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Full Length Research Paper

The effect of sward type, cutting frequency and fertilizer-N application on tiller production, yield and proportions of crop fractions of *Panicum maximum* with or without *Stylosanthes hamata*

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This experiment was a 3 × 3 × 2 factorial laid out in a randomized complete block design and was replicated three times. Treatments comprised three sward types (pure grass, pure legume and grass/legume mixed swards), three cutting regimes (4, 8 and 12 weeks) and two nitrogen fertilizer rates (0 and 300 kg N ha^{-1}). Tiller density per m^{-2} was increased ($P < 0.05$) with increase in cutting frequency and with fertilizer-N application. Tiller number per m^{-2} was higher ($P < 0.05$) in pure grass sward compared with where grass was in mixture with legume in 2007. Increasing cutting interval from 4 to 12 weeks reduced ($P < 0.05$) the proportion of leaf fraction from 55 to 40% in 2006. The stem fraction was increased ($P < 0.05$) from 32 to 42%, while the proportion of inflorescence was increased from 13 to 15% when the interval between cuts was increased from 4 to 8 weeks but decreased later at 12 weeks. The proportion of leaf fraction decreased significantly ($P < 0.05$) from 49 to 43% with fertilizer-N application compared with the control in 2006. The proportion of inflorescence in the total herbage dry matter was, however, increased ($P < 0.05$) from 11 to 14% with fertilizer application compared with the control in 2006. Type of sward treatment did not influence the proportions of crop fractions in both years.

Key words: Type of sward, cutting interval, nitrogen application, plant parts.

INTRODUCTION

Most pastures in Nigeria lack proper management because of poor defoliation frequency and lack of proper fertilization. Pastures are often subjected to burning and extreme grazing, which have been shown to result in serious deterioration of herbage (Dev, 2001). A viable commercial livestock industry needs the establishment of suitable sown pasture and feed lots to meet the higher nutritional needs of more productive animals (Bamikole et al*.,* 2004). Improvement of feed availability for the future requires development of sown pastures that are to be sustained under intensive systems of management. Intensive production system involves the use of forage species that must prove their superiority in terms of their bulk productivity (dry matter yield per unit area), palatability, chemical composition, nutrient availability, persistence under defoliation regimes and climatic conditions, competition and compatibility with other forages in the pasture ecosystem (Muhammad and Abubakar, 2004). The use of adapted, improved and high yielding pasture grasses as sole crop or in mixture with legume is one of the ways of achieving good quality forage availability (Omokanye et al., 1998). Earlier works (Omaliko, 1980, 1983; Edokwe, 1991) on established *Panicum maximum* pastures in Nsukka, Nigeria, lacked information on the combined effect of sward type, cutting frequency and fertilizer-N application on the productivity of *P. maximum* pastures found in Nsukka. The present investigation was therefore designed to determine the effect of sward type, cutting frequency and nitrogen fertilizer application on tiller production, yield and

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proportions of crop fractions of *P. maximum* with or without *Stylosanthes hamata*.

MATERIALS AND METHODS

The experiment was carried out in the Department of Crop Science Research and Teaching farm, University of Nigeria, Nsukka. Nsukka is located at latitude 06°52' N and longitude 07°24' E, and on altitude of 447.2 m above sea level. The experiment was a 3 × 3 × 2 factorial laid out in a randomized complete block design and was replicated three times. Treatments comprised three sward types (pure grass, pure legume and grass/legume mixed swards), three cutting regimes (4, 8 and 12 weeks) and two nitrogen fertilizer rates (0 and 300 kg N/ha). These gave 18 treatment combinations. In May 2006, an area of land 37.8 × 13 m with an area of 491.4 m^2 was ploughed and marked out into three blocks of 37.8 × 3 m each. Each block was further divided into 18 plots of 3 × 2.1 m each with a sampling area of 0.9 × 1.8 m. Each block was separated by one meter path-way. Basal application of 75 kg K ha^{-1} and 44 kg P ha^{-1} as muriate of potash and single superphosphate, respectively was made by broadcasting. Rooted cuttings of *P. maximum* with height of 15 cm were planted after land preparation at 20 × 30 cm spacing. The seeds of *S. hamata* were planted by broadcast at the rate of 5.6 kg ha^{-1}. The treatment combinations were allocated completely at random in each of the three blocks. Cutting was done with shears at a uniform height of 7 cm.

The harvest intervals of 4, 8 and 12 weeks gave 4, 2, and 1 samples, respectively in 2006 and 6, 3 and 2 samples, respectively in 2007 season. The required quantity of nitrogen as Urea (46%N) was divided according to the number of cuts in a year for each harvest interval and evenly applied on the plot after each cut. The fresh weight of herbage was taken by weighing the fresh herbage harvested within the 0.9 × 1.8 m sample area. The grass herbage harvested was separated into leaf, stem and inflorescence fractions using a sub-sample weighing about 500 g. The different grass fractions were weighed fresh. The sub-samples of leaf, stem and inflorescence fractions of the grass species were put in paper envelops and dried in a forced air oven set at 80°C and weighed after attaining constant dry weight. These were used to calculate the total dry weights of the total herbage and of the different crop fractions. Tiller counts were made in each plot using a 25 cm square quadrat. The mean of three throws per plot was used to calculate tiller population m^{-2}.

The soil of the experimental site was sandy in texture and acidic in reaction. The soil had low amounts of nitrogen content, potassium, magnesium and base saturation. The soil was also low in cation exchange capacity, and in available phosphorus (Onyeonagu and Asiegbu, 2010). All data collected were statistically analyzed using GENSTAT 7.22 DE (1995) statistical package and employing the procedure for a randomized complete block design. Separation of treatment means for statistical significance was done using the standard error of the difference between two means (s.e.d).

RESULTS

Guinea grass (*P. maximum*) tiller population decreased significantly ($P < 0.05$) with increase in interval between cuts in 2006 (Table 1). Guinea grass tiller number was not significantly affected by intervals between cut in 2007. The type of sward had no effect on the tiller number during the first year. However, greater ($P < 0.05$) tiller number was produced in guinea grass swards than in guinea grass/verano stylo mixed swards in the second year. Fertilizer N application significantly increased the tiller number compared with where no N was applied in 2006 but there was no effect on tiller number in 2007. Fertilizer-N application in guinea grass swards produced significantly the highest tiller number when the medium interval of 8 weeks was employed in 2007.

Cutting interval, fertilizer application and type of sward and their interactions did not influence guinea grass tiller number during the first harvest period of the year 2006 (Table 2). Frequent cutting interval of 4-weeks significantly ($P < 0.05$) increased plant tiller number in the second period compared with the 8-weeks interval of cut. Tiller number was also increased with fertilizer application compared with where no fertilizer was applied. Grass plants growing in mixture with legume produced significantly higher tiller numbers compared with where grass was grown alone. Grass tiller number per square meter was not affected by sward type x cutting interval x nitrogen application interaction in any of the periods. Grass tiller production seemed to increase with season.

Grass tiller number was not affected by cutting interval and fertilizer-N application in all the periods in 2007 (Table 3). Type of sward treatment did not influence plant tiller number at the first and third periods. However, plants grown in pure grass swards had more ($P < 0.05$) tillers than those grown in mixture with legume during the second period. Tiller number per square meter appeared to increase with season.

Sward type, cutting frequency and fertilizer-N and their interactions did not significantly influence the leaf dry matter yield in 2006 (Table 4). Fertilizer N and sward type did not influence the stem dry matter yield; but the stem dry matter yield increased ($P < 0.05$) with increase in interval between cuts. The 12 weeks interval of cuts produced higher ($P < 0.05$) stem yield than 4-weekly interval of cut but was similar with the 8 weeks interval of cut in its effect. Fertilizer N increased the inflorescence dry matter yield compared with where N was not applied. Cutting at 8 weeks interval gave significantly higher inflorescence dry matter yield than the 3-, 6- or 12-weekly interval between cuts. Inflorescence dry matter yield was similar for 4- and 12-weekly intervals of cut. Sward type did not affect the inflorescence dry matter yield. Inflorescence dry matter yield was high with fertilizer application when cutting was done at 8-week interval under guinea grass/verano swards.

In 2007, the 8 weeks interval between cuts gave higher ($P < 0.05$) leaf blade dry matter yield than the 4 weeks interval but had similar effect with the 12 weeks interval (Table 5). Infrequent cutting interval of 12 weeks produced higher leaf dry matter yield than the 4 weeks. Fertilizer-N application in pure grass swards produced significantly the highest leaf blade dry matter yield when

Table 1. Effects of sward type, cutting frequency and fertilizer-N application on tiller population (per m^2) of guinea grass in 2006 and 2007.

Sward type	Cutting frequency (week)				
	Fertilizer-N (kg ha^{-1})	4	8	12	Mean
2006					
Guinea grass	0	495.5	443.5	201.1	380.0
	300	547.7	489.9	309.3	449.0
	Mean	521.6	466.7	255.2	414.5
Guinea grass in mixture	0	505.3	397.4	266.7	389.8
	300	586.8	516.5	348.8	484.0
	Mean	546.1	457.0	307.7	436.9
Cutting frequency mean		533.8	461.8	281.5	425.7
Fertilizer mean	0 kg Nha^{-1} = 384.9		300 kg Nha^{-1} = 466.5		
2007					
Guinea grass	0	377.6	406.0	437.1	406.9
	300	470.2	525.2	344.0	446.5
	Mean	423.9	465.6	390.5	426.7
Guinea grass in mixture	0	340.4	385.9	244.5	323.6
	300	358.9	380.4	388.5	376.0
	Mean	349.7	383.2	316.5	349.8
Cutting frequency mean		386.8	424.4	353.5	388.2
Fertilizer mean	0 kg Nha^{-1} =365.3		300 kg Nha^{-1} =411.2		

	2006	2007
S.e.d. between 2 sward type means (S) =	20.10	23.70
S.e.d. between 2 cutting frequency means (C) =	24.64	29.02
S.e.d. between 2 nitrogen means (N) =	20.10	23.70
S.e.d. between 2 S × C means =	34.82	41.04
S.e.d. between 2 S ×N =	28.43	33.51
S.e.d. between 2 C × N =	34.82	41.04
S.e.d. between 2 S × C × N =	49.24	58.04

cutting was done every 8 weeks. Fertilizer N application and sward type had no significant effect on the stem dry matter yield in 2007. The 12-weeks interval between cuts gave higher ($P < 0.05$) stem dry matter yield than the 4 weeks but had similar effect with the 8 weeks interval. The pure grass swards gave the highest stem dry matter yield when cutting was done every 8 weeks. Fertilizer N application, cutting frequency and sward type treatments did not influenced the inflorescence dry matter yield. Cutting every 8 weeks with zero N application gave the highest inflorescence dry matter in pure grass swards.

Sward type and fertilizer N application did not influence the grass leaf-blade dry matter yield in the two periods in 2006 (Table 6). Cutting treatment showed no significant effect on leaf blade yield in the first period but leaf blade yield was decreased ($P < 0.05$) with the longer interval of cutting of 8 weeks than with 4-weekly schedule in the second period. Leaf blade dry matter yield was on average higher during the early period than later.

Increase in interval between harvests significantly ($P < 0.05$) increased the leaf blade dry matter yield in the first two periods of 2007 (Table 7). Fertilizer-N application increased ($P < 0.05$) leaf blade yield over where N was not applied at the second period of the year. The leaf blade yield was not affected by fertilizer and cutting regime treatments in the last period. Higher ($P < 0.05$)

Table 2. Effect of Sward type, cutting frequency and fertilizer N application on mean tiller count (per m^2) of guinea grass plant at various periods of the year 2006.

Sward type	Cutting frequency (week)			
	Fertilizer N (kg ha^{-1})	4	8	Mean
August 12 to October 7 (1st 8 week period)				
	0	530.7	490.7	510.7
Guinea grass	300	498.1	522.7	510.4
	Mean	514.4	506.7	510.5
	0	462.4	556.2	509.3
Guinea grass in mixture	300	494.1	508.3	501.2
	Mean	478.3	532.2	505.2
Cutting frequency mean		496.3	519.5	507.9
Fertilizer mean	0 kg Nha^{-1} = 510.5		300 kg Nha^{-1} = 505.8	
October 7 to December 2 (2nd 8 week period)				
	0	459.9	398.4	429.2
Guinea grass	300	597.3	457.1	527.2
	Mean	528.6	427.7	478.2
	0	548.3	424.5	486.4
Guinea grass in mixture	300	679.5	524.8	602.1
	Mean	613.9	474.7	544.3
Cutting frequency mean		571.3	451.2	511.2
Fertilizer mean	0 kg Nha^{-1} = 457.8		300 kg Nha^{1} = 564.7	
		1st period	**2nd period**	
S.e.d. between 2 sward type means (S) =		39.74	18.44	
S.e.d. between 2 cutting frequency means (C) =		39.74	18.44	
S.e.d. between 2 nitrogen means (N) =		39.74	18.44	
S.e.d. between 2 S X C means =		56.21	26.07	
S.e.d. between 2 S X N =		56.21	26.07	
S.e.d. between 2 C X N =		56.21	26.07	
S.e.d. between 2 S X C X N =		79.49	36.87	

leaf dry matter yield was consistently produced in pure grass swards compared with where grass was in mixture with legume in all the periods. The leaf blade dry matter seemed to increase with advancing season.

Cutting frequency influenced stem dry matter yield only during the first harvest period of 2006 with higher ($P < 0.05$) stem yield obtained from the 8-weeks interval of cuts compared with the 4-weeks interval of cuts (Table 8). Sward type treatment did not affect stem yield in any of the periods. Fertilizer N application showed no significant effect on stem dry matter during the first period of the year. However, fertilizer treatment produced stem yield that was low ($P < 0.05$) compared with the zero application at the second period. Stem dry matter yield was depressed at the late season compared to the early season.

The stem dry matter yield in 2007 followed similar trends as for the leaf blade dry matter with respect to cutting interval (Table 9). Fertilizer-N application did not influence the stem dry matter yield in any of the periods. Type of sward treatment did not affect stem yield at the second and third periods. However, guinea grass swards produced greater ($P < 0.05$) stem dry matter than where guinea grass was in mixture with verano stylo at the first period of the year. Stem dry matter appeared to increase with advancement in season.

Fertilizer application and increase in interval between harvests up to the 8-weeks brought about increase in inflorescence dry matter yield only at the first period of the year 2006 (Table 10). Sward type did not influence inflorescence dry matter in any of the periods. However, inflorescence dry matter yield was high ($P < 0.05$) during the first period under pure grass sward when cutting interval at 8 weeks was combined with fertilizer application. Inflorescence yield was decreased at the late season compared with the early season.

Table 3. Effect of Sward type, cutting frequency and fertilizer N application on mean tiller count of grass plant (per m^2) at various periods of the year 2007.

Sward type	Cutting frequency (week)		
Fertilizer N (kg ha^{-1})	4	8	Mean
May 29 to July 24 (1st 8 week period)			
0	234.4	289.6	262.0
Guinea grass 300	336.0	496.0	416.0
mean	285.2	392.8	339.0
0	320.5	251.2	285.9
Guinea grass in mixture 300	237.5	293.3	265.4
mean	279.0	272.3	275.6
Cutting frequency mean	282.1	332.5	307.3
Fertilizer mean 0 kg Nha^{-1} = 273.9		300 kg Nha^{-1} =340.7	
July 24 to September 18 (2nd 8 week period)			
0	489.6	521.1	505.3
Guinea grass 300	576.8	683.2	630.0
mean	533.2	602.1	567.7
0	350.1	509.9	430.0
Guinea grass in mixture 300	378.7	502.9	440.8
mean	364.4	506.4	435.4
Cutting frequency mean	448.8	554.3	501.5
Fertilizer mean 0 kg Nha^{-1} = 467.7		300 kg Nha^{-1} =535.4	
September 18 to November 13 (3rd 8 week period)			
0	387.8	407.5	397.6
Guinea grass 300	497.9	396.3	447.1
mean	442.8	401.9	422.4
0	350.7	396.8	373.7
Guinea grass in mixture 300	460.5	345.1	402.8
mean	405.6	370.9	388.3
Cutting frequency mean	424.2	386.4	405.3
Fertilizer mean 0 kg Nha^{-1} = 385.7		300 kg Nha^{-1} =424.9	
	1st period	**2nd period**	**3rd period**
S.e.d. between 2 sward type means (S) =	39.03	61.61	31.59
S.e.d. between 2 cutting frequency means (C) =	39.03	61.61	31.59
S.e.d. between 2 nitrogen means (N) =	39.03	61.61	31.59
S.e.d. between 2 S X C means =	55.19	87.13	44.67
S.e.d. between 2 S X N =	55.19	87.13	44.67
S.e.d. between 2 C X N =	55.19	87.13	44.67
S.e.d. between 2 S X C X N =	78.05	123.22	63.18

Cutting interval, fertilizer-N application, type of sward treatments and their interactions did not influence the inflorescence dry matter yield in all the periods of harvest in 2007 (Table 11). The inflorescence dry matter yield seemed to increase with season.

Leafiness in terms of leaf blade yield as percentage of the total herbage dry matter was significantly ($P < 0.05$) highest with 4-, followed by 8-weekly interval of cuts and decreased with the infrequent cutting interval of 12 weeks in 2006 (Table 12). On the average, leafiness decreased ($P < 0.05$) with application of fertilizer. Sward type did not affect the percentage of grass leaf blade dry matter in

Table 4. Effect of Sward type, cutting frequency and fertilizer N application on dry matter yield of guinea grass leaf, stem and inflorescence (kg ha^{-1}) in 2006.

Sward type	Cutting frequency (week)				
	Fertilizer-N (Kg h^{1})	4	8	12	Mean
Leaf					
Guinea grass	0	1792.1	1632.1	1353.6	1592.6
	300	1529.4	1471.1	1608.5	1536.4
	Mean	1660.8	1551.6	1481.0	1564.5
Guinea grass in mixture	0	1242.4	1631.5	1685.5	1519.8
	300	1647.1	1420.7	1098.5	1388.8
	Mean	1444.7	1526.1	1392.0	1454.3
Cutting frequency mean		1552.8	1538.9	1436.5	1509.4
Fertilizer mean	0 kg Nha^{-1} = 1556.2		300 kg Nha^{-1} = 1462.6		
Stem					
Guinea grass	0	863.4	1119.0	1319.1	1100.5
	300	905.7	1663.2	1857.9	1475.6
	Mean	884.5	1391.1	1588.5	1288.0
Guinea grass in mixture	0	772.6	1784.7	2161.5	1572.9
	300	1002.6	1467.2	1859.4	1443.1
	Mean	887.6	1626.0	2010.5	1508.0
Cutting frequency mean		886.1	1508.5	1799.5	1398.0
Fertilizer mean	0 kg Nha^{-1} = 1336.7		300 kg Nha^{-1} = 1459.3		
Inflorescence					
Guinea grass	0	377.2	338.8	239.6	318.6
	300	429.8	636.1	364.2	476.7
	Mean	403.5	487.5	301.9	397.6
Guinea grass in mixture	0	243.3	592.7	361.3	399.1
	300	451.8	556.5	337.4	448.6
	Mean	347.6	574.6	349.4	423.8
Cutting frequency mean		375.5	531.0	325.6	410.7
Fertilizer mean	0 kg Nha^{-1} = 358.8		300 kg Nha^{-1} = 462.6		

	Leaf	Stem	Inflorescence
S.e.d. between 2 sward type means (S) =	172.83	182.84	34.71
S.e.d. between 2 cutting frequency means (C) =	211.67	223.93	42.51
S.e.d. between 2 nitrogen means (N) =	172.83	182.84	34.71
S.e.d. between 2 S X C means =	299.34	316.69	60.12
S.e.d. between 2 S X N =	244.41	28.58	49.09
S.e.d. between 2 C X N =	299.34	316.69	60.12
S.e.d. between 2 S X C X N =	423.33	447.87	85.02

2006. The percentage of stem fraction increased significantly with increase in intervals between cut. Nitrogen fertilizer application did not significantly influence the stem fraction. Sward type × cutting interval × fertilizer application effects on percentages of leaf and stem were not statistically significant. The inflorescence as a percentage of the total herbage dry matter was on average low although, it was significantly highest with 8-weekly interval of cuts compared with others. It was also significantly increased with fertilizer application, but was not affected by the type of sward. The cutting interval of 8-weeks with fertilizer-N application yielded significantly the highest percentage of inflorescence fraction when grass was grown alone.

Table 5. Effect of Sward type, cutting frequency and fertilizer N application on dry matter yield of guinea grass leaf, stem and inflorescence (kg ha^{-1}) in 2007.

Sward type	Fertilizer-N (kg ha^{-1})	Cutting frequency (week) 4	8	12	Mean
Leaf fraction					
Guinea grass	0	1733.6	2407.6	1413.3	1851.5
	300	1648.2	3003.5	1957.1	2202.9
	Mean	1690.9	2705.5	1685.2	2027.2
Guinea grass in mixture	0	721.5	964.8	1375.7	1020.7
	300	1060.5	2296.3	2558.0	1971.6
	Mean	891.0	1630.5	1966.8	1496.1
Cutting frequency mean		1290.9	2168.0	1826.0	1761.7
Fertilizer mean	0 kg Nha^{-1} = 1436.1		300 kg Nha^{-1} = 2087.3		
Stem fraction					
Guinea grass	0	378.4	1001.4	419.5	599.8
	300	330.4	566.7	437.6	444.9
	Mean	354.4	784.1	428.6	522.4
Guinea grass in mixture	0	135.0	137.3	463.9	245.4
	300	297.8	534.6	942.1	591.5
	Mean	216.4	336.0	703.0	418.4
Cutting frequency mean		285.4	560.0	565.8	470.4
Fertilizer mean	0 kg Nha^{-1} = 422.6		300 kg Nha^{-1} = 518.2		
Inflorescence fraction					
Guinea grass	0	119.2	251.9	60.3	143.8
	300	101.7	60.2	136.5	99.5
	Mean	110.4	156.1	98.4	121.6
Guinea grass in mixture	0	29.3	24.0	83.2	45.5
	300	128.7	138.8	62.0	109.8
	Mean	79.0	81.4	72.6	77.7
Cutting frequency mean		94.7	118.7	85.5	99.7
Fertilizer mean	0 kg Nha^{-1} = 94.7		300 kg Nha^{-1} = 104.7		

	Leaf	Stem	Inflorescence
S.e.d. between 2 sward type means (S) =	186.84	67.18	24.89
S.e.d. between 2 cutting frequency means (C) =	228.83	82.28	30.49
S.e.d. between 2 nitrogen means (N) =	186.84	67.18	24.89
S.e.d. between 2 S X C means =	323.62	116.36	43.11
S.e.d. between 2 S X N =	264.23	95.01	35.20
S.e.d. between 2 C X N =	323.62	116.36	43.11
S.e.d. between 2 S X C X N =	457.66	164.56	60.97

There were no significant effects of fertilizer and sward type treatments on the proportions of leaf, stem and inflorescence in 2007 (Table 13). The proportions of leaf and inflorescence were not affected by cutting frequency treatment. Infrequent cutting interval of 12-weeks significantly increased the percentage of stem fraction compared with the more frequent cutting interval of 4 weeks. The 12- and 8-weekly interval of cuts had similar effects on the proportion of stem fraction. The percentage of the inflorescence fraction was highest (P <

Table 6. Effect of sward type, cutting frequency and fertilizer N application on leaf dry matter yield of guinea grass (kg ha^{-1}) at various periods of the year 2006.

Sward type	Cutting frequency (week)			
	Fertilizer N (kg ha^{-1})	4	8	Mean
		August 12 to October 7 (1st 8 week period)		
Guinea grass	0	1383.6	1477.2	1430.4
	300	1257.3	1362.3	1309.8
	mean	1320.4	1419.7	1370.1
Guinea grass in mixture	0	952.5	1493.3	1222.9
	300	1350.8	1358.2	1354.5
	mean	1151.6	1425.7	1288.7
Cutting frequency mean		1236.0	1422.7	1329.4
Fertilizer mean	0 kg Nha^{-1} = 1326.7		300 kg Nha^{-1} = 1332.1	
		October 7 to December 2 (2nd 8 week period)		
Guinea grass	0	408.5	154.9	281.7
	300	272.2	108.9	190.5
	mean	340.4	131.9	236.1
Guinea grass in mixture	0	289.9	138.2	214.1
	300	296.3	62.6	179.4
	mean	293.1	100.4	196.4
Cutting frequency mean		316.7	116.1	216.4
Fertilizer mean	0 kg Nha^{-1} = 247.9		300 kg Nha^{1} = 185.0	

	1st period	2nd period
S.e.d. between 2 sward type means (S) =	93.19	55.79
S.e.d. between 2 cutting frequency means (C) =	93.19	55.79
S.e.d. between 2 nitrogen means (N) =	93.19	55.79
S.e.d. between 2 S X C means =	131.79	78.90
S.e.d. between 2 S X N =	131.79	78.90
S.e.d. between 2 C X N =	131.79	78.90
S.e.d. between 2 S X C X N =	186.39	111.59

0.05) in grass-legume mixed swards when the cutting interval of 4 weeks was combined with fertilizer application.

DISCUSSION

The observed decrease in the leaf proportion and increase in the stem and inflorescence proportions of the grass species with longer interval of cutting have earlier been reported in *P. maximum* (Omaliko, 1980; Asiegbu and Onyeonagu, 2008). Omaliko (1980) working with *P. maximum* in Nsukka, Nigeria, reported that the proportion of leaf in the dry matter dropped from 67% at 3-week intervals to 37% at 10-week intervals, while the proportion of stem increased from 25% at 3-week intervals to 47% at 10-week intervals. In the present study, the proportion of leaf in the dry matter dropped from 55% at 4-week intervals to 40% at the 12-week intervals, while that of stem increased from 32% at 4-week intervals to 42% at 12-week intervals in 2006. The proportion of inflorescence was also increased from 13% at 4-week intervals to 15% at 8-week intervals and later dropped. Asiegbu and Onyeonagu (2008) working in a degraded *P. maximum* pasture showed that the proportion of leaf was highest at 3 weeks of regrowth and subsequently declined very considerably at 12-week intervals. They also reported that increase in nitrogen application resulted in decrease in leaf proportion and increase in the percentage of the stem fraction. Wilman et al. (1976) working with perennial ryegrass (*Lolium perenne*) in a perennial ryegrass-white clover swards showed that the proportion of green leaf was highest after 2 to 3 weeks of regrowth and subsequently declined very

Table 7. Effect of sward type, cutting frequency and fertilizer N application on leaf dry matter yield of guinea grass (kg ha^{-1}) at various periods of the year 2007.

Sward type	Fertilizer N (kg ha^{-1})	Cutting frequency (week) 4	8	Mean
		May 29 to July 24 (1st 8 week period)		
Guinea grass	0	526.5	809.8	668.2
	300	324.6	1312.3	818.5
	Mean	425.6	1061.0	743.3
Guinea grass in mixture	0	227.1	313.0	270.1
	300	149.9	838.0	494.0
	Mean	188.5	575.5	382.0
Cutting frequency mean		307.0	818.3	562.7
Fertilizer mean	0 kg Nha^{-1} = 469.1		300 kg Nha^{-1} = 656.2	
		July 24 to September 18 (2nd 8 week period)		
Guinea grass	0	510.6	752.3	631.4
	300	536.7	856.4	696.6
	Mean	523.7	804.4	664.0
Guinea grass in mixture	0	232.6	287.8	260.2
	300	458.5	923.7	691.1
	Mean	345.5	605.8	475.6
Cutting frequency mean		434.6	705.1	569.8
Fertilizer mean	0 kg Nha^{-1} = 445.8		300 kg Nha^{-1} = 693.8	
		September 18 to November 13 (3rd 8 week period)		
Guinea grass	0	696.5	845.5	771.0
	300	786.8	834.8	810.8
	Mean	741.7	840.1	790.9
Guinea grass in mixture	0	261.8	364.0	312.9
	300	452.1	534.5	493.3
	Mean	357.0	449.3	403.1
Cutting frequency mean		549.3	644.7	597.0
Fertilizer mean	0 kg Nha^{-1} = 542.0		300 kg Nha^{-1} = 652.1	

	1st period	2nd period	3rd period
S.e.d. between 2 sward type means (S) =	139.87	65.75	110.60
S.e.d. between 2 cutting frequency means (C) =	139.87	65.75	110.60
S.e.d. between 2 nitrogen means (N) =	139.87	65.75	110.60
S.e.d. between 2 S X C means =	197.80	92.98	156.41
S.e.d. between 2 S X N =	197.80	92.98	156.41
S.e.d. between 2 C X N =	197.80	92.98	156.41
S.e.d. between 2 S X C X N =	279.73	131.50	221.20

considerably. The proportion of stem was lowest after 2 to 3 weeks, increased quickly from 3 to 6 weeks and more slowly to 9 weeks. They also reported that the crop responded to applied N by lengthening the stem to better display the leaves to receive light, resulting in an increase in the proportion of stem by weight and a reduction in the proportion of leaf. The present findings are in agreement with these conclusions.

The significant increase in grass tiller number per square meter of ground observed with frequent cutting interval and with incremental application of fertilizer N was also reported by Wilman and Asiegbu (1982), Harris

Table 8. Effect of sard type, cutting frequency and fertilizer N application on stem dry matter yield of guinea grass (kg ha^{-1}) at various periods of the year 2006.

Sward type	Cutting frequency (week)			
	Fertilizer N (kg ha^{-1})	4	8	Mean
		August 12 to October 7 (1st 8 week period)		
	0	779.1	1044.2	911.7
Guinea grass	300	840.1	1626.9	1233.5
	Mean	809.6	1335.6	1072.6
	0	658.9	1697.2	1178.1
Guinea grass in mixture	300	928.9	1430.2	1179.5
	Mean	793.9	1563.7	1178.8
Cutting frequency mean		801.8	1449.7	1125.7
Fertilizer mean	0 kg Nha^{-1} = 1044.9		300 kg Nha^{-1} = 1206.5	
		October 7 to December 2 (2nd 8 week period)		
Guinea grass	0	84.2	74.8	79.5
	300	65.6	36.3	51.0
	Mean	74.9	55.6	65.2
	0	113.6	87.5	100.6
Guinea grass in mixture	300	73.8	37.0	55.4
	Mean	93.7	62.2	78.0
Cutting frequency mean		84.3	58.9	71.6
Fertilizer mean	0 kg Nha^{-1} = 90.0		300 kg Nha^{1} = 53.2	

	1st period	2nd period
S.e.d. between 2 sward type means (S) =	114.63	15.87
S.e.d. between 2 cutting frequency means (C) =	114.63	15.87
S.e.d. between 2 nitrogen means (N) =	114.63	15.87
S.e.d. between 2 S X C means =	162.11	22.45
S.e.d. between 2 S X N =	162.11	22.45
S.e.d. between 2 C X N =	162.11	22.45
S.e.d. between 2 S X C X N =	229.25	31.74

et al. (1996) and Asiegbu and Onyeonagu (2005). Wilman and Pearse (1984), working on perennial ryegrass (*L. perenne*), utilized nitrogen rates of 0, 66 and 132 kg ha^{-1} and observed number of tillers of 844, 988 and 1076 for an area of 0.1 m^2, respectively. Harris et al. (1996) reported an increase in tiller density of 4072, 6295, 6673 tillers m^{-2} and numbers of tillers per plant of 3.37, 4.10, and 4.26 when nitrogen was applied at 0, 200, and 400 kg ha^{-1}, respectively.

The significant reductions in grass tiller number occasionally observed in grass-legume mixed swards in the present work had earlier been shown as a morphogenetic change, which could be mechanism for plants to adapt to changes in light availability (Ballare et al., 1995). Changes in sward structure as a result of fragmentation and loss of plant stands or species had been shown to alter light environment and further influenced competitive interactions among plants (Ballare et al., 1995). The increase due to applied N in the density of grass tillers was expected (Premazzi et al. 2003; Onyeonagu and Asiegbu, 2005a).

The general reduction in tiller number and dry matter yields of crop fractions obtained during the dry season had been reported for tropical pastures (Onyeonagu and Asiegbu, 2005b). Yield increases obtained in the present study followed the rainfall patterns in 2006 and 2007 seasons (Onyeonagu and Asiegbu, 2010). Whether for 4 or 8-weeks interval of cuts, the October-December or

Table 9. Effect of sward type, cutting frequency and fertilizer N application on stem dry matter yield of guinea grass (kg ha^{-1}) at various periods of the year 2007.

Sward type	Cutting frequency (week)			
	Fertilizer N (kg ha^{-1})	4	8	Mean
		May 29 to July 24 (1st 8 week period)		
	0	52.0 (6.79)	264.2 (15.97)	158.1 (11.38)
Guinea grass	300	52.4 (7.21)	186.9 (13.50)	119.6 (10.35)
	Mean	52.2 (7.00)	225.5 (14.74)	138.9 (10.87)
	0	33.9 (5.61)	72.4 (7.15)	53.2 (6.38)
Guinea grass in mixture	300	21.9 (4.49)	152.5 (11.10)	87.2 (7.79)
	Mean	27.9 (5.05)	112.5 (9.12)	70.2 (7.09)
Cutting frequency mean		40.0 (6.02)	169.0 (11.93)	104.5 (8.98)
Fertilizer mean	0 kg Nha^{-1} =105.6 (8.88)		300 kg Nha^{-1} =103.4 (9.07)	
		July 24 to September 18 (2nd 8 week period)		
	0	58.8	395.5	227.2
Guinea grass	300	102.7	317.1	209.9
	Mean	80.7	356.3	218.5
	0	50.8	31.9	41.3
Guinea grass in mixture	300	117.8	350.6	234.2
	Mean	84.3	191.3	137.8
Cutting frequency mean		82.5	273.8	178.1
Fertilizer mean	0 kg Nha^{-1} = 134.2		300 kg Nha^{-1} = 222.0	
		September 18 to November 13 (3rd 8 week period)		
	0	267.6 (14.9)	341.6 (13.0)	304.6 (13.9)
Guinea grass	300	175.4 (11.5)	62.8 (6.2)	119.1 (8.9)
	Mean	221.5 (13.2)	202.2 (9.6)	211.9 (11.4)
	0	50.3 (6.6)	33.0 (5.8)	41.6 (6.2)
Guinea grass in mixture	300	158.1 (11.9)	31.5 (4.4)	94.8 (8.2)
	Mean	104.2 (9.2)	32.2 (5.1)	68.2 (7.2)
Cutting frequency mean		162.8 (11.2)	117.2 (7.3)	140.0 (9.3)
Fertilizer mean	0 kg Nha^{-1} =173.1 (10.0)		300 kg Nha^{-1} =106.9 (8.5)	
		1st period	**2nd period**	**3rd period**
S.e.d. between 2 sward type means (S) =		1.471	77.25	3.38
S.e.d. between 2 cutting frequency means (C) =		1.471	77.25	3.38
S.e.d. between 2 nitrogen means (N) =		1.471	77.25	3.38
S.e.d. between 2 S X C means =		2.080	109.24	4.78
S.e.d. between 2 S X N =		2.080	109.24	4.78
S.e.d. between 2 C X N =		2.080	109.24	4.78
S.e.d. between 2 S X C X N =		2.942	154.49	6.76

Comparison is based on transformed means in parenthesis because of zero values in some instances.

September-November periods generally had the least dry matter yield compared with the May-October periods. This could be partly attributed to reduced moisture and nutrient availability and uptake at the dry periods of year

Table 10. Effect of Sward type, cutting frequency and fertilizer N application on inflorescence dry matter yield of guinea grass (kg ha^{-1}) at various periods of the year 2006.

Sward type	Fertilizer N (kg ha^{-1})	Cutting frequency (week) 4	8	Mean
		August 12 to October 7 (1st 8 week period)		
Guinea grass	0	341.4	312.1	326.7
	300	397.7	603.1	500.4
	Mean	369.5	457.6	413.6
Guinea grass in mixture	0	211.9	568.5	390.2
	300	415.3	542.9	479.1
	Mean	313.6	555.7	434.6
Cutting frequency mean		341.6	506.6	424.1
Fertilizer mean	0 kg Nha^{-1}= 358.5		300 kg Nha^{-1}= 489.8	
		October 7 to December 2 (2nd 8 wees period)		
Guinea grass	0	35.9	26.7	31.3
	300	32.1	33.0	32.6
	Mean	34.0	29.8	31.9
Guinea grass in mixture	0	31.4	24.2	27.8
	300	36.5	18.7	27.6
	Mean	34.0	21.5	27.7
Cutting frequency mean		34.0	25.7	29.8
Fertilizer mean	0 kg Nha^{-1} = 29.5		300 kg Nha^{1} = 30.1	

	1st period	2nd period
S.e.d. between 2 sward type means (S) =	41.41	8.68
S.e.d. between 2 cutting frequency means (C) =	41.41	8.68
S.e.d. between 2 nitrogen means (N) =	41.41	8.68
S.e.d. between 2 S X C means =	58.56	12.28
S.e.d. between 2 S X N =	58.56	12.28
S.e.d. between 2 C X N =	58.56	12.28
S.e.d. between 2 S X C X N =	82.81	17.36

Table 11. Effect of Sward type, cutting frequency and fertilizer N application on inflorescence dry matter yield of guinea grass (kg ha^{-1}) at various periods of the year 2007.

Sward type	Fertilizer N (kg ha^{-1})	Cutting frequency (week) 4	8	Mean
		May 29 to July 24 (1st 8 week period)		
Guinea grass	0	0.8 (1.04)	20.0 (3.55)	10.4 (2.29)
	300	0.0 (0.71)	0.0 (0.71)	0.0 (0.71)
	Mean	0.4 (0.87)	10.0 (2.13)	5.2 (1.50)
Guinea grass in mixture	0	0.0 (0.71)	4.5 (1.99)	2.3 (1.35)
	300	0.0 (0.71)	2.5 (1.41)	1.2 (1.06)
	Mean	0.0 (0.71)	3.5 (1.70)	1.8 (1.20)
Cutting frequency mean		0.2 (0.79)	6.8 (1.91)	3.5 (1.35)
Fertilizer mean	0 kg Nha^{-1} = 6.3 (1.82)		300 kg Nha^{-1} = 0.6 (0.88)	

Table 11. Continue

		July 24 to September 18 (2nd 8 week period)		
Guinea grass	0	15.9 (3.86)	115.8 (9.32)	65.9 (6.59)
	300	35.4 (5.19)	49.0 (6.99)	42.2 (6.09)
	Mean	25.7 (4.53)	82.4 (8.16)	54.1 (6.34)
Guinea grass in mixture	0	7.9 (2.55)	17.3 (4.19)	12.6 (3.37)
	300	60.9 (7.14)	115.4 (9.03)	88.2 (8.09)
	Mean	34.4 (4.85)	66.4 (6.61)	50.4 (5.73)
Cutting frequency mean		30.0 (4.69)	74.4 (7.38)	52.2 (6.04)
Fertilizer mean	0 kg Nha^{-1} = 39.2 (4.98)		300 kg Nha^{-1} =65.2 (7.09)	
		September 18 to November 13 (3rd 8 week period)		
Guinea grass	0	102.4 (8.98)	116.0 (9.70)	109.2 (9.34)
	300	66.3 (7.36)	29.6 (5.58)	47.9 (6.47)
	Mean	84.3 (8.17)	72.8 (7.64)	78.6 (7.91)
Guinea grass in mixture	0	21.4 (4.02)	2.2 (1.54)	11.8 (2.78)
	300	67.8 (7.68)	20.9 (4.33)	44.3 (6.01)
	Mean	44.6 (5.85)	11.6 (2.94)	28.1 (4.40)
Cutting frequency mean		64.5 (7.01)	42.2 (5.29)	53.3 (6.15)
Fertilizer mean	0 kg Nha^{-1} = 60.5 (6.06)		300 kg Nha^{-1} = 46.1 (6.24)	46.1 (6.24)
		1st period	**2nd period**	**3rd period**
S.e.d. between 2 sward type means (S) =		0.571	1.486	1.752
S.e.d. between 2 Cutting frequency means (C) =		0.571	1.486	1.752
S.e.d. between 2 nitrogen means (N) =		0.571	1.486	1.752
S.e.d. between 2 S X C means =		0.807	2.101	2.478
S.e.d. between 2 S X N =		0.807	2.101	2.478
S.e.d. between 2 C X N =		0.807	2.101	2.478
S.e.d. between 2 S X C X N =		1.141	2.972	3.504

Comparison is based on transformed means in parenthesis because of zero values in some instances.

Table 12. Effect of Sward type, cutting frequency and fertilizer N application on the leaf blade, stem and inflorescence fractions as percentage of the total guinea grass herbage dry matter in 2006.

Sward type	**Cutting frequency (week)**				
	Fertilizer-N (kg ha^{-1})	**4**	**8**	**12**	**Mean**
		Leaf fraction			
Guinea grass	0	59.65	52.51	46.82	52.99
	300	53.13	38.77	40.63	44.17
	Mean	56.39	45.64	43.72	48.58
Guinea grass in mixture	0	55.23	41.61	39.55	45.46
	300	53.03	41.31	33.96	42.77
	Mean	54.13	41.46	36.76	44.11
Cutting frequency mean		55.26	43.55	40.24	46.35
Fertilizer mean	0kg Nha^{-1} = 49.23		300 kg Nha^{-1} = 43.47		

Table 12. Continue

			Stem fraction		
	0	28.16	36.41	44.77	36.44
Guinea grass	300	31.93	44.55	49.70	42.06
	Mean	30.04	40.48	47.23	39.25
	0	33.97	43.87	51.60	43.15
Guinea grass in mixture	300	32.27	42.59	55.04	43.30
	Mean	33.12	43.23	53.32	43.22
Cutting frequency mean		31.58	41.85	50.28	41.24
Fertilizer mean	0kg Nha^{-1} = 39.80		300 kg Nha^{-1} = 42.68		
			Inflorescence fraction		
	0	12.19	11.08	8.42	10.56
Guinea grass	300	14.94	16.68	9.67	13.76
	Mean	13.57	13.88	9.04	12.16
	0	10.80	14.52	8.85	11.39
Guinea grass in mixture	300	14.70	16.10	11.00	13.93
	Mean	12.75	15.31	9.92	12.66
Cutting frequency mean		13.16	14.60	9.48	12.41
Fertilizer mean	0kg Nha^{-1}= 10.89		300 kg Nha^{-1} = 13.85		
			Total grass yield ($kgha^{-1}$)		
	0	3032.7	3089.9	2912.3	3011.7
Guinea grass	300	2865.0	3770.5	3830.5	3488.7
	Mean	2948.8	3430.2	3371.4	3250.2
	0	2258.3	4008.9	4208.4	3491.9
Guinea grass in mixture	300	3101.5	3444.5	3295.3	3280.4
	Mean	2679.9	3726.7	3751.8	3386.1
Cutting frequency mean		2814.4	3578.5	3561.6	3318.2
Fertilizer mean	0kg Nha^{-1} =3251.8		300 kg Nha^{-1} = 3384.5		
		Leaf	**Stem**	**Inflorescence**	**Whole grass**
S.e.d. between 2 sward type means (S) =		2.303	2.214	0.415	342.15
S.e.d. between 2 cutting frequency means (C) =		2.821	2.711	0.508	419.05
S.e.d. between 2 nitrogen means (N) =		2.303	2.214	0.415	342.15
S.e.d. between 2 S X C means =		3.989	3.835	0.719	592.63
S.e.d. between 2 S X N =		3.257	3.131	0.587	483.88
S.e.d. between 2 C X N =		3.989	3.835	0.719	592.63
S.e.d. between 2 S X C X N =		5.642	5.423	1.017	838.10

(Onyeonagu and Asiegbu, 2010).

Conclusion

Tiller production per square meter and proportion of leaf in the total herbage were significantly increased with the frequent cutting interval at 4 weeks compared with the 8- or 12- weekly intervals. The proportion of leaf in the total herbage was significantly reduced with fertilizer-N application, while tiller density per m^{-2} was increased with nitrogen application. Stem and inflorescence fractions were generally increased with increase in interval between cuts and with incremental application of fertilizer-N.

Table 13. Effect of Sward type, cutting frequency and fertilizer N application on the leaf blade, stem and inflorescence fractions as percentage of the total guinea grass herbage dry matter in 2007.

Sward type	Cutting frequency (week)				
	Fertilizer-N (kg ha^{-1})	4	8	12	Mean
			Leaf fraction		
	0	78.22	66.07	74.58	72.95
Guinea grass	300	81.38	81.94	77.26	80.19
	Mean	79.80	74.00	75.92	76.57
	0	82.01	84.20	70.00	78.74
Guinea grass in mixture	300	73.41	77.86	70.23	73.84
	Mean	77.71	81.03	70.12	76.29
Cutting frequency mean		78.76	77.52	73.02	76.43
Fertilizer mean	0 kg Nha^{-1} = 75.85		300 kg Nha^{-1} = 77.02		
			Stem fraction		
	0	16.66	27.08	22.23	21.99
Guinea grass	300	14.37	16.27	17.26	15.97
	Mean	15.52	21.67	19.75	18.98
	0	15.17	13.10	25.50	17.92
Guinea grass in mixture	300	18.92	17.52	27.70	21.38
	Mean	17.05	15.31	26.60	19.65
Cutting frequency mean		16.28	18.49	23.17	19.31
Fertilizer mean	0 kg Nha^{-1} = 19.96		300 kg Nha^{-1} = 18.67		
			Inflorescence fraction		
	0	5.12	6.85	3.20	5.06
Guinea grass	300	4.25	1.80	5.47	3.84
	Mean	4.68	4.32	4.33	4.45
	0	2.82	2.70	4.50	3.34
Guinea grass in mixture	300	7.67	4.62	2.07	4.78
	Mean	5.24	3.66	3.28	4.06
Cutting frequency mean		4.96	3.99	3.81	4.25
Fertilizer mean	0 kg Nha^{-1} = 4.20		300 kg Nha^{-1} = 4.31		
			Total grass yield (kg ha^{-1})		
	0	2231.1	3660.8	1893.1	2595.0
Guinea grass	300	2080.3	3630.4	2531.2	2747.3
	Mean	2155.7	3645.6	2212.2	2671.2
	0	885.8	1126.2	1922.8	1311.6
Guinea grass in mixture	300	1486.9	2969.7	3562.2	2672.9
	Mean	1186.4	2047.9	2742.5	1992.3
Cutting frequency mean		1671.0	2846.8	2477.3	2331.7
Fertilizer Mean	0 kg Nha^{-1} = 1953.3		300 kg Nha^{-1} = 2710.1		

	Leaf	Stem	Inflorescence	Whole grass
S.e.d. between 2 sward type means (S) =	2.848	2.286	0.835	220.64
S.e.d. between 2 cutting frequency means (C) =	3.488	2.800	1.023	270.23
S.e.d. between 2 nitrogen means (N) =	2.848	2.286	0.835	220.64
S.e.d. between 2 S X C means =	4.932	3.960	1.447	382.16
S.e.d. between 2 S X N =	4.027	3.233	1.182	312.03
S.e.d. between 2 C X N =	4.932	3.966	1.447	382.16
S.e.d. between 2 S X C X N =	6.975	5.600	2.047	540.46

Grass tiller number per m^{-2} was higher in pure grass swards than in grass-legume mixed swards. Type of sward treatment did not influence the proportions of crop fractions in both years. Whether for 4- or 8-weeks interval of cut, the tiller number per m^{-2} and dry matter yields of crop fractions were generally lower at late seasons than at the early season.

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