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Comparative Dry Matter Yields Assessment of Benue State Local Accession of *Andropogon gayanus* Kunth and Other Forage Grass Species in the Southern Guinea Savannah, Nigeria

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Abstract
To meet the need for productive grasses for forage utilization in Benue State, a study was conducted in the state to identify suitable genotypes from among local and introduced grasses. The study comprised evaluation of improved genotypes of *Andropogon gayanus* from the dry savanna, *Brachiaria, Cynodon, Panicum* and *Pennisetum purpureum* species along with their local counterpart species, arranged in a randomized complete block design with three replicates. In this trial, there were significant differences in annual rainy season DM yields which ranged from 5.3 (*C. nlemfuensis*) to 16.9 t/ha (*P. purpureum* S.15) at Makurdi and 5.4 (*C. nlemfuensis*) to 14.2 t/ha (*P. purpureum* S.13) at Yandev. On the basis of superior DM yield, *Andropogon gayanus* Acc.10, *Panicum maximum* cv. Ntchisi and *Pennisetum purpureum* S.15 are recommended for forage utilization in Benue State.

1. Introduction

Dry matter (DM) yield is an important characteristic, determining to a large extent the animal-carrying capacity of a pasture. Many selection programmes aim to select those species which give the maximum DM yield within the limitations of the environment [1]. However, production of large amounts of DM of low nutritive value may be of little use in animal production, particularly where stocking rate is limited by periods of stress such as the dry season in tropical regions. Also selection for high yield in grasses may limit the ability of associated legumes to compete and remain in the sward. Thus selection of suitable grasses should not be based on yield alone [2], [14]. In legumes, however, selection for high yield has an added importance, since nitrogen fixation is closely related to total DM yield [1], [16].

Hitherto, very little attention has been directed towards developing the vast areas of natural grasslands vis-à-vis livestock production in Benue State in the southern guinea savanna. It has been estimated that *A. gayanus* Kunth, gamba grass, the predominant grass species constitutes 60% of the grass biomass in the natural vegetation of the southern guinea savanna, which can contribute to livestock production in the state [3].

However, the abundant grassland resources are underutilized and even depleted through annual bush burning often in search of large wild rodents and other small mammals which when processed for consumption are collectively termed 'bush meat', a local delicacy. The fires have caused economic hardship in the loss of buildings and agricultural produce apart from the exposure of the soils to erosion. It is known that the state is endowed with able-bodied men and women who are actively engaged in farming. A knowledge of forage crops production in this area, which does not have any major industries, could lead to more systematic livestock production. An increase in livestock production would help solve part of the perennial protein shortage in the diet of the people, the major reason for hunting 'bush meat' as well as provide diversification in agricultural activities. Thus, increased livestock production will also help in the development of meat production, dairy and leather works.

For improved livestock production in Benue State, there is need to identify suitable genotypes of forage grass species such as *A. gayanus* which is abundant in the state, as well as other species. The present study was therefore embarked upon to:

Evaluate dry matter yields of Benue State local accession of *Andropogon gayanus* (Acc.10) along with other forage grass species including introductions to determine those that may be suitable for utilization in the state.

2. Materials and Methods

2.1. Evaluation of Local and Introduced Grass Genotypes

This trial involved six improved forage genotypes viz. *Brachiaria ruziziensis, Cynodon* Ib.8, *Cynodon* Ib. X7, *Panicum maximum* cv. Ntchisi, *Pennisetum purpureum* S.13 and *Pennisetum purpureum* S.15, obtained from the University of Ibadan Teaching and Research Farm as well as a genotype of *Andropogon gayanus* recommended for the dry savanna, obtained from the National Animal Production Research Institute (NAPRI) Ahmadu Bello University, Shika near Zaria. They were evaluated along with five local counterpart species in Benue State i.e. Benue *Andropogon gayanus* Accession (Acc.) 10, *Brachiaria decumbens, Cynodon nlemfuensis, Panicum maximum* and *Pennisetum purpureum*. The Benue *A. gayanus* Acc.10 was selected for its high DM yields in a previous trial. Thus, 12 genotypes were evaluated in a randomized complete block layout with three blocks.

During July and August, when rainfall had become steady, crown splits of the *A. gayanus* Acc.10, *Brachiaria*, *Cynodon* and *Panicum maximum*, and stem cuttings of *Pennisetum purpureum* genotypes, were planted every 50.0 cm in plots consisting of three, 5.5 m long rows spaced 1.0 m apart while the seeds of *A. gayanus* (NAPRI) were sown in plots consisting of three, 5.5 m long rows spaced 1.0 m apart arranged in a randomized complete block layout with three blocks in the University of Agriculture Livestock Teaching and Research Farm (LTRF), Makurdi and the Agricultural Experiment Station at Yandev.

2.2. Replants

Missing stands resulting from failure of some propagules to establish were replaced early in the rainy season of the following year. Established stands were cut back during this time to minimize competition with the replants and make for more uniform establishment.

2.3. Establishment of Uniform Growth

During establishment, observations were made on the following characteristics: percent survival in terms of stand counts, i.e. number of plant stands per plot divided by the number of propagules planted multiplied by 100, and stem and leaf characteristics i.e. visual observation of the plants. Weeding was done as necessary to prevent competition with planted propagules and subsequently during the harvests.

When rains were fully established in the second year, plants were cut 15 cm above ground level and the cut herbage discarded without weighing. Thereafter, plants were cut every six weeks 15 cm above ground level and fresh weights of cut herbage from the inner row of each plot were recorded to estimate fresh herbage yield.

Proportion of leaf in the cut herbage was determined as the weight of the lamina divided by the weight of cut herbage sample multiplied by 100 on fresh weight basis.

Proportion of weeds in the plots was also estimated during the harvests as fresh weight of weeds in cut plot divided by weight of total biomass in the plot multiplied by 100.

Harvests were repeated at six-weekly interval until the third and the last in December, in the dry season. After each harvest, except the last, nitrogen fertilizer (N:P:K, 20:10:10) was applied at a rate to supply 20 kg N/ha. After the last harvest, the plants were rested for the rest of the dry season. Sub-samples of freshly cut herbage were weighed and oven-dried at 70°C to constant weight for the determination of dry matter content and hence dry matter yield. The oven-dried herbage samples were milled in a RETSCH milling machine equipped with a 0.50 mm sieve.

2.4. Second Year Trial

In the second year of this trial as in the previous year, plants were cut 15 cm above ground level every six weeks and cut herbage weighed. Sub-samples were taken for dry matter content determination and dry matter yield calculated. All data generated were subjected to analysis of variance based on randomized complete block design using MSS [7], and where significant differences occurred amongst means they were separated using Fisher's Least Significant Difference embedded in MSS [7] which was based on Duncan's principle of mean separation [8].

3. Results - Evaluation of Local and Introduced Forage Grasses

3.1. Establishment Rate

Table 1 shows the plant establishment rates and weed infestation levels at the trial sites in Makurdi and Yandev, and their mean values. The results indicated that establishment rates at the commencement of harvest ranged from 0% for *B. decumbens* (local) to 98% for *C. nlemfuensis* (local) and *P. purpureum* S.15 at Makurdi site, while at Yandev, it ranged from 0% for *B. decumbens* (local) and *B. ruziziensis* to 100% for *P. maximum* (local). On the average, establishment appeared better at Makurdi (76%) ($P<0.05$) than at Yandev (66%).

3.2. Weed Proportion

The estimation of weed infestation of six weeks growth at each harvest at the trial sites is shown in Table 1. The results indicated that the better established genotypes tended to have relatively low weed infestation levels.

The weed infestation levels ranged from 10% in *Andropogon gayanus* Acc.10 which averaged 96% stand establishment to 100% in *Brachiaria decumbens* for which stand establishment was nil. Poor stand establishment (1.5%) was also recorded by the other species of *Brachiaria* i.e. *B. ruziziensis* in which weed infestation was 90%. Stand establishment of *A. gayanus* (NAPRI) averaged 87% over the two sites with relatively low weed infestation of 15%.

Cynodon Ib.8 recorded good stand establishment at Makurdi (87%) but only fair (52%) at Yandev. Its competitive ability with weeds was apparently low hence the high weed infestation of 70%. On the other hand, although stand survival of *Cynodon* Ib. X7 was high averaging 87%, weed infestation was high at 90%, reflecting poor competitive ability of this individual genotype. *Cynodon nlemfuensis* exhibited good establishment (88%) with low weed infestation of 12%. It spread rapidly by its stolons out-competing the weeds.

Table 1. *Plant stand establishment and weed infestation of local and introduced forage grass genotypes at Makurdi and Yandev trial sites.*

Genotype	Makurdi		Yandev		Mean	
	Establishment+	Weed+	Establishment+	Weed+	Establishment++	Weed++
	%					
Andropogon gayanus Acc.10	93ab*	12d	99ab	8f	96a	10d
A. gayanus NAPRI	90bc	13d	83c	17def	86.5abc	15d
Brachiaria decumbens	0d	100a	0g	100a	0d	100a
B. ruziziensis	3d	80b	0g	100a	1.5d	90ab
Cynodon Ib. X7	93ab	85b	80cd	95a	86.5abc	90ab
Cynodon Ib.8	87bc	56c	52f	84b	69.5c	70b
Cynodon nlemfuensis	98a	9d	77d	15def	87.5abc	12d
Panicum maximum (local)	93ab	60c	100a	20cde	96.5a	40c
P. maximum cv. Ntchisi	82c	9d	63e	15def	72.5bc	12d
Pennisetum purpureum (local)	82c	19d	65ep	25cd	73.5bc	22cd
P. purpureum S.13	95ab	20d	89bc	24cd	92.0ab	22cd
P. purpureum S.15	98a	9d	83c	13ef	90.5abc	11d
Mean	76	39	66	43		

Note Stand establishment classification: 70 -100% = Good, 50 – 69% = Fair, Less than 50% = Poor
* Means in the column followed by the same letter(s) are not significantly different at the 5% level by Duncan's multiple range test
+ Averaged over three harvests
++ Averaged over sites

Panicum maximum (local) established very well and rapidly. However, its canopy cover was not enough to shade out weeds such that there was a relatively high weed infestation of 40% in the plots. Stand survival of *P. maximum* cv. Ntchisi was high leading to a low weed infestation of 12%.

There was good stand establishment of the local *Pennisetum purpureum* leading to well developed plant canopy that contributed through shading, to reduction of weed infestation to 22%. Stand establishment of *P. purpureum* S.13 was good averaging 92% over sites with a relatively low weed infestation of 22%. *Pennisetum purpureum* S.15 exhibited good stand establishment and also survived weed competition by having well developed plant canopy which suppressed weed infestation to as low as 11%.

Some of the major weed species that invaded the Makurdi trial site include the following: Itch weed (*Rottboelia cochinchinensis*), Spear grass (*Imperata cylindrica*), both northern and southern gamba grass (*Andropogon gayanus* and *A. tectorum*), *Hyparrhenia* species, Guinea grass (*Panicum maximum*) and some wild *Stylosanthes* species. At Yandev: Siam weed (*Chromolina odorata*), Itch weed (*Rottboelia cochinchinensis*), buffel grass (*Cenchrus ciliaris*), *Cynodon nlemfuensis*, *A. gayanus* and *A. tectorum,* and *Hyparrhenia* species and *P. maximum*.

3.3. Dry matter Yield and Proportion of Leaf

Measurements of plant growth parameters viz. dry matter (DM) yield, and proportion of leaves in harvested herbage commenced at six-weekly intervals (except rest periods) until the end of the trial.

3.3.1. Dry Matter Yields

In this trial, some genotypes viz. *Brachiaria decumbens*, *B.*

ruziziensis, *Cynodon* Ib.8 and *Cynodon* Ib. X7 established poorly at the trial sites. No record of DM yields and proportion of leaves were obtainable from them and were thus, excluded from further evaluation and labelled 'no records' (nr) in Table 2.

The total forage DM yields of local and introduced genotypes at the two sites are shown in Table 2. In the first year of harvest at Makurdi, *P. purpureum* S.15 had the highest total DM yield of 8.7 t/ha which was significantly different from the yields of the remaining six genotypes viz. *A. gayanus* Acc.10, *A. gayanus* (NAPRI), *C. nlemfuensis* (local), *Panicum maximum* (local), *P. maximum* cv. Ntchisi and *Pennisetum purpureum* (local) with DM yields ranging between 3.7 (*C. nlemfuensis* (local)) and 7.8 t/ha (*P. maximum* cv. Ntchisi). *Panicum maximum* cv. Ntchisi yield of 7.8 t/ha was not significantly different from the yield of the local *P. purpureum* with DM yield of 7.5 t/ha. These top two yielding genotypes were, however, significantly different from the remaining four genotypes i.e. *A. gayanus* Acc.10, *A. gayanus* (NAPRI), *C. nlemfuensis* (local) and *P. maximum* (local) which recorded yields of 6.7, 3.9, 3.7 and 5.4 t/ha, respectively. *Cynodon nlemfuensis* (local) had the lowest total DM yield of 3.7 t/ha which was not significantly different from that of *A. gayanus* (NAPRI) with 3.9 t/ha.

At Yandev, *P. purpureum* S.13 had the highest DM yield with 6.7 t/ha. This was not significantly different (P>0.05) from the yield of the local *P. purpureum* with 6.5 t/ha. Excluding *P. purpureum* S.13, the local *P. purpureum* recorded DM yield that was not significantly (P>0.05) different from the DM yield of two other genotypes viz. *A. gayanus* Acc.10 and *P. maximum* (local) with 6.3 and 5.0 t/ha, respectively. *Cynodon nlemfuensis* (local) recorded the lowest DM yield of 3.8 t/ha which was not significantly different from the DM yield of *A. gayanus* (NAPRI) with 3.8 t/ha but significantly so from all other genotypes. In the second year of harvest, *P. purpureum* S.15 had the highest DM yield of 25.1 t/ha at Makurdi which was significantly different from the yields of the remaining seven genotypes for which yield was measured. *Pennisetum purpureum* S.13 had the second highest DM yield of 21.8 t/ha which was significantly different from the yields of the other six genotypes viz. *A. gayanus* Acc.10, *A. gayanus* (NAPRI), *C. nlemfuensis* (local), *P. maximum* (local), *P. maximum* cv. Ntchisi and *P. purpureum* (local), 11.1, 7.9, 6.8, 10.1, 15.7 and 18.9 t/ha, respectively. There were also significant differences among the six genotypes as shown in Table 2.

Table 2. *Dry matter yield and proportion of leaf of local and introduced forage grass genotypes.*

Genotype	1st. Year		2nd. Year		Annual average			Proportion + of leaf (fresh weight)
	Mak. ++	Yan.	Mak.	Yan.	Mak.	Yan.	Mean	- % -
	%							
A. gayanus (Acc.10)	6.7c*	6.3a	11.1e	10.7d	8.9bcd	8.5bcd	8.7b	61.7b
A. gayanus (NAPRI)	3.9e	3.8c	7.9f	8.0e	5.9d	5.9d	5.9cd	50.3f
B. decumbens (local)	nr	nr	nr	nr	nr	nr	nr	nr
B. ruziziensis	nr	nr	nr	nr	nr	nr	nr	nr
Cynodon Ib. X7	nr	nr	nr	nr	nr	nr	nr	nr
Cynodon Ib.8	nr	nr	nr	nr	nr	nr	nr	nr
C. nlemfuensis (local)	3.7e	3.4c	6.8f	7.4e	5.3d	5.4d	5.4d	60.2c
P. maximum (local)	5.4d	5.0b	10.1e	10.0d	7.8cd	7.5cd	7.7bc	57.3d
P. maximum cv. Ntchisi	7.8b	nr	15.7d	13.5c	11.8bc	6.8cd	9.3b	69.7a
P. purpureum (local)	7.5b	6.5a	18.9c	18.0b	13.2ab	12.3ab	12.8a	57.1d
P. purpureum S.13	nr	6.7a	21.8b	21.6a	10.9bc	14.2a	12.6a	56.0e
P. purpureum S.15	8.7a	nr	25.1a	21.2a	16.9a	10.6bc	13.8a	50.7f

* Means in the column followed by the same letter(s) are not significantly different at the 5% level by Duncan's multiple range test
+ Proportion of leaf values were of six-week regrowth averaged over sites
++ Mak. = Makurdi; Yan. = Yandev
nr = no records owing to poor stand establishment

The six genotypes as shown in Table 2. The lowest DM yield of 6.8 t/ha by *C. nlemfuensis* (local) was not significantly different from the yield of *A. gayanus* (NAPRI) of 7.9 t/ha.

At Yandev, *P. purpureum* S.13 recorded the highest DM yield of 21.6 t/ha which was not significantly different from the second highest yield of 21.2 t/ha for *P. purpureum* S.15. The yields of these two genotypes i.e. *P. purpureum* S.13 and *P. purpureum* S.15, were however, significantly different from those of the remaining six genotypes viz. *A. gayanus* Acc.10, *A. gayanus* (NAPRI), *C. nlemfuensis* (local), *P. maximum* (local), *P. maximum* cv. Ntchisi and *P. purpureum* (local), and with 10.7, 8.0, 7.4, 10.0, 13.5 and 18.0 t/ha, respectively. There were also significant differences among these six genotypes as shown in Table 2. *Cynodon nlemfuensis* (local) recorded the lowest DM yield of 7.4 t/ha which was not significantly different from that of *A. gayanus* (NAPRI) with 8.0 t/ha.

Pennisetum purpureum S.15 recorded the highest average annual DM yield of 16.9 t/ha at Makurdi. This was not significantly different from the 13.2 t/ha yield of the local *P. purpureum* but significantly different from the yields of the remaining genotypes with yields ranging from 5.3 to 11.8 t/ha. The DM yield of 13.2 t/ha by *P. purpureum* (local) was also not significantly different from the yields of three other genotypes viz. *A. gayanus* Acc.10, *P. maximum* cv. Ntchisi and *P. purpureum* S.13. These three genotypes were also not significantly better in DM yield than *P. maximum* (local) which recorded 7.8 t/ha. *Cynodon nlemfuensis* (local) recorded the lowest average annual DM yield of 5.3 t/ha which was not significantly different from the average annual DM yield of *A. gayanus* Acc.10 (8.9 t/ha), *A. gayanus* (NAPRI) (5.9 t/ha), and *P. maximum* (local) (7.8 t/ha) but significantly different from the remaining four genotypes.

Pennisetum purpureum S.13 recorded the highest average annual DM yield of 14.2 t/ha at Yandev. This was not significantly different from the average annual yields for *P. purpureum* (local) with 12.3 t/ha, but significantly different from the yields of the remaining six genotypes. *Pennisetum purpureum* S.15 recorded an average annual DM yield of 10.6 t/ha. There were some significant differences among the six genotypes (Table 2). *Cynodon nlemfuensis* (local) recorded the lowest average annual DM yield of 5.4 t/ha which was not significantly different from yields of four other genotypes i.e. *A. gayanus* Acc.10, *A. gayanus* (NAPRI), *P. maximum* (local) and *P. maximum* cv. Ntchisi, respectively (Table 2).

Averaged over sites, *P. purpureum* S.15 had the highest DM yield of 13.8 t/ha which was not significantly different from the yields of the two other *Pennisetum* genotypes. The yields of these three highest yielding *Pennisetum* genotypes were significantly different from those of the remaining five genotypes. *Panicum maximum* cv. Ntchisi had an average DM yield of 9.3 t/ha which was not significantly different from those of *A. gayanus* Acc.10 and *P. maximum* (local). *Cynodon nlemfuensis* (local) recorded the lowest average DM yield of 5.4 t/ha which was similar to the yield for *A. gayanus* (NAPRI) (Table 2).

There was significant genotype x environment interaction such that, for example, *P. purpureum* S.15 recorded the highest yield of 16.9 t/ha among genotypes at Makurdi but was significantly out-yielded by *P. purpureum* S.13 with 14.2 t/ha at Yandev.

3.3.2. Proportion of Leaf

The proportion of leaf in the cut herbage of the grass genotypes which was replicate values of three harvests averaged over sites, Is presented in Table 2. *Panicum maximum* cv. Ntchisi had the Highest proportion of 69.7%. This was significantly different from the values for the remaining seven genotypes. *Andropogon gayanus* Acc.10 recorded the second highest value of 61.7% which was significantly different from the values of the remaining six genotypes. There were some significant differences among the seven genotypes (Table 2). *Andropogon gayanus* (NAPRI) recorded the lowest leaf proportion of 50.3% which was significantly different from all other genotypes (Table 2).

4. Discussion

Satisfactory plant establishment starts with adequate germination of seeds and seedling emergence or a high rate of sprouting of shoots in the case of vegetative propagation [1], [16]. This is followed by rooting and growth. Ease of establishment as reflected by high rate of germination or sprouting and rapid early growth is desirable in forage species [2], [13].

There was variation in stand establishment among introduced genotypes of different species and their Benue State counterpart species. Both *Brachiaria* genotypes, one of *B. ruziziensis* and the other of *B. decumbens*, exhibited very poor establishment and they were dropped from the trial. As for the *Cynodon* genotypes, constituting the other short sod-forming grasses, they exhibited establishment levels comparable to those of the tall bunch type species of *Andropogon, Panicum* and *Pennisetum*. However, only the local *Cynodon nlemfuensis* exhibited sufficient growth vigour to outperform the weeds. The two introduced *Cynodon* genotypes i.e. *Cynodon* Ib.8 and *Cynodon* Ib. X7 were therefore also omitted from further evaluation. The introduced *Cynodon* genotypes may be regarded as poorly adapted to the prevailing conditions of the trial locations. Out of the remaining eight genotypes that were further evaluated, seven were tall bunch type grasses with the local *Cynodon* being the only short sod-forming type. The tall growth habit of the bunch type species may have contributed to their ability to outperform the weeds many of which were of short growth habit and therefore susceptible to shading by the taller forage species.

The pubescent nature of the leaves of grasses contributes to their acceptability to livestock. An abundance of stiff hairs on the leaf margins and lamina tends to reduce acceptability, and hence intake [4], [5], [15]. In *A. gayanus*, both the local and NAPRI genotypes, the hairs were soft to touch whereas in *P. purpureum*, particularly the S.13 and S.15, the hairs were stiff and moderately coarse. Differences in pubescence have been observed within species particularly *A. gayanus* [6], [10], with those in the more northern dry areas having hairy leaves while glabrous leaves are characteristic of the late flowering varieties found in the southern Nigeria.

Proportion of leaf in herbage is one of the indicators of nutritive value in grasses [9], [14]. In the present study, there were significant differences among the genotypes for the character. Three introductions viz. *P. purpureum* S.13, *P. purpureum* S.15 and *A gayanus* (NAPRI) recorded the lowest proportion of leaf while *P. maximum* cv Ntchisi, also an introduction, recorded the highest. The high proportion of leaf of the Ntchisi cultivar may be partly due to its shorter internodes which, coupled with the relatively thin stems, would result in a reduction in stem mass.

Dry matter yields obtained in the present study are comparable to those reported elsewhere in Nigeria. The DM yields of *P. purpureum* S.13 and *P. purpureum* S.15 in the present study were higher than those reported for the two genotypes at Ibadan [11], [9], [12]. These differences may be related to differences in environmental conditions such as differences in soil nutrient status and climatic conditions in terms of temperature and rainfall.

5. Conclusion

While some introduced improved genotypes exhibited very poor establishment, an indication of poor adaptation, other introduced genotypes produced higher DM yields than their local counterparts. *Pennisetum purpureum* S.15, an improved genotype, recorded the highest annual DM yield of 13.8 t/ha averaged over trial sites. Proportion of fresh leaf ranged from 50.3% for *A. gayanus* (NAPRI) to 69.7% in *P. maximum* cv Ntchisi. Among the local species, annual DM yield ranged between 5.4 (*C. nlemfuensis*) and 12.8 t/ha (*P. purpureum*). Proportion of fresh leaf in the cut herbage ranged between 57.1 (*P. purpureum*) and 61.7% (*A. gayanus* Acc.10). On the basis of the results in terms of DM yield, the following genotypes appear the most promising for forage utilization in Benue State: *A. gayanus* Acc. 10, *P. maximum* cv. Ntchisi and *P. purpureum* S.15.

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