humidity $\frac{1}{2}$ (10am + 4pm)	Mean daily sunshine hours
1974					
Jan.	0.0	26.8	14.5	18.3	4.6
Feb.	0.0	32.3	15.6	7.2	8.8
March	30.5	34.8	19.6	14.0	8.5
April	29.2	35.6	23.0	39.1	7.8
May	43.4	33.2	21.5	48.0	7.6
June	165.6	31.4	20.9	56.7	7.9
July	252.2	27.4	19.7	74.9	5.4
Aug.	323.3	27.8	20.0	73.9	5.9
Sept.	241.4	28.6	19.3	71.6	6.3
Oct.	49.0	30.7	19.0	54.9	8.8
Nov.	0.0	29.9	14.3	21.8	9.2
Dec.	0.0	27.1	12.5	18.9	8.6
1975					
Jan.	0.0	25.9	12.0	16.6	7.8
Feb.	0.0	32.2	15.9	9.4	9.5
March	0.0	34.9	19.1	21.2	7.3
April	85.8	35.2	21.0	42.3	8.9
May	113.3	31.3	21.0	62.4	7.9

+ Samaru : Lat. $11^{\circ} 11' N$, Long. $7^{\circ} 38' E$
 + + Shika : Lat. $11^{\circ} 12' N$, Long. $7^{\circ} 33' E$

on 21 May 1975 after only 86 days' regrowth was higher than the yield on 24 February 1975 can be attributed mostly to the rise in environmental temperature and the attendant April and May rainfall. A striking feature of the third harvest was the significant overall yield difference between the varieties which suggests that "Shika" was the quicker to respond to recently improved soil moisture conditions.

Whereas the stem component accounted for between 53 per cent ("Shika") and 58 per cent ("Ngala") of the dry matter production during the 1974 rainy season, the green leaf component constituted the bulk of the dry season yield. In a descending order of dry matter contribution, the sequence of the remaining plant fractions was green leaf sheath, dry leaf and dry leaf sheath. "Shika" produced significantly higher green leaf and lower stem dry matter yield than "Ngala" when harvested in October 1974.

Weed growth, 70 per cent of which was produced by annual grasses, was higher at the 60 x 90 cm spacing and under "Ngala".

Crude Protein Content

The green leaf component had the highest, and the dry leaf sheath the lowest, percentage CP content (Table 3). CP content reached a maximum during the dry season, and the green leaf and stem data suggested that season, and not necessarily harvesting frequency, determined the CP level. Irrespective of spacing, "Ngala" contained significantly higher CP than "Shika" during the 1974 rainy season in all the plant parts examined except the green leaf.

Crude Protein Yield

The effect of season on plant performance was reflected in the CP yield which maximised in October 1974 and declined considerably during the following dry season (Table 4). Total CP yield of each variety at every harvest rose with increasing plant population and resulted in significant differences among spacing treatments. "Shika" yielded significantly lower than "Ngala" in October 1974 but higher in February and May 1975, so that the pooled data indicated a non-significant

TABLE 2
Distribution of dry matter yield (kg/ha)

Treatments	1st harvest, 26/10/74*	2nd harvest 24/2/75										3rd harvest 21/5/75
Spacing x variety (cm)	Total	Green leaf	Green leaf sheath	Dry leaf	Dry leaf sheath	Stem	Weed	Total	Leaf**	Stem**	Total**+	Total of three harvests
60 x 90	"Shika"	1135a	3200b	1363c	478a	336a	5978a	278b	501a	167a	778b	12634a
	"Ngala"	12207b	2771a	992a	758b	477b	7299b	467c	484a	170a	528a	13309b
	"Shika"	13162c	3591d	1354c	850c	494b	6873b	174a	596b	192a	948c	14706c
	"Ngala"	13477c	3154b	1140b	843c	603c	7737bc	262b	613b	250b	640a	14730c
60 x 60	"Shika"	16735c	4411c	1349c	1093d	755d	9127d	139a	749c	275d	1018c	18502c
	60 x 30											
	"Ngala"	15284d	3412c	1094b	1235c	833c	8701d	242b	776c	272b	798b	16857d
Main plot	60 x 90	11826a	2986a	1177a	618a	406a	6638a	373b	493a	168a	653a	12972a
	60 x 60	13319b	3372b	1247a	846b	548b	7305a	218a	605b	221b	794b	14718b
	60 x 30	16009c	3911c	1221a	1164c	794c	8918b	191a	762c	273c	908c	17680c
Sub-plot	"Shika"	13751a	3734b	1355b	807a	528a	7326a	197a	615a	211a	915b	15281a
	"Ngala"	13686a	3112a	1075a	945b	638b	7915b	324b	624a	231a	655a	14966a

Means in the same column not described by identical letters differ significantly at $P < 0.05$

* Harvested on day 108 at silage stage.

** All leaves above cutting height green.

+ Green leaf sheath and undifferentiated tissue inclusive.

+ + Predominantly all-leaf above cutting height.

TABLE 3
Crude protein content (% of DM) of plant parts

Treatments	Spacing x variety (cm)	1st harvest 26/10/74*			2nd harvest 24/2/75			3rd harvest 21/5/75		
		Green leaf sheath	Dry leaf	Dry leaf sheath	Green leaf sheath	Dry leaf	Stem	Leaf**	Stem	Total
Main plot	60 x 90	9.10a	2.10a	1.51a	3.70ab	2.70bc	13.60cd	14.72b	13.60cd	12.77a
	"Shika"	8.90a	2.20a	2.01c	4.41c	3.90e	10.65b	11.80a	10.65b	12.12a
	"Ngala"	9.00a	2.10a	1.50a	3.50a	2.50b	13.32c	14.17b	13.32c	12.17a
	60 x 60	9.11a	2.30ab	1.81b	3.90ab	3.40d	10.10b	11.32a	10.10b	11.30a
	"Shika"	8.40a	1.90a	1.40a	3.20a	2.20a	12.37c	13.82b	12.37c	11.52a
Sub-plot	60 x 30	8.60a	2.20a	1.80b	3.71ab	3.70e	8.42a	11.30a	8.42a	11.07a
	"Shika"	9.00a	2.15a	1.75a	4.05ab	3.30b	12.26a	13.26a	12.26a	12.45a
	60 x 60	9.06a	2.20a	1.65a	3.70a	2.95a	11.71b	12.75a	11.71b	11.74a
	60 x 90	8.50a	2.05	1.60a	3.45a	2.95a	10.40a	12.56a	10.40a	11.30a
	"Shika"	8.83a	2.03a	1.47a	3.47a	2.47a	13.10b	14.24b	13.10b	12.16a
	"Ngala"	8.87a	2.23b	1.87b	4.00b	3.67b	9.72a	11.47a	9.72a	11.50a

Means in the same column not described by identical letters differ significantly at $P < 0.05$

* Harvested on day 108 at silage stage.

** All leaves above cutting height green.

+ Green leaf sheath and undifferentiated tissue inclusive.

++ Predominantly all-leaf above cutting height.

TABLE 4
Distribution of crude protein yield (kg/ha)

Treatments	1st harvest, 26/10/74 *				2nd harvest, 24/2/75				3rd harvest, 21/5/75			
Spacing × variety (cm)	Total	Green leaf	Green leaf sheath	Dry leaf	Dry leaf sheath	Stem	Total	Leaf**	Stem †	Total † †	Total of three harvests	
60 × 90	517.2a	290.9b	50.3bc	10.0a	5.0a	160.9a	71.8c	49.1b	22.7b	99.2bc	688.2a	
	599.4b	246.4a	34.6a	16.6b	9.5c	283.3c	55.0a	36.9a	18.1a	63.9a	718.4a	
	567.6b	323.2bc	47.3ab	17.9b	7.4b	171.8a	82.7d	57.2c	25.5bc	115.4cd	765.7bc	
60 × 60	622.7bc	286.3b	44.2a	19.3bc	10.8d	262.1c	66.2b	41.1a	25.1bc	72.3a	761.3a	
	644.5cd	370.2d	43.2a	20.7bc	10.6d	199.8b	99.2c	65.4d	33.8d	117.0cd	860.8d	
	697.7c	293.2b	40.5a	27.1d	14.9c	321.9d	79.6d	56.8c	22.8b	88.4ab	865.8d	
Main plot												
	558.3a	268.7a	46.9ab	13.3a	7.3a	222.1a	63.4a	43.0a	20.4a	81.6a	793.3a	
	595.2b	304.7b	45.8a	18.6d	9.1b	217.0a	74.4b	49.1b	25.3b	93.9b	763.5b	
Sub-plot												
	671.1c	332.7c	41.8a	23.9c	12.7c	260.9b	89.6c	61.1c	28.3c	102.7b	863.3c	
	576.5a	328.1b	46.9b	16.2a	7.7a	177.5a	84.5b	57.2b	27.2b	110.5b	771.6a	
	640.0b	275.3a	42.8a	21.0b	11.7b	289.1b	66.9a	44.9a	22.0a	74.9a	781.8a	

Means in the same column not described by identical letters differ significantly at $P < 0.05$

* Harvested on day 108 at silage stage.

** All leaves above cutting height green.

† Green leaf sheath and undifferentiated tissue inclusive.

† † Predominantly all-leaf above cutting height.

variatal difference. At all the spacings "Shika" green leaf exceeded its stem, whilst at the two spacing extremes "Ngala" stem superceded its green leaf, in CP yield at the first harvest when the stem proportion (DM) was high. At other harvests the stem component was much reduced and therefore the CP yield attributable to the stem was also much lower.

Field Components

Vegetative propagation of variety "Ngala" in early July 1974 under the unsteady Shika rainfall conditions appeared uneconomic in view of the high mortality recorded at the early post-planting period (Table 5). Since no stand losses were observed a month after replanting, it could be assumed that planting variety "Ngala" in late July or early August would be beneficial. Stand mortality as observed on 26 October 1974 could be attributed to competitive stress but did not appear to have adversely affected yield performance.

The spacing x variety interaction was not significant for tiller population, plant height and leaf numbers per tiller. However, over all spacing treatments, "Ngala" produced significantly fewer but taller shoots than "Shika".

DISCUSSION

The experimental data suggested that in the establishment year only slight differences existed between the two elephant grass varieties in terms of DM and CP yields averaged over plant parts and harvests. Seasonal fluctuation in yield was marked and the drastic reduction in the February yield could be associated particularly with soil moisture shortage. It was evident from this study that timing, and not necessarily the interval between cuts, determined to a large extent the yield and chemical composition of elephant grass (Oyenuga, 1959). Although total DM and CP yields maximised during the 1974 rainy season, CP concentration attained higher levels during the dry season presumably due to a slow rate of DM accumulation. Oakes (1968) reported similar findings. The higher forage yield in May compared with February resulted in CP

content either falling slightly ("Shika") or hardly changing ("Ngala"). This improvement in crop growth rate, combined with the relatively high forage CP content, could be explained as responses to moistening the already dry soil which in April and May, probably promoted mineralisation of soil organic matter and made more nitrogen available for plant absorption and utilisation (Birch, 1960).

The green leaf at all times, and the stem during the rainy season contributed substantially to forage yield. Forage as obtained in October 1974 is of particular interest from the stand point of conservation as silage. However the average DM content over all plant components at this harvest was about 31 per cent and 18 per cent for "Shika" and "Ngala" respectively and suggested that "Ngala" should be wilted before ensiling. Although the dry season yield was low, light animal grazing was considered practicable as no indications of stand degeneration were observed after the third cutting.

Closer spacing gave higher yields of DM and CP. Considerable reduction in the total amount of dry leaf at wider spacing might indicate that inter-plant competition and mutual shading of lower leaves occurred more slowly at lower plant populations even though significant weed suppression accompanied higher populations. It would be suggested that spacing as widely as 60 x 90 cm could facilitate the incorporation of suitable forage legumes in an elephant grass pasture for green soiling, grazing or ensiling. Erect, less spreading pigeon pea (*Cajanus cajan*) selections might particularly fit into such a programme (IITA, 1973).

"Shika" demonstrated a significantly higher tolerance of the relatively dry soil condition at planting than "Ngala". The indications were that in environments similar to Shika large scale establishment of elephant grass should rely on the "Shika" variety. Investing in "Ngala" would necessitate shelving planting until regular rainfall has been ensured during the wet season. Further work has been initiated and aims at comparing the yield and persistency of these varieties under rainfed

TABLE 5
Components of yield performance

Treatments <i>Spacing x variety</i> (cm)	Stand mortality (%)		Growth components, 26/10/74		
	31/7/74+	26/10/74++	Tillers/m ²	Plants height (cm)	No. of green leaves per tiller
"Shika"	7.6a	2.5a	18.2b	232a	12.1ab
60 x 90					
"Ngala"	34.8b	2.5a	11.5a	255ab	11.7a
"Shika"	4.4a	3.6a	20.6b	236a	12.0ab
60 x 60					
"Ngala"	41.5bc	9.4b	12.3a	262bc	11.6a
"Shika"	2.9a	3.4a	27.4c	242a	10.7a
60 x 30					
"Ngala"	28.1b	12.5c	17.5b	266bc	10.0a
Main plot					
60 x 90	21.2a	2.5a	14.9a	244a	11.9b
60 x 60	22.9ab	6.5b	16.5a	249a	11.8b
60 x 30	15.5a	8.0c	22.5b	254a	10.4a
Sub-plot					
"Shika"	5.0a	3.2a	22.1b	237a	11.6a
"Ngala"	34.8b	8.1b	13.8a	261b	11.1a

Means in the same column not described by identical letters differ significantly at $P < 0.05$

-|-21 days after planting and before dead stands were replaced.

++ At first harvest, day 108.

and/or irrigation conditions and different fertiliser regimes.

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