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INFLUENCE OF HARVESTING MANAGEMENT AND NITROGEN FERTILIZER APPLICATION ON PLANT FRACTIONS IN FIELD SWARDS.

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ABSTRACT

An investigation to determine the influence of harvesting management and nitrogen (N) fertilizer application on plant fractions of Northern gamba (Ngg), guinea grass S112 (Gg) and star grass (Sg) was conducted at the University of Nigeria, Nsukka in 1985 and 1986 wet seasons. The experiment comprised all possible combinations of the three grass species and four N fertilizer levels: (0, 150, 300 and 450 Kg N ha^{-1}) and six harvesting intervals (3, 4, 5, 6, 8, and 10 weeks) and was laid out as a 3 x 4 x 6 split – split – plot in a randomized complete block design, replicated three times.

Nitrogen fertilizer and harvesting management exerted significant effects on plant fractions of each species. Species differences, and differences due to N supply and harvesting management on stem, green and dead leaves, and inflorescence fractions were significant ($P < 0.05$). Extending the interval between harvests from 3 to 10 – weekly cuts significantly reduced the proportion of green leaves and increased the proportion of dead leaves and stem in the three species during the two study periods. There was a 183.1% (18.1 – 6.5) unit drop in green leaves in 1985 and 200% (16.8 – 5.6) unit drop in 1986 when cutting intervals increased, on the average from a 3, 4 and 5 weeks to a 6, 8 and 10 weeks. The application of N increased the numbers of leaf primordial per tiller delayed flowering in Ngg and reduced flowering in Gg. Delaying cutting reduced the proportion of green leaf blade but increased that of 'stem'. These results are discussed in relation to management of the sward during the growing season.

KEYWORDS: Harvesting Management, Nitrogen fertilizer and plant fractions in field swards.

INTRODUCTION

Northern gamba grass *(Andropogon gayanus)* Guinea grass, *(Panicum maximum)* and Star grass *(Cynodon polystarchyus)* have been found to be well adapted to the derived Savannah zone of Nigeria. The responses of these three species to N fertilizer (0, 150, 300 and 450 Kg N ha^{-1}) application with good management system as influenced by frequency of harvests (3, 4, 5, 6, 8 and 10 weeks) will lead to a greater economic returns to the farmer.

Several studies have been conducted with both tropical and temperate species of forages to evaluate the effect of N fertilizer application and interval between harvests on yield of plant fractions (Oyenuga, 1959, Chheda and Akintola, 1980; Omaliko, 1980; Wilman and Pearse, 1984; Wilman et al, 1999; Sphi *et al*, 1999; Warren, 2000). Report from these researchers showed that both interval between harvests and N application had positive effect on yield and plant fractions. The present study is to investigate further the influence of interval between harvests and N application on the proportion of plant fractions of stem, green leaves, dead leaves and inflorescence of field swards in a derived savannah.

MATERIALS AND METHODS

The experiment was conducted in 1985 and 1986 during the wet seasons using swards of grasses established in March, 1985 on the University of Nigeria Farm, at Nsukka, (latitude 06°52'N and longitude 07°24'E, altitude 447.3m above mean sea level) on the ferrallitic fine sandy loam soil of the Nkpologwu series.

The experimental site was previously cropped with maize followed by four years in which *Panicum maximum* (guinea grass and *Cynodon polystachyus* (star grass) were dominant fallow species. The three grass species used in the experiments are: Northern gamba grass (*Andropogon gayanus)*, Ngg; of erect growth habit and flowers late in the growing season; guinea grass *(Panicum maximum cv. S112)* Gg; with semi postrate growth habit, characterised by early flowering, star grass *(Cynodon polystarchyus)*, Sg: has stoloniferous stem, and is a runner, and takes more than a year to flower.

The trial was in a 3 x 4 x 6 split – split – plot in a randomized complete block (RCB) design replicated three times. The main plot treatment consisted of three grass species, the sub-plots were the N-fertilizer rates and the harvesting intervals were the sub-sub-plots. The main plot size was 3m x 48_m, sub-plot size was 3_m x 12_m and sub-sub plot size was 3_m x 2_m. An area of $2m^2$ at the centre of each sub-sub plot unit was marked and harvested as sample.

A set of 10 tillers were randomly harvested and separated into "stem", green leaf blade, dead leaf blade, and inflorescence. A leaf was regarded green when it had over 50% green area. The "stem" is the true stem plus leaf sheath. The inflorescence was therefore that part appearing beyond the ligule of the flag leaf.

The four components were then dried to a constant weight at a temperature of 60°C for 48 hours in a Gallen Kamp forced air laboratory oven, and then weighed. The weight of each component was divided by the sum of all components (sum of 'stem' with green leaf

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Table 1: Average rainfall values (mm) for 1985, 1986 and 1977 – 1986 (10 years) at Nsukka, Nigeria.

MONTHS	RAINFALL (MM)		
	1985	1986	1977 – 86 Mean
January	0.2	0.4	0.4
February	0.8	2.7	1.8
March	27.6	38.3	10.6
April	62.3	53.3	36.1
May	77.5	76.2	53.4
June	68.9	84.5	55.7
July	59.7	112.2	68.9
August	69.9	73.2	59.2
September	78.3	47.7	86.1
October	24.6	29.2	68.5
November	5.1	4.8	22.6
December	0.3	0.2	0.5
Total	475.2	517.9	463.8
Mean	39.6	43.2	38.6

Source: Meterological Station, University of Nigeria, Nsukka, Nigeria.

TABLE 2: Effect of species and harvesting intervals on the proportion of green leaves (%)

Species	Harvesting Intervals (Weeks)						Species Mean
	3	4	5	6	8	10	
			1985				
Ngg	27.7	24.4	22.1	12.0	7.4	4.3	16.3
Gg	24.9	21.3	13.9	10.2	6.1	5.1	13.4
Sg	11.3	12.0	9.5	6.0	5.2	3.1	7.5
Mean	21.3	18.6	15.2	9.7	6.2	3.6	
			1986				
Ngg.	28.5	24.6	22.1	12.4	7.2	4.5	16.6
Gg.	23.4	28.1	12.5	9.3	4.4	3.1	12.1
Sg.	10.8	6.5	5.8	4.4	3.3	3.6	5.6
Mean	19.2	14.2	12.8	8.4	5.0	3.4	

LSD (0.05) between treatment means

	1985	1986
Species	1.8	1.2
Harvesting interval	2.4	1.4
Species x Harvesting interval	2.8	1.8

TABLE 3: Effect of harvesting intervals and nitrogen application on the proportion of green leaves (%)

Nitrogen (Kg ha^{-1})	Harvesting Intervals (Weeks) 3	4	5	6	8	10	Nitrogen Mean
			1985				
0	14.5	13.6	12.5	9.7	6.2	3.0	9.7
150	17.4	15.0	14.8	10.2	6.0	3.2	11.1
300	20.4	16.5	15.7	12.2	7.1	5.8	12.9
450	23.4	18.9	16.1	12.8	7.2	6.0	14.1
Mean	18.8	16.0	14.8	11.2	6.6	4.5	
			1986				
0	12.2	13.1	9.3	8.2	4.4	3.1	8.5
150	16.9	13.6	10.2	7.4	4.3	3.2	12.0
300	19.1	14.0	12.1	8.5	5.0	3.4	13.4
450	22.9	16.3	12.3	8.4	5.0	3.4	14.4
Mean	17.8	14.2	11.3	8.1	4.8	3.3	

LSD (0.05) between treatment means

	1985	1986
Harvesting Intervals	0.08	0.92
Nitrogen	1.20	1.41
Harvesting Interval x Nitrogen	1.63	1.74

wt + dead leaf wt + inflorescent wt) and multiplied by 100 to express each proportion as a percentage on dry matter basis.

STATISTICAL ANALYSIS

Data were subjected to analysis of variance (ANOVA) and means compared with Fisher's Least Significant Difference (F - LSD) at 5% level.

RESULT

The rainfall data collected about 20m from the experimental site are presented in Table 1. The data showed that by April the rainfall was sufficiently high to support good growth. Sg did not flower till the end of the study period but Gg had on set of flowers from the 3 – weeks cut due to the effect of N-application. Ngg, however started flowering late in the season, 6 weekly cuts in 1986. Increasing harvesting frequency significantly ($p < 0.05$) influenced the proportion of green leaves. The highest proportion of green leaf blades, 21.3% in 1985 and 19.2% in 1986, on the average, were obtained at the 3 – weekly cut plots, while the least 3.6% in1985 and 3.4% in 1986 were obtained at the 10 – weekly the least cuts. (Table 2).

During the two planting seasons the proportion of green leaf blades tended to decrease with increase in the harvesting intervals. Taking the means of 3, 4, and 5 – weekly cuts in 1985 and 1986, compared with those of 6, 8 and 10 weeks, there was a 11.9% (18.3% - 6.5) drop in the proportion of green leaf blades in 1985 and a 11.2% (5.6 – 15.4%) drop in 1986 (Table 2). The interaction of species x harvesting intervals was significant ($P < 0.05$). The three species had their maximum proportion of green leaf blades in plots cut every weeks while the leaf occurred in plots cut every 10 weeks. Ngg on the average had the highest proportion of green leaf blades 16.3% in 1985 and 16.6% in 1986, and these were significantly higher than those of either Gg or Sg.

The interaction of harvesting intervals x nitrogen is presented in Table 3. The highest proportion of green

leaf blades (23.4% in 1985 and 22.9% in 1986) on the average, occurred in plots cut every 3 weeks where 450 Kg N ha^{-1} was applied while the least, 3.0% in 1985 and 3.1 9% in 1986 were obtained from plots cut every 10 weeks where no nitrogen fertilizer was applied. The values obtained by cutting every 5, 6, 8 and 10 weeks with 300 Kg N ha^{-1} was almost equal to those obtained from plots that received 450 Kg N ha^{-1} throughout the study period. Highest proportion of green leaf blades ran closely with high levels of nitrogen applied.

The effect of harvesting intervals on the proportion of dead leaf blades is presented in Table 4. Highest proportion of dead leaf blades 25.4% in 1985 and 23.3% in 1986 were obtained from plots cut every 10 weeks and was significantly ($P < 0.05$) higher than 5.4% in 1985 and 8.2% in 1986 obtained in plots cut every 3 weeks. The interaction of harvesting interval and species on the proportion of dead leaf blades was significant ($P < 0.05$). The proportion of dead leaf blades in each of the three species tended to increase with increase in interval between harvests throughout the study period. The species had their maximum proportion of dead leaf blades in plots cut every 10 weeks. Ngg on the average had the highest proportion of dead leaves (19.2% in 1985 and 18.2% in 1986) and these were significantly ($P < 0.05$) higher than those of either Gg or Sg.

The response of species and nitrogen on the proportion of dead leaf blades is presented in Table 5. The proportion of dead leaf blades was restarted by applied N in the early stages of the experimental period and subsequently accelerated by applied N. Highest proportion of dead leaf blades, on the average (20.6% in 1985 and 19.4% in 1986) for Ngg occurred in plots that received 450 Kg ha^{-1} while the least (5.3% in 1985 and 7.8% in 1986) for Sg occurred in plots where no nitrogen fertilizer was applied.

The species differences on the proportion of dead leaf blades as influenced by nitrogen application was highly significant ($P < 0.05$). Ngg consistently gave the highest proportion of dead leaves while Sg had the least irrespective of the n-rates. Taking the average of 4 nitrogen levels, Ngg produced the highest proportion of dead leaf blades, (19.4%) and the values were significantly higher than those of either Gg or Sg.

The response of species and harvesting interval on the proportion of 'stem' is presented in Table 6.

TABLE 4: Effect of species and harvesting intervals on the proportion of dead leaves (%)

Species	Harvesting Intervals (Weeks)						Species Mean
	3	4	5	6	8	10	
			1985				
Ngg	12.4	13.9	15.3	23.8	24.3	25.4	19.2
Gg	9.7	10.9	11.2	12.0	13.4	15.2	12.1
Sg	5.4	6.0	5.5	8.7	8.8	9.3	7.3
Mean	8.4	9.6	10.7	14.8	15.5	16.6	
			1986				
Ngg.	12.8	14.5	16.0	20.3	22.1	23.3	18.2
Gg.	12.9	13.9	13.2	13.8	15.2	15.4	14.1
Sg.	8.2	9.6	10.2	10.5	10.6	11.0	10.0
Mean 11.2	12.7	13.2	14.9	15.9	16.6		

LSD (0.05) between treatment means

	1985	1986
Species	0.64	0.51
Harvesting interval	0.82	0.73
Species x Harvesting interval	1.25	0.96

TABLE 5: Effect of species and nitrogen on the proportion of dead leaves (%)

Species	Nitrogen rate (Kg ha^{-1})				Species Mean
	0	150	300	450	
			1985		
Ngg	15.9	18.6	19.0	20.6	19.4
Gg	10.4	11.1	12.8	13.8	12.1
Sg	5.3	6.0	7.5	9.6	7.3
Mean	10.6	11.4	13.1	14.5	
			1986		
Ngg.	16.6	17.7	18.6	19.4	18.2
Gg.	11.8	14.7	15.3	16.7	14.1
Sg.	7.8	9.0	10.4	11.3	10.1
Mean	12.1	13.1	14.7	15.6	

LSD (0.05) between treatment means

	1985	1986
Species	0.62	0.61
Nitrogen	0.81	0.76
Species x Nitrogen	1.20	1.21

Increasing the intervals between harvest, from 3 – weekly cuts to 10 weekly cuts significantly ($P < 0.05$) increased the proportion of 'stem' in the three species throughout the growing season. Cutting any of the three species every 10 weeks gave the highest proportion of 'stem' while the least occurred in plots cut every 3 weeks during the study period. Highest proportion of 'stem' (87.6 in 1985 and 89.4 in 1986), from the 10 – weekly cut plots was produced by Sg and these were significantly higher than those of either Ngg or Gg.

The interaction of species x nitrogen on the proportion of 'stem' is presented on Table 7. Increasing N application from 150 to 300 and from 300 to 450 Kg N ha^{-1} significantly ($P < 0.05$) increased the proportion of 'stem' during the study period. There was a 3.4% (60.4 – 62.5%) increase in 1985 and a 6.1% (57.3 – 60.8%) increase in 1986 when N-rate was increased from 150 to 300 Kg N ha^{-1} and a further 6.2% (62.5 – 66.4%) increase in 1986 when N – rate increased from 300 Kg N ha^{-1}to 450 Kg N ha^{-1} (Table 7).

The average effect of n-application on the species in terms of proportion of 'stem' was highly significantly ($P < 0.05$). The three species had their maximum proportion of 'stem' in plots that received 450 Kg N ha^{-1} and this was significantly higher than those of other treatments. Species differences as influenced by N application in terms of proportion of 'stem' was significant. Sg consistently gave the highest proportion of stem while Gg had the least irrespective of N – rates.

The effect of species and harvesting intervals on the proportion of inflorescence is presented on Table 8. Increasing cutting intervals from 3 weeks to 10 weeks significantly ($P < 0.05$) increased the proportion of inflorescence in the two species studied during the season. Highest proportion of inflorescence, (20.0% in 1985 and 31.1% in 1986), for Gg, was obtained from plots cut every 10 weeks while the least, (3.1% in 1985 and 4.3% in 1986), for Ngg were obtained from 8 – weekly and 6 – weekly cut plots respectively. Gg started flowering early in the season and produced on the average, (16.6% in 1985 and 27.4% in 1986) and these were significantly higher than those of the other treatment throughout the study period. The effect of harvesting interval x nitrogen rates on proportion of inflorescence is presented on Table 9.

N – rates exerted significant ($P < 0.05$) influence on the proportion of inflorescence. Highest proportion of inflorescence (20.2% in 1985 and 34.4% in 1986) occurred in the 6 – weekly cut plots, and 5 – weekly cut plots respectively where 450 Kg N ha^{-1} was applied, while the least (3.4% in 1985 and 3.5 in 1986) occurred in the 8 weekly cut plots. Plots that did not receive nitrogen fertilizer treatment did not flower at 6 weeks in the study periods, but plots that receive nitrogen

TABLE 6: Effect of species and harvesting intervals on the proportion of 'stem' (%)

Species	Harvesting Intervals (Weeks)						Species Mean
	3	4	5	6	8	10	
			1985				
Ngg	59.9	61.7	62.6	64.2	65.2	66.0	63.1
Gg	52.8	53.8	58.4	60.4	61.5	62.0	58.2
Sg	83.3	84.0	84.6	85.3	86.0	87.6	85.1
Mean	65.3	66.2	68.5	70.0	70.9	71.9	
			1986				
Ngg.	58.7	60.9	61.9	63.0	64.3	65.0	62.2
Gg.	40.1	41.0	47.9	48.9	50.2	60.2	46.4
Sg.	81.0	83.9	84.0	85.0	86.2	89.4	84.4
Mean	59.9	61.9	64.6	65.6	66.9	71.5	

LSD (0.05) between treatment means

	1985	1986
Species	0.6	0.7
Harvesting intervals	0.8	0.9
Species x Harvesting interval	1.2	1.3

TABLE 7: Effect of species and nitrogen on the proportion of 'stem' (%)

Species	Nitrogen rate (Kg ha^{-1})				Species Mean
	0	150	300	450	
			1985		
Ngg	58.5	61.9	64.1	68.2	63.1
Gg	46.4	48.4	62.8	64.3	58.2
Sg	75.2	81.0	84.4	86.7	85.1
Mean	56.7	60.4	62.5	66.4	
			1986		
Ngg.	49.6	58.3	66.7	49.4	62.2
Gg.	34.5	36.7	41.2	46.0	46.4
Sg.	76.8	82.9	84.6	87.0	84.4
Mean	53.6	57.3	60.8	64.1	

LSD (0.05) between treatment means

	1985	1986
Species	1.2	1.3
Nitrogen	2.0	2.1
Species x Nitrogen	2.6	3.0

TABLE 8: Effect of species and harvesting intervals on proportion of inflorescence (%)

Species	Harvesting Intervals (Weeks)						Species Mean
	3	4	5	6	8	10	
			1985				
Ngg	0.0	0.0	0.0	0.0	3.1	4.3	3.7
Gg	12.6	14.0	16.5	17.4	19.0	20.0	16.6
Mean	12.6	14.0	16.5	17.4	11.1	12.1	
			1986				
Ngg.	0.0	0.0	0.0	4.3	6.4	7.2	6.0
Gg.	23.6	25.0	26.4	28.0	30.2	31.1	27.4
Mean 23.6	25.0	26.4	16.2	18.3	19.3		

LSD (0.05) between treatment means

	1985	1986
Species	0.8	0.9
Harvesting interval	01.2	1.3
Species x Harvesting interval	2.1	2.2

treatment had on-set of flowers as early as 3weekly during the study period. There was an increased in the proportion of inflorescence for every addition of 150Kg N ha^{-1} and this effect was greater early in the season than later in the season, from 3 – weekly cut to 6 weekly cuts in 1985 and from 3 – weekly cut to 5 – weekly cut in 1986 and then dropped.

DISCUSSION

The positive effect of applied nitrogen on the proportion of green leaves, dead leaves, 'stem' and inflorescence reported in this study is in agreement with other results (Pearse, 1983 and Wilman and Pearse, 1984, Leitch and Kurt, 1999). This experiment and the report of other researchers showed that an increase in interval between harvests allowed positive responses to applied N in respect of the proportion of green leaves, dead leaves, stem and inflorescence of field swards. In 1985 and 1986 study periods, many of the tillers were still elongating after 20 and 30 weeks study period, so that the average proportion of green leaves by weight would have been higher at some stage by extra production of sheath and true stem. The 20 weeks study period for 1985 and 30 weeks period for 1986 appeared to be short and insufficient to allow for full 'stem' development, green leaves, dead leaves and inflorescence. It seems from the present experiment that the proportion of green and dead leaves were greater in northern gamba grass than in either guinea or star grasses during the experimental period as would be expected. Evidently, guinea grass and star grass have slower rate of leaf turn over than northern gamba grass, and also rather fewer leaves per tiller, nevertheless, because of the heavier and greater number of green leaves per tiller and their size, "northern" gamba grass recorded the greater proportion of plant fraction per tiller and this agreed with the findings of (Wilman and Pearse, 1984; Ryle 1984; Wilman and Fisher 1996; Sahi et al 1999). The proportion of green leaves dropped from 21.5% at 3 – weekly cuts to 3.6% at 10 weekly cuts. It is true that the growth of grass leaves is usually studied from the beginning of emergence to full expansion. The evidence in this study showed that this period represents a little less than one fifth of the time in which a leaf is growing (Pearse and Wilman, 1984; Ansar *et al* 1986; Wilman *et al* 1999). It is the period that extension rate (cm/day) is greatest.

The production of inflorescence characterised by wind pollination marks the beginning of sexual reproductive stage in flowering plants. However,

TABLE 9: Effect of harvesting intervals and nitrogen rates on the proportion of inflorescence (%)

Nitrogen (Kg ha^{-1})	Harvesting Intervals (Weeks) 3	4	5	6	8	10	Nitrogen Mean
			1985				
0	0.0	0.0	0.0	0.0	3.4	4.1	3.7
150	10.8	12.0	13.6	14.6	11.2	11.2	12.2
300	12.0	14.0	16.5	17.4	17.5	17.0	15.7
450	14.9	16.0	19.4	20.2	18.8	18.2	17.9
Mean	12.6	14.0	16.5	17.4	11.1	12.1	
			1986				
0	0.0	0.0	0.0	0.0	3.5	4.2	3.9
150	15.6	16.0	18.8	16.0	18.4	19.4	17.4
300	23.0	25.0	26.0	14.0	15.0	16.0	20.1
450	32.2	34.0	34.4	17.6	21.0	22.5	26.9
Mean	23.6	25.0	26.4	16.2	19.3	19.3	

LSD (0.05) between treatment means

	1985	1986
Species	0.06	1.2
Nitrogen	0.8	1.4
Harvesting Interval x Nitrogen	1.2	1.6

environmental factors strongly influence the differentiation of the leaf primodia into male or female inflorescence. The leaf and the inflorescence are initiated at the same time but sex differentiation of the inflorescence takes place some time earlier before anthesis Wilman and Fisher (1996). More investigation may be required with extended study period above 30 weeks used in this study so as to have a complete view of the true effect of treatment combination on the proportion of inflorescence.

CONCLUSION

It is obvious that any condition that will result in a higher proportion of green leaves with a smaller or delayed development of 'stem' will contribute to a higher quality herbage. For this reason, the leaf-stem ratio is a fair indicator of quality. From our investigation in this study, this leaf-stem ratio can be maintained by cutting every 4, 5 and 6 weeks, with N-application of 300 Kg N ha^{-1}for Ngg, Gg and Sg respectively, is suggested as a good management practice that will maintain a longer productive stand, with greater economic value to the farmer.

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