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Full Length Research Paper

Influence of cutting frequency and fertilizer-N application on tiller production and herbage yield distribution over time in a guinea grass (*Panicum maximum)* sown pasture

Onyeonagu, C. C* and Asiegbu, J. E.

Department of Crop Science, University of Nigeria, Nsukka, Nigeria.

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An experiment was carried out to evaluate the effects of cutting frequency and nitrogen rates on guinea grass (*Panicum maximum*) tiller production and herbage yield distribution over time. Plants were grown in the Department of Crop Science Research and Teaching Farm, University of Nigeria, Nsukka. A 4 × 4 factorial experiment replicated three times was set in a randomized complete block design. Treatments comprised four levels of nitrogen fertilizer at 0, 150, 300 and 450 kg ha^{-1} and four harvesting frequencies of three-, six-, nine- and 12-weekly intervals. Tiller number per square meter of ground significantly ($P < 0.05$) decreased with increasing interval of cuts, but significantly ($P < 0.05$) increased with incremental application of fertilizer N in all the years. The three-weeks interval of cuts significantly produced the highest tiller number when combined with the highest N rate of 450 kg N ha^{-1} in 2003 compared with six-, nine- or 12-week intervals of cut. Grass tiller number significantly ($P < 0.05$) increased with frequent cutting of intervals earlier in the 2001 season (June to August) than later (September to November) when compared with the infrequent cutting intervals. In most periods of the years, dry matter yields of grass herbage and crop fractions were significantly increased with increase in interval between cuts and with incremental application of nitrogen. However, grass dry matter yields were significantly reduced with longer intervals, relative to the shorter intervals late in the 2001, 2002 and 2003 seasons.

Key words: Nitrogen fertilizer, crop fractions, interval between cuts, seasons.

INTRODUCTION

In the tropics, supply of herbage for livestock during the dry months of the year declines substantially (Omaliko, 1983; Oloyo and Ilelaboye, 2002). Enough herbage must be produced during the production period through intensive management techniques in order to make possible conservation for the lean season or off-season periods. Intensive management practices include the use of fertilizers, choice of forage species, cutting management, control of bushes and weeds and pasture establishment (Omaliko, 1983; Dev, 2001). The response to cutting of a forage plant depends upon its seasonal yield of carbohydrate storage, its growth habit and extent of inflorescence development (Dev, 2001). Seasonal effects on tiller production, pasture growth and development and on the harvesting intervals have been reported (Omaliko, 1980; Romero et al., 1987; Venuto et al., 1998; Bamikole et al., 2004; Onyeonagu and Asiegbu, 2005).

According to Omaliko (1980), some combinations of longer harvesting intervals early in the season with shorter intervals towards the end of the season increased the annual dry matter yield of a pasture sward in Nsukka, derived savanna zone of Nigeria compared with using either type of the regimes all through the year. Considering the production pattern throughout the growing season, Omaliko observed that harvesting every three weeks instead of once in six weeks gave lower dry matter yield early in the season. However, between August and the end of the growing season in October, the yield from

*Corresponding author. E-mail: onyeonagu@yahoo.com.

six-weekly interval of cuts dropped, while those of three-weekly cuts increased, thereby reducing the difference between the two regimes. Similar results were obtained comparing the four-weekly cuts with eight-weekly cuts. In addition, similar seasonal effects have also been reported by Binnie et al. (1997). They observed that lengthening the re-growth interval by a single six-week interval increased the annual yield of herbage dry matter (DM) and digestible organic matter (DOM) of perennial ryegrass from 10.13 to 11.15 and from 6.73 to 7.47 t/ha, respectively. The effect increased with increasing length of re-growth period and was greatest in the early part of the season.

The responses to initial cutting date and cutting frequency on dry matter yield production have been reported for *Panicum maximum* grown under Nsukka, derived savanna zone conditions of Nigeria (Omaliko, 1980). However, information is scanty on the effects of cutting frequency and nitrogen fertilizer application on tiller production, herbage dry matter yield and yields of crop fractions of *P. maximum* sown and maintained pastures at different seasons of the year in Nigeria. The objective of this work was to evaluate the effect of cutting frequency and nitrogen fertilizer application on tiller production and herbage yield distribution over time in a guinea grass (*P. maximum*) pasture established and maintained in Nsukka.

MATERIALS AND METHODS

The experiment was carried out in the Department of Crop Science Research and Teaching Farm, University of Nigeria, Nsukka, 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 4 × 4 factorial experiment, laid out in a randomized complete block design with three replications. Treatments comprised four levels of nitrogen fertilizer at 0, 150, 300 and 450 kg ha^{-1} and four harvesting frequencies of three-, six-, nine- and 12-weekly intervals, resulting in sixteen treatment combinations per block. An area of land 21.2 × 11.2 m (226.24 m^2) was marked out into three blocks of 19.2 × 2.4 m each. Each block was further divided into 16 plots of 2.4 × 1.2 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 in August 2000 at 20 × 30 cm spacing. The treatment combinations were allocated completely at random in each of the three blocks. Cutting was done at uniform height of about 15 cm with shears. Total fresh weight of the harvested grass material per plot was recorded and about 500 g fresh weight per plot was separated into leaf, stem and inflorescence fractions. The fractions were subsequently oven-dried and weighed. These were used to calculate the total dry weights of the crop fractions and the total herbage. The harvest intervals of three, six, nine and 12 weeks gave eight, four, two and two samples, respectively, in 2001, 2002, 2003 and 2004 seasons (that is 24 weeks from May to November). 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 soil of the experimental site was a sandy loam and was 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 high in available phosphorus (Onyeonagu, 2010).

Tiller counts were made in each plot using a 25 cm square quadrant. The mean of three throws per plot was used to calculate tiller population m^{-2}. All data collected were statistically analysed using GenStat (1995) statistical package and employing the procedure for a randomized complete block design. Separation of treatment means for significant effects was done using the procedure for the least significant difference (LSD) as outlined by Carmer and Swanson (1971) and Obi (1986). Data from different years were combined for analyses after Bartlett's test for homogeneity of variances. Square root transformation of the form $\sqrt{x + 0.5}$, where x is the observation, was employed whenever there is zero value.

RESULTS

Tiller number per square meter in most instances decreased with increasing interval of cuts in various years (Table 1). On the other hand, tiller number increased significantly with incremental application of fertilizer N in all the four years. The highest tiller number was obtained with three-weekly cuts when 450 kg N ha^{-1} was applied in 2003. Cutting frequency × nitrogen interaction effect on grass tiller number was not significant in 2001, 2002 and 2004. Moreover, tiller number always appeared to increase from the early period of May to July through the subsequent advancing periods in 2001 and 2002 (Table 2). In most of the periods, tiller number was greater at three- than at six-weekly interval of cut and with greater N-rate. Tiller number per square meter also increased significantly with intense than with lax cutting in all the periods for comparable intervals (six or 12 weekly cuts) in all the four years except for 2001 (Table 3). Tiller number was clearly increased by N application compared with where N was not applied in all the years except for the first and last harvest periods in 2001 and 2004, respectively. Tiller number seemed to increase with advancing season in both 2001 and 2002, but tended to decrease at the late season in both 2003 and 2004. On average of four year's data, tiller number was lower with 12-weekly interval compared with three- or six-weekly interval while the values for nine- and 12-weekly intervals did not differ significantly (Table 4). There was progressive significant ($P < 0.05$) increase in tiller population with increasing rates of N-fertilizer application.

In most instances, six-weekly interval of cuts gave higher dry matter yield of grass than the three-weekly interval of cut in 2001 (Table 5). Cutting interval did not influence grass herbage yield in 2002 although yield tended to increase with increase in interval between cut. Also, N treatment significantly ($P < 0.05$) increased yield compared with where N was not applied except in the third and last periods of 2001 and during the last period in 2002 where nitrogen fertilizer treatment did not affect grass yield. Grass yield seemed to pick up early in 2001 (May to June) and decreased with advancing season up

Table 1. Effects of cutting frequency and fertilizer N application on tiller number (per m^2).

Cutting frequency (week)	Nitrogen fertilizer (kg N ha^{-1})				Mean
	0	150	300	450	
Year 2001					
3	1180.3	1347.6	1557.8	1656.9	1435.7
6	1148.5	1393.7	1504.5	1695.6	1435.6
9	893.3	994.7	1155.7	1123.5	1041.8
12	1510.1	1758.9	1912.8	1800.8	1745.7
Mean	1183.1	1373.7	1532.7	1569.2	1414.7
Year 2002					
3	1939.7	2396.7	2668.7	2891.3	2474.1
6	1365.2	1691.2	1820.9	1967.5	1711.2
9	1129.1	1295.2	1455.2	1457.6	1334.3
12	837.3	1073.6	1254.1	1178.9	1086.0
Mean	1317.8	1614.2	1799.7	1873.8	1651.4
Year 2003					
3	1891.0	2219.9	2461.1	2651.1	2305.8
6	1260.0	1421.7	1499.9	1539.6	1430.3
9	1036.6	1122.7	1189.3	1204.3	1138.1
12	600.8	817.6	831.7	925.3	793.9
Mean	1197.0	1395.5	1495.5	1580.1	1417.0
Year 2004					
3	1860.1	1965.8	2048.3	2134.3	2002.1
6	1356.0	1454.3	1540.3	1644.8	1498.8
9	971.5	1078.9	800.0	1158.1	1002.1
12	607.2	681.6	1280.2	800.0	705.3
Mean	1198.7	1295.1	1363.6	1434.3	1302.1
		2001	**2002**	**2003**	**2004**
$LSD_{0.05}$ for 2 cutting frequency means (C)		100.29	125.76	89.48	54.30
$LSD_{0.05}$ for 2 nitrogen means (N)		100.29	125.76	89.48	54.30
$LSD_{0.05}$ for 2 C × N means		–	–	178.95	–

–, Non-significant F-test at 5% probability level.

to about mid September and then increased. In 2002, grass yield appeared to increase with season up to mid September and then decreased. In 2003 and 2004, the 6-weekly interval of cut significantly ($P < 0.05$) gave higher dry matter yield of grass than the three-weekly interval of cut except at the late season in 2003 where the three-weekly interval of cut significantly ($P < 0.05$) produced higher grass yield than the six-weekly interval of cut (Table 6). In 2003, grass dry matter yield was higher in the mid seasons of August to September and September to November compared with the earlier season of June to August, and was always drastically depressed in the final period of November/December.

Furthermore, yield was generally higher during the 12 weeks of May to August compared with the harvest period of August to November in 2001 and 2002 (Table 7). Similar trend in decrease in yield at late season occurred in 2003 but not in 2004. Over the two periods, yield distribution was better with 12-weekly cut than with the 6-weekly cut except at the late seasons of 2001 and 2002 where the 6-weekly cut had better yield distribution than the 12-weekly cut. Harvest made from May to August 2001 in the three- and six-weekly schedules gave no inflorescence fractions but produced progressively more inflorescence in the third and fourth periods of August/September and September/November (Table 8). Leaf yield was similar in the first two periods (May to June and June to August) than with the last two periods (August to September and September to November). The six-weekly schedule significantly ($P < 0.05$) produced

Table 2. Tiller number (per m^2) at various periods of the year for 3- and 6- weekly intervals.

Cutting frequency (week)	Nitrogen fertilizer (kg N ha^{-1})				Mean
	0	150	300	450	
Year 2001					
May 17 to June 28					
3	1184.0	1245.3	2301.3	1736.0	1616.7
6	1264.0	1370.7	1306.7	1370.7	1328.0
Mean	1224.0	1308.0	1804.0	1553.3	1472.3
June 28 to Aug. 9					
3	1184.0	1296.0	1456.0	1464.0	1350.0
6	1141.3	1232.0	1333.3	1344.0	1262.7
Mean	1162.7	1264.0	1394.7	1404.0	1306.3
Aug. 9 to Sept. 20					
3	1151.2	1424.0	1610.9	1716.5	1475.7
6	881.6	1306.7	1278.4	1562.7	1257.3
Mean	1016.4	1365.3	1444.7	1639.6	1366.5
Sept. 20 to Nov. 1					
3	1201.9	1425.1	1756.3	2145.9	1632.3
6	1307.2	1665.6	2099.7	2505.1	1894.4
Mean	1254.5	1545.3	1928.0	2325.5	1763.3
Year 2002					
May 20 to July 1					
3	1797.6	2246.7	2373.3	2755.4	2293.2
6	1130.7	1445.9	1571.7	1724.3	1468.1
Mean	1464.1	1846.3	1972.5	2239.8	1880.7
July 1 to Aug. 12					
3	1894.1	2397.3	2604.5	2817.6	2428.4
6	1319.5	1605.3	1797.3	1929.1	1662.8
Mean	1606.8	2001.3	2200.9	2373.3	2045.6
Aug. 12 to Sept. 23					
3	1969.9	2278.9	2639.2	2763.5	2412.9
6	1475.2	1861.3	1990.9	2038.9	1841.6
Mean	1722.5	2070.1	2315.1	2401.2	2127.2
Sept. 23 to Nov.4					
3	2097.1	2664.0	3057.6	3228.5	2761.8
6	1535.5	1852.3	1923.7	2177.6	1872.3
Mean	1816.3	2258.1	2490.7	2703.1	2317.0

	Year 2001				Year 2002			
	1st period	2nd period	3rd period	4th period	1st period	2nd period	3rd period	4th period
$LSD_{0.05}$ for 2 cutting frequency means (C)	–	–	147.50	184.57	176.20	188.96	99.99	191.23
$LSD_{0.05}$ for 2 nitrogen means (N)	–	179.93	208.50	261.02	249.18	267.23	141.40	270.44
$LSD_{0.05}$ for 2 C × N means	–	–	–	–	–	–	–	–

–, Non-significant F-test at 5% probability level.

Table 3. Tiller number (per m^2) at various periods of the year for 6- and 12- weekly intervals.

Cutting frequency (week)	Nitrogen fertilizer (kg N ha^{-1})				Mean
	0	150	300	450	
Year 2001					
May 17 to Aug. 9					
6	1202.7	1301.3	1320.0	1357.3	1295.3
12	1280.0	1408.0	1653.3	1456.0	1449.3
Mean	1241.3	1354.7	1486.7	1406.7	1372.3
Aug. 9 to Nov. 1					
6	1094.4	1486.1	1689.1	2033.9	1575.9
12	1740.3	2109.9	2172.3	2145.6	2042.0
Mean	1417.3	1798.0	1930.7	2089.7	1808.9
Year 2002					
May 20 to Aug. 12					
6	1225.1	1525.6	1684.5	1826.7	1565.5
12	732.3	974.4	1048.5	1106.1	965.3
Mean	978.7	1250.0	1366.5	1466.4	1265.4
Aug. 12 to Nov. 4					
6	1462.1	1856.8	1957.3	2108.3	1846.1
12	942.4	1172.8	1459.7	1251.7	1206.7
Mean	1202.2	1514.8	1708.5	1680.0	1526.4
Year 2003					
June 30 to Sept. 22					
6	1465.1	1506.7	1600.8	1666.7	1559.8
12	677.3	956.3	952.5	1049.1	908.8
Mean	1071.2	1231.5	1276.7	1357.9	1234.3
Sept. 22 to Dec. 15					
6	1054.9	1336.8	1398.9	1412.5	1300.8
12	524.3	630.9	710.9	801.6	666.9
Mean	789.6	983.9	1054.9	1107.1	983.9
Year 2004					
June 1 to Aug. 24					
6	1422.1	1529.9	1661.3	1699.5	1578.2
12	690.1	732.3	753.6	798.4	743.6
Mean	1056.1	1131.1	1207.5	1248.9	1160.9
Aug. 24 to Nov.16					
6	1289.9	1378.7	1419.2	1590.1	1419.5
12	524.3	630.9	710.9	801.6	666.9
Mean	907.1	1004.8	1065.1	1195.9	1043.2

	Year 2001		Year 2002		Year 2003		Year 2004	
	1st period	2nd period	1st period	2nd period	1st period	2nd period	1st period	2nd period
$LSD_{0.05}$ for 2 cutting frequency means (C)	128.16	179.43	104.81	91.10	81.93	126.96	61.93	145.36
$LSD_{0.05}$ for 2 nitrogen means (N)	–	253.75	148.23	128.84	115.86	179.55	87.58	–
$LSD_{0.05}$ for 2 C × N means	–	–	–	182.21	–	–	–	–

–, Non-significant F-test at 5% probability level.

Table 4. Effects of cutting frequency and fertilizer N application on the tiller number (per m^2), mean of 4 years data (2001, 2002, 2003 and 2004).

Cutting frequency (week)	Nitrogen fertilizer (kg N ha^{-1})				Mean
	0	150	300	450	
3	1717.8	1982.5	2184.0	2333.4	2054.4
6	1282.4	1489.4	1591.4	1711.9	1518.8
9	1007.5	1122.9	1150.1	1235.9	1129.1
12	888.9	1082.9	1182.7	1176.3	1082.7
Mean	1224.2	1419.4	1527.0	1614.4	1446.2
$LSD_{0.05}$ for 2 cutting frequency means (C)	59.93				
$LSD_{0.05}$ for 2 nitrogen means (N)	59.93				
$LSD_{0.05}$ for 2 C × N means	119.87				

higher stem yields in all the harvest periods than the three-weekly cuts. Cutting frequency, however, showed no significant effect on leaf dry matter yield in any of the harvest periods in 2002 (Table 9). The stem and inflorescence dry matter yields were significantly ($P < 0.05$) increased with increase in interval between cuts in all the periods except at the second period, where the inflorescence yield remained similar for the three and six-weekly intervals. The 450 kg N ha^{-1} significantly ($P < 0.05$) produced higher leaf yield than the control in the first three periods but had similar effect with the other N rates. Nitrogen application did not significantly influence the stem and inflorescence yields except at the third harvest period where stem and inflorescence yields were significantly ($P < 0.05$) increased with N application compared with the control treatment.

The six weeks cutting interval significantly ($P < 0.05$) produced higher leaf dry matter yield during the second period in 2003 than the three-weekly cuts (Table 10). Cutting treatment showed no significant effect on leaf yield at the first and third periods. The six weeks interval between cuts significantly ($P < 0.05$) gave lower leaf yield than the three-weekly cuts at the last period. Stem dry matter yield was significantly ($P < 0.05$) increased during the first three harvest periods with increase in interval between cuts. Cutting treatment effect on stem dry matter yield was not significant at the last period. Inflorescence dry matter yield was significantly ($P < 0.05$) increased only during the second period with increase in interval between cuts. Nitrogen application significantly ($P < 0.05$) increased leaf yield compared with the control except in the second period where N effect was not significant. Stem dry matter yield was significantly increased at the first two periods with N application over the control treatment but was not significantly affected by N treatment at the last two periods. Moreover, nitrogen application significantly increased the inflorescence dry matter yield only at the second and third periods compared with the control treatment but had no significant effect at the first and fourth periods.

In 2004, the six-weekly schedule always produced higher leaf blade and stem dry matter than the three-weekly cuts (Table 11). Fertilizer N application always gave higher ($P < 0.05$) leaf blade yield compared with where N was not applied except at the last period. Fertilizer application significantly increased stem yield only at the first and third periods. Leaf blade dry matter was highest at the July to August period followed by the June to July period, October to November and then the August to early October period. Stem dry matter yield seemed to increase with season. There were no records of inflorescence yield at the first and second periods of the year 2004. Inflorescence yield was higher at the August to early October period than the October to November period. Whether for six or 12 weeks intervals of cut, leaf dry matter yield was greatest earlier in the season in both 2001 and 2002 seasons than later (Table 12). Leaf yield was higher with six- weekly cuts than the 12-weekly cuts at the last period in 2001. Stem yield was also greatest earlier in the season (May to August) than later (August to early November) in 2001. The reverse was the case in 2002. There were no records of inflorescence dry matter during the first period of 2001. Inflorescence yield was significantly ($P < 0.05$) higher with six-weekly harvests than the 12-weekly cuts at the last period in 2001. Cutting treatment had no effect on inflorescence yield at the first and second periods in 2002.

Leaf dry matter yield was higher earlier in the season in both 2003 and 2004 seasons than later (Table 13). Yield was more evenly distributed with 12-weekly cut than with the 6-weekly cut in both years. Stem dry matter yield was also greatest earlier in the season (June to September) than later (September to mid December) in 2003. In 2004, stem yield was higher at the August to November period than the June/August period. At all periods, harvest at six- or 12-weekly intervals allowed for development and harvest of inflorescence which was generally greater at August to November period compared with other periods.

Table 5. Grass herbage yield (kg Dm/ha) at various periods in 2001 and 2002 for 3- and 6-weekly intervals.

Cutting frequency (week)	Nitrogen fertilizer (kg N ha^{-1})				Mean
	0	150	300	450	
Year 2001					
May 17 to June 28					
3	1346.2	2317.9	1845.5	2107.9	1904.4
6	2178.6	2772.0	4206.4	2997.9	3038.8
Mean	1762.4	2544.9	3026.0	2552.9	2471.6
June 28 to Aug. 9					
3	1605.8	2199.2	2072.6	2266.0	2035.9
6	2191.3	2860.0	3063.1	3189.3	2825.9
Mean	1898.6	2529.6	2567.9	2727.6	2430.9
Aug. 9 to Sept. 20					
3	1357.8	2177.1	1960.8	1520.2	1754.0
6	1535.8	1956.4	2233.1	2431.4	2039.2
Mean	1446.8	2066.8	2097.0	1975.8	1896.6
Sept. 20 to Nov. 1					
3	1903.9	1849.1	2340.6	2324.8	2104.6
6	3759.9	3893.8	4389.3	4163.5	4051.6
Mean	2831.9	2871.5	3364.9	3244.2	3078.1
Year 2002					
May 20 to July 1					
3	1140.3	1744.9	1922.7	1966.6	1693.6
6	1026.6	1532.4	1493.4	2296.3	1587.2
Mean	1083.4	1638.7	1708.1	2131.4	1640.4
July 1 to Aug. 12					
3	1063.6	1606.3	2014.6	2134.7	1704.8
6	1243.4	2207.8	2087.7	2303.0	1960.5
Mean	1153.5	1907.1	2051.2	2218.9	1832.6
Aug. 12 to Sept. 23					
3	1040.8	1745.2	2090.6	2033.0	1727.4
6	1291.4	2066.7	2228.4	2054.0	1910.1
Mean	1166.1	1906.0	2159.5	2043.5	1818.8
Sept. 23 to Nov.4					
3	1219.3	1502.4	1679.2	1489.2	1472.5
6	1353.8	2109.8	2322.6	1788.6	1893.7
Mean	1286.6	1806.1	2000.9	1638.9	1683.1

	2001				2002			
	1st period	2nd period	3rd period	4th period	1st period	2nd period	3rd period	4th period
LSD $_{0.05}$ for 2 cutting frequency means (C)	507.97	362.30	–	1283.63	–	–	–	–
LSD $_{0.05}$ for 2 nitrogen means (N)	718.37	512.36	–	–	651.73	378.78	383.46	–
LSD $_{0.05}$ for 2 C × N means	–	–	–	–	–	–	–	–

–, Non-significant F-test at 5% probability level.

Table 6. Grass herbage yield (kg Dm/ha) at various periods in 2003 and 2004 for 3- and 6- weekly intervals.

Cutting frequency (week)	Nitrogen fertilizer (kg N ha^{-1})				Mean
	0	150	300	450	
Year 2003					
June 30 to Aug. 11					
3	795.4	970.7	1394.3	1322.2	1120.7
6	1011.4	1399.1	1577.1	1493.5	1370.3
Mean	903.4	1184.9	1485.7	1407.8	1245.5
Aug. 11 to Sept. 22					
3	939.1	1115.8	1391.0	1314.6	1190.1
6	1525.5	1747.1	2344.0	2065.9	1920.6
Mean	1232.3	1431.4	1867.5	1690.3	1555.4
Sept. 22 to Nov. 3					
3	699.8	1299.6	1278.6	1420.8	1174.7
6	846.8	1857.9	1546.6	1868.0	1529.8
Mean	773.3	1578.8	1412.6	1644.4	1352.3
Nov. 3 to Dec. 15					
3	211.6	519.5	558.9	530.8	455.2
6	234.4	425.2	408.4	365.8	358.4
Mean	223.0	472.4	483.6	448.3	406.8
Year 2004					
June 1 to July 13					
3	912.8	1435.4	1749.4	2058.0	1538.9
6	1381.0	2436.6	2638.9	2338.6	2198.8
Mean	1146.9	1936.0	2194.1	2198.3	1868.8
July 13 to Aug. 24					
3	839.8	1482.9	1749.9	1944.0	1504.2
6	1628.7	2205.8	2820.1	2576.9	2307.9
Mean	1234.3	1844.3	2285.0	2260.5	1906.0
Aug. 24 to Oct. 5					
3	892.3	1157	1629.9	1765.1	1361.3
6	1642.0	2401.1	3176.1	2579.0	2449.5
Mean	1267.1	1779.5	2403.0	2172.0	1905.4
Oct. 5 to Nov.16					
3	910.0	1175.5	1482.3	1672.7	1310.1
6	1654.7	2664.0	2766.0	2047.2	2283.0
Mean	1282.3	1919.8	2124.1	1860.0	1796.6

	Year 2003				Year 2004			
	1st period	2nd period	3rd period	4th period	1st period	2nd period	3rd period	4th period
LSD $_{0.05}$ for 2 cutting frequency means (C)	195.94	267.13	342.15	76.44	304.97	487.54	234.98	459.66
LSD $_{0.05}$ for 2 nitrogen means (N)	277.11	377.78	483.88	108.10	431.29	689.48	332.32	–
LSD $_{0.05}$ for 2 C × N means	–	–	–	–	–	–	–	–

–, Non-significant F-test at 5% probability level.

Table 7. Grass herbage yield (kg Dm/ha) at various periods of the year for 6- and 12-weekly interval.

Cutting frequency (week)	Nitrogen fertilizer (kg N ha^{-1})				Mean
	0	150	300	450	
Year 2001					
May 17 to Aug. 9					
6	4369.9	5632.0	7269.5	6187.2	5864.7
12	6551.5	5829.5	8533.0	10632.0	7886.5
Mean	5460.7	5730.7	7901.3	8409.6	6875.6
Aug. 9 to Nov. 1					
6	5295.7	5850.3	6622.4	6594.9	6090.8
12	2547.4	2983.5	3216.4	3678.4	3106.4
Mean	3921.6	4416.9	4919.4	5136.7	4598.6
Year 2002					
May 20 to Aug. 12					
6	2270.0	3740.3	3581.1	4599.3	3547.7
12	3428.9	4211.7	4432.5	3430.1	3875.8
Mean	2849.5	3976.0	4006.8	4014.7	3711.8
Aug. 12 to Nov. 4					
6	2645.2	4176.5	4551.0	3842.6	3803.8
12	3721.0	3043.4	2606.9	2028.3	2849.9
Mean	3183.1	3610.0	3578.9	2935.5	3326.9
Year 2003					
June 30 to Sept. 22					
6	2536.9	3146.1	3921.1	3559.4	3290.9
12	3887.5	2348.5	3947.8	3538.7	3430.6
Mean	3212.2	2747.3	3934.4	3549.1	3360.8
Sept. 22 to Dec. 15					
6	1081.2	2283.2	1954.9	2233.8	1888.2
12	2428.3	3070.2	3061.4	2795.3	2838.8
Mean	1754.8	2676.7	2508.2	2514.6	2363.5
Year 2004					
June 1 to Aug. 24					
6	3009.7	4642.3	5459.0	4915.6	4506.7
12	5415.3	7594.7	7956.8	6251.7	6804.6
Mean	4212.5	6118.5	6707.9	5583.6	5655.6
Aug. 24 to Nov.16					
6	3296.7	5065.1	5942.1	4626.2	4732.5
12	5655.9	7404.2	9259.9	7341.2	7415.3
Mean	4476.3	6234.7	7601.0	5983.7	6073.9

	Year 2001		Year 2002		Year 2003		Year 2004	
	1st period	2nd period	1st period	2nd period	1st period	2nd period	1st period	2nd period
LSD $_{0.05}$ for 2 cutting frequency means (C)	1401.79	1628.89	–	–	–	492.01	1061.30	1021.84
LSD $_{0.05}$ for 2 nitrogen means (N)	1982.42	–	–	–	–	–	1500.90	1445.10
LSD $_{0.05}$ for 2 C × N means	–	–	–	–	–	–	–	–

–, Non-significant F-test at 5% probability level.

Table 8. Dry matter yields of leaf, stem and inflorescence fractions at various periods of the year for 3- and 6- weekly intervals in 2001.

Cutting frequency (week)	Leaf blade					Stem					Inflorescence				
	Nitrogen fertilizer (kg N ha^{-1})				Mean	Nitrogen fertilizer (kg N ha^{-1})				Mean	Nitrogen fertilizer (kg N ha^{-1})				Mean
	0	150	300	450		0	150	300	450		0	150	300	450	
May 17 to June 28															
3	1306.5	2256.4	1800.1	2032.3	1848.8	39.7 (5.0)	61.5 (6.6)	45.4 (6.7)	75.6 (8.4)	55.6 (6.7)					
6	2053.8	2570.1	3581.4	2629.4	2708.7	124.8 (10.0)	201.9 (13.0)	625.0 (24.9)	368.6 (18.4)	330.1 (16.6)	NY	NY	NY	NY	NY
Mean	1680.2	2413.3	2690.7	2330.9	2278.8	82.3 (7.5)	131.7 (9.8)	335.2 (15.8)	222.1 (13.4)	192.8 (11.6)					
June 28 to Aug. 9															
3	1599.3	2189.6	2052.8	2222.5	2016.0	6.5 (2.0)	9.6 (2.3)	19.8 (3.9)	43.5 (6.4)	19.8 (3.6)					
6	2031.1	2543.2	2608.5	2771.9	2488.7	160.2 (12.6)	316.8 (17.4)	454.6 (21.3)	417.4 (20.4)	337.3 (17.9)	NY	NY	NY	NY	NY
Mean	1815.2	2366.4	2330.6	2497.2	2252.4	83.4 (7.3)	163.2 (9.8)	237.2 (12.6)	230.5 (13.4)	178.6 (10.8)					
Aug. 9 to Sept. 20															
3	1315.1	2082.5	1881.9	1457.6	1684.3	27.9 (4.5)	54.9 (6.2)	61.7 (7.6)	45.4 (5.4)	47.5 (5.9)	14.8 (2.7)	39.7 (6.3)	17.3 (3.7)	17.3 (3.7)	22.3 (4.1)
6	1285.5	1652.4	1887.3	2014.7	1710.0	216.2 (13.6)	276.7 (16.6)	314.2 (17.6)	372.4 (18.0)	294.9 (16.5)	34.1 (5.6)	27.3 (4.3)	31.5 (5.4)	44.3 (5.7)	34.3 (5.2)
Mean	13003	1867.5	1884.6	1736.2	1697.1	122.0 (9.1)	165.8 (11.4)	188.0 (12.6)	208.9 (11.7)	171.2 (11.2)	24.5 (4.2)	33.5 (5.3)	24.4 (4.5)	30.8 (4.7)	28.3 (4.7)
Sept. 20 to Nov. 1															
3	1423.7	1438.6	1958.0	1614.3	1608.7	344.0	293.9	270.7	522.5	357.8	136.2	116.6	111.8	188.0	138.1
6	2612.7	2462.6	2966.7	2443.4	2621.4	972.8	1162.1	1221.8	1434.3	1197.7	174.4	269.1	200.8	285.8	232.5
Mean	2018.2	1950.6	2462.4	2028.8	2115.0	658.4	728.0	746.3	978.4	777.8	155.3	192.9	156.3	236.9	185.3

	Leaf blade				Stem				Inflorescence			
	1st period	2nd period	3rd period	4th period	1st period	2nd period	3rd period	4th period	1st period	2nd period	3rd period	4th period
$LSD_{0.05}$ for 2 cutting frequency means (C)	413.73	357.51	412.13	805.52	4.09	2.10	3.76	529.14	NY	NY	–	–
$LSD_{0.05}$ for 2 nitrogen means (N)	585.10	–	–	–	5.78	2.97	–	–	NY	NY	–	–
$LSD_{0.05}$ for 2 C × N means	–	–	–	–	–	–	–	–	NY	NY	–	–

–, Non-significant F-test at 5% probability level. The comparison is based on transformed means in parenthesis because of zero values in some instances. NY, No Inflorescence yield.

DISCUSSION

The significant increase in grass tiller number per square meter of ground observed with frequent cutting interval and with incremental application of fertilizer N in all the years, was reported by Wilman and Asiegbu (1982) and Harris et al. (1996). Onyeonagu and Asiegbu (2005) obtained similar results in a degraded pasture typified by *P.*

Table 9. Dry matter yields of leaf, stem and inflorescence fractions at various periods of the year for 3- and 6- weekly intervals in 2002.

Cutting frequency (week)	Leaf blade					Stem					Inflorescence				
	Nitrogen fertilizer (kg N ha^{-1})				Mean	Nitrogen fertilizer (Kg N ha^{-1})				Mean	Nitrogen fertilizer (kg N ha^{-1})				Mean
	0	150	300	450		0	150	300	450		0	150	300	450	
May 20 to July 1															
3	1140.3	1744.9	1922.7	1966.6	1693.6	0.0 (0.7)	0.0 (0.7)	0.0(0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)
6	1006.1	1488.3	1474.0	2191.4	1539.9	17.0 (4.1)	40.7 (5.9)	16.9(2.9)	98.2 (9.2)	43.2 (5.5)	3.6 (2.0)	3.4 (1.8)	2.5 (1.4)	6.7 (2.3)	4.1 (1.9)
Mean	1073.2	1616.6	1698.4	2079.0	1616.8	8.5 (2.4)	20.4 (3.3)	8.5(1.8)	49.1 (5.0)	21.6 (3.1)	1.8 (1.3)	1.7 (1.2)	1.3 (1.0)	3.4 (1.5)	2.0 (1.3)
July 1 to Aug. 12															
3	1063.4	1604.4	2014.6	2134.7	1704.3	0.0 (0.7)	1.9 (1.3)	0.0(0.7)	0.0 (0.7)	0.5 (0.8)	0.1 (0.8)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)
6	1193.0	2120.6	2032.7	2079.2	1856.4	50.4 (6.4)	87.2 (8.6)	55.0(6.2)	221.3 (14.6)	103.5 (9.0)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	2.5 (1.4)	0.6 (0.9)
Mean	1128.2	1862.5	2023.7	2107.0	1780.3	25.2 (3.6)	44.6 (4.9)	27.5(3.4)	110.6 (7.7)	52.0 (4.9)	0.1 (0.7)	0.0 (0.7)	0.0 (0.7)	1.3 (1.0)	0.3 (0.8)
Aug. 12 to Sept. 23															
3	1000.1	1667.0	1996.5	1891.3	1638.8	29.6	52.4	69.3	100.4	62.9	11.1 (2.8)	25.7 (5.1)	24.8 (4.9)	41.3 (6.4)	25.7 (4.8)
6	1162.9	1692.1	1744.1	1564.9	1541.0	112.0	327.5	414.9	440.9	323.8	16.5 (4.1)	47.2 (6.8)	69.4 (7.9)	48.2 (6.9)	45.3 (6.4)
Mean	1081.5	1679.6	1879.6	1728.1	1589.9	70.8	189.9	242.1	270.7	193.4	13.8 (3.5)	36.5 (5.9)	47.1 (6.4)	44.7 (6.7)	35.5 (5.6)
Sept. 23 to Nov.4															
3	1077.9	1288.4	1529.6	1377.3	1318.3	100.9	153.7	105.5	77.5	109.4	40.5	60.2	44.1	34.5	44.8
6	1072.5	1505.1	1691.0	1379.1	1411.9	242.7	505.5	522.4	336.8	401.9	38.6	99.1	109.1	72.7	79.9
Mean	1075.2	1396.8	1610.3	1378.2	1365.1	171.8	329.6	314.0	207.1	255.6	39.6	79.7	76.6	53.6	62.4
		Leaf blade					Stem					Inflorescence			
		1st period	2nd period	3rd period	4th period		1st period	2nd period	3rd period	4th period		1st period	2nd period	3rd period	4th period
LSD 0.05 for 2 cutting frequency means (C)		–	–	–	–		1.93	2.70	69.98	135.32		0.67	–	1.34	27.86
LSD 0.05 for 2 nitrogen means (N)		631.98	349.46	318.68	–		–	–	98.97	–		–	–	1.89	–
LSD 0.05 for 2 C × N means		–	–	–	–		–	–	139.96	–		–	–	–	–

–, Non-significant F-test at 5% probability level. The comparison is based on transformed means in parenthesis because of zero values in some instances.

maximum where they obtained higher tiller number with the three-weekly interval (655 tillers per m^2) com-pared with the nine-weeks interval of cuts (521 tillers per m^2) in 2001. They also observed that nitrogen fertilizer increased grass tiller number from 558 tillers per m^2 with zero N to 1315 tillers per m^2 with 450 kg N ha^{-1} in 2002 season.

In the present investigation, the highest tiller number was obtained in 2002 season, with three-weekly interval (2474 tillers per m^2) and the least tiller number with 12-weeks interval of cuts (1086 tillers per m^2). Nitrogen fertilizer increased grass tiller number from 1318 tillers per m^2 with zero N to 1874 tillers per m^2 with 450 kg N ha^{-1} in 2002 season. It would, however, be noted that while Onyeonagu and Asiegbu (2005) worked on degraded pasture, the present study was on sown and maintained pasture, and this could account for the great differences in tiller numbers obtained. Degraded pastures tend to be unstable and have shorter growing period when compared with improved and well maintained species (Kennett et al., 1992). Wilman and Asiegbu (1982) working with perennial ryegrass (*Lolium perenne*) also obtained the highest tiller number with three-weekly interval (691 tillers per 0.1 m^2) and the

Table 10. Dry matter yields of leaf, stem and inflorescence fractions at various periods of the year for 3- and 6- weekly intervals in 2003.

Cutting frequency (week)	Leaf blade					Stem					Inflorescence				
	Nitrogen fertilizer (kgNha^{-1})				Mean	Nitrogen fertilizer (KgNha^{-1})				Mean	Nitrogen fertilizer (kgNha^{-1})				Mean
	0	150	300	450		0	150	300	450		0	150	300	450	
June 30 to Aug. 11															
3	791.1	965.3	1389.6	1300.3	1111.6	4.3 (1.7)	5.4 (1.8)	4.8 (1.7)	21.9 (3.9)	9.1 (2.3)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)
6	1011.4	1324.2	1420.2	1324.1	1270.0	0.0 (0.7)	74.9 (7.3)	156.9 (12.2)	168.1 (13.0)	100.0 (8.3)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	1.3 (1.2)	0.3 (0.8)
Mean	901.3	1144.8	1404.9	1312.2	1190.8	2.1 (1.2)	40.1 (4.6)	80.8 (7.0)	95.0 (8.4)	54.5 (5.3)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.7 (0.9)	0.2 (0.8)
Aug. 11 to Sept. 22															
3	937.2	1115.8	1378.4	1272.6	1176.0	1.9 (1.3)	0.0 (0.7)	10.2 (2.3)	34.3 (5.0	11.6 (2.3)	0.0 (0.7)	0.0 (0.7)	2.4 (1.4)	7.7 (2.4)	2.5 (1.3)
6	1482.8	1625.6	1874.7	1557.3	1635.1	39.3 (5.9)	118.7 (10.1)	452.5 (21.0)	468.6 (21.6)	269.7 (14.6)	3.4 (1.6)	2.7 (1.5)	16.8 (3.6)	40.0 (5.9)	15.7 (3.1)
Mean	1210.0	1370.7	1626.5	1415.0	1405.6	20.6 (3.6)	59.4 (5.4)	231.3 (11.7)	251.4 (13.3)	140.7 (8.5)	1.7 (1.1)	1.3 (1.1)	9.6 (2.5)	23.9 (4.1)	9.1 (2.2)
Sept. 22 to Nov. 3															
3	616.4	1194.2	1098.2	1174.7	1020.9	62.2	78.3	127.4	168.8	109.2	21.2 (4.5)	27.1 (5.2)	53.0 (7.3)	77.3 (8.6)	44.7 (6.4)
6	782.2	1381.7	1173.5	1272.6	1152.5	53.4	414.3	320.2	524.7	328.2	11.2 (3.0)	62.0 (7.9)	52.8 (7.3)	70.7 (8.2)	49.2 (6.6)
Mean	699.3	1288.0	1135.9	1223.7	1086.7	57.8	246.3	223.8	346.8	218.7	16.2 (3.8)	44.5 (6.5)	52.9 (7.3)	74.0 (8.4)	46.9 (6.5)
Nov. 3 to Dec. 15															
3	211.6	519.5	557.4	529.3	454.5	0.0 (0.7)	0.0 (0.7)	1.3 (1.2)	0.9 (1.1)	0.5 (0.9)	0.0 (0.7)	0.0 (0.7)	0.2 (0.9)	0.6 (1.0)	0.2 (0.8)
6	234.4	425.2	408.4	360.1	357.0	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	5.6 (1.9)	1.4 (1.0)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)
Mean	223.0	472.4	482.9	444.7	405.7	0.0 (0.7)	0.0 (0.7)	0.6 (0.9)	3.3 (1.5)	1.0 (0.9)	0.0 (0.7)	0.0 (0.7)	0.1 (0.8)	0.3 (0.8)	0.1 (0.8)

	Leaf blade				Stem				Inflorescence			
	1st period	2nd period	3rd period	4th period	1st period	2nd period	3rd period	4th period	1st period	2nd period	3rd period	4th period
LSD $_{0.05}$ for 2 cutting frequency means (C)	–	225.41	–	75.88	2.60	2.76	155.31	–	–	1.63	–	–
LSD $_{0.05}$ for 2 nitrogen means (N)	244.24	–	270.65	107.31	3.68	3.91	–	–	–	2.30	2.03	–
LSD $_{0.05}$ for 2 C × N means	–	–	–	–	5.21	5.52	–	–	–	–	–	–

–, Non-significant F-test at 5% probability level. The comparison is based on transformed means in parenthesis because of zero values in some instances.

least tiller number with eight to 12 weeks interval of cuts (426 tillers per 0.1 m^2). They observed that nitrogen fertilizer increased grass tiller number from 492 tillers per 0.1 m^2 with zero N to 675 tillers per 0.1 m^2 with 224 kg N ha^{-1}.

In the present study, the three-weeks interval of cuts produced the highest tiller number when combined with the highest N rate of 450 kg N ha^{-1} in 2003 compared with six-, nine- or 12-week intervals of cut. In other forage grass genera, nitrogen application was also effective to increase tillering. Wilman and Pearse (1984) while 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 and 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. Increases in total tiller density (tiller m^{-2}) up to the rate of 480 kg ha^{-1} year^{-1} were observed by McKenzie (1998) when nitrogen rates ranging from 120 to 720 kg ha^{-1} year^{-1} were utilized. Herling et al. (1991) in a setaria grass evaluation study verified that tillering increases beginning with the absence of nitrogen application up to rates of 80 and 160 kg ha^{-1}; values were 11.49, 14.74 and 15.06 tillers per pot, respectively. The reduction in tiller number with

Table 11. Dry matter yields of leaf, stem and inflorescence fractions at various periods of the year for 3- and 6- weekly intervals in 2004.

Cutting frequency (week)	Leaf blade					Stem					Inflorescence				
	Nitrogen fertilizer (kg N ha^{-1})				Mean	Nitrogen fertilizer (Kg N ha^{-1})				Mean	Nitrogen fertilizer (kg N ha^{-1})				Mean
	0	150	300	450		0	150	300	450		0	150	300	450	
June 1 to July 13															
3	905.1	1435.4	1687.1	1687.1	1492.1	7.7 (2.1)	0.0 (0.7)	62.3 (7.6)	117.1 (10.5)	46.8 (5.2)					
6	1283.9	2086.7	2100.1	1998.5	1867.3	97.1 (9.8)	349.8 (18.1)	538.8 (22.7)	340.1 (18.4)	331.5 (17.2)	NY	NY	NY	NY	NY
Mean	1094.5	1761.1	1893.6	1969.7	1679.7	52.4 (6.0)	174.9 (9.4)	300.6 (15.1)	228.6 (14.4)	189.1 (11.2)					
July 13 to Aug. 24															
3	836.7	1482.9	1746.7	1873.3	1484.9	3.1 (1.5)	0.0 (0.7)	3.2 (1.5)	70.8 (7.6)	19.3 (2.8)					
6	1408.9	1973.5	2324.3	2115.7	1955.6	219.8 (12.3)	232.3 (13.4)	495.8 (20.7)	461.2 (20.4)	352.3 (16.7)	NY	NY	NY	NY	NY
Mean	1122.8	1728.2	2035.5	1994.5	1720.2	111.5 (6.9)	116.1 (7.1)	249.5 (11.1)	266.0 (14.0)	185.8 (9.8)					
Aug. 24 to Oct 5															
3	836.1	1099.9	1467.3	1491.1	1223.6	41.1	42.7	119.5	212.6	104.0	15.1	15.4	43.1	61.4	33.7
6	1352.8	1706.4	2212.6	1685.3	1739.3	229.8	573.5	757.4	696.5	564.3	59.4	121.1	206.1	197.1	145.9
Mean	1094.5	1403.2	1839.9	1588.2	1481.4	135.4	308.1	438.5	454.6	334.1	37.2	68.2	124.6	129.3	89.8
Oct 5 to Nov. 16															
3	855.3	1130.7	1369.2	1535.5	1222.7	42.4	34.5	86.5	103.0	66.6	12.3	10.3	26.6	34.3	20.9
6	1447.3	2118.6	2144.2	1530.9	1516.4	178.7	420.6	530.1	424.8	388.6	28.8	124.9	91.7	91.5	84.2
Mean	1151.3	1624.7	1756.7	1533.2	1516.4	110.6	227.5	308.3	263.9	227.6	20.5	67.6	59.1	62.9	52.5

	Leaf blade				Stem				Inflorescence			
	1st period	2nd period	3rd period	4th period	1st period	2nd period	3rd period	4th period	1st period	2nd period	3rd period	4th period
LSD $_{0.05}$ for 2 cutting frequency means (C)	225.62	353.97	232.88	350.14	2.44	4.45	141.03	131.81	NY	NY	51.30	35.55
LSD $_{0.05}$ for 2 nitrogen means (N)	319.08	500.59	329.34	–	3.45	–	199.45	186.41	NY	NY	72.55	–
LSD $_{0.05}$ for 2 C × N means	–	–	–	–	4.88	–	–	–	NY	NY	–	–

–, Non-significant F-test at 5% probability level. The comparison is based on transformed means in parenthesis because of zero values in some instances. NY, No Inflorescence yield.

increasing intervals of cuts up to nine weeks as observed in 2001 season could be partly explained by the development of dense canopy and increased dead materials in the canopy in infrequently cut swards, and this has been reported (Bircham and Hodgson, 1983) to increase the shading of green living tissues and tiller bases. These effects were reported to reduce tillering and the absorption of light energy to no useful purpose, thereby reducing light-use efficiency (Bircham and Hodgson, 1983).

The present investigation revealed that grass tiller number increased with frequent cutting intervals earlier in the 2001 season (June to August) than later (September to November) when compared with the infrequent cutting intervals. Hebblethwaite and Ivins (1977) reported similar differences in the seasonal production of tillers but however, showed that in severely lodged pastures of infrequently cut swards, secondary growth of vegetative tillers occurred during the last few weeks of the season and consequently increased the total number of tillers in infrequent than in frequently cut swards at the end of the season.

Table 12. Dry matter yields of leaf, stem and inflorescence fractions at various periods of the year for 6- and 12- weekly intervals in 2001 and 2002.

Cutting frequency (week)	Leaf blade					Stem					Inflorescence				
	Nitrogen fertilizer (KgNha⁻¹)				Mean	Nitrogen fertilizer (KgNha⁻¹)				Mean	Nitrogen fertilizer (KgNha⁻¹)				Mean
	0	150	300	450		0	150	300	450		0	150	300	450	
2001 May 17 to Aug.9															
6	4084.9	5113.3	6189.9	5401.3	5197.3	285.1	518.7	1079.7	786.0	667.4					
12	3990.5	4232.0	5899.6	6036.2	5039.6	2561.1	1597.5	2633.4	4595.7	2846.9	NY	NY	NY	NY	NY
Mean	4037.7	4672.6	6044.7	5718.8	5118.5	1423.1	1058.1	1856.5	2690.9	1757.1					
Aug. 9 to Nov. 1															
6	3898.2	4115.0	4854.1	4458.2	4331.4	1189.0	1438.8	1536.0	1806.7	1492.6	208.5 (14.2)	296.5 (15.2)	232.3 (14.4)	330.1 (16.4)	266.8 (15.0)
12	1985.3	2350.0	1960.9	2539.0	2208.8	545.0	612.0	1193.7	1096.0	861.7	17.1 (2.9)	21.5 (3.8)	61.8 (5.0)	43.4 (4.3)	35.9 (4.0)
Mean	2941.7	3232.5	3407.5	3498.6	3270.1	867.0	1025.4	1364.8	1451.3	1177.2	112.8 (8.5)	159.0 (9.5)	147.1 (9.7)	186.7 (10.3)	151.4 (9.5)
2002 May 20 to Aug. 12															
6	2199.1	3608.9	3506.7	4270.6	3396.3	67.4 (7.6)	128.0 (10.5)	71.9 (6.9)	319.5 (17.4)	146.7 (10.6)	3.6 (2.0)	3.4 (1.8)	2.5 (1.4)	9.2 (2.8)	4.7 (2.0)
12	2855.9	3289.8	3409.9	2855.9	3102.9	564.9 (23.1)	896.0 (28.0)	996.6 (30.3)	566.0 (23.7)	755.9 (26.3)	8.2 (2.1)	26.0 (4.4)	25.9 (5.0)	8.3 (2.6)	17.1 (3.6)
Mean	2527.5	3449.3	3458.3	3563.2	3249.6	316.1 (15.4)	512.0 (19.3)	534.3 (18.6)	442.7 (20.6)	451.3 (18.4)	5.9 (2.1)	14.7 (3.1)	14.2 (3.2)	8.8 (2.7)	10.9 (2.8)
Aug. 12 to Nov.4															
6	2235.4	3197.2	3435.1	2944.0	2952.9	354.7	833.0	937.3	777.7	725.7	55.1	146.3	178.5	121.0	125.2
12	1936.2	1946.8	1757.5	1336.1	1744.1	1581.1	995.0	797.1	627.5	1000.1	203.7	101.5	52.3	64.7	105.6
Mean	2085.8	2572.0	2596.3	2140.0	2348.5	967.9	914.0	867.2	702.6	862.9	129.4	123.9	115.4	92.8	115.4

	2001						2002					
	Leaf blade		Stem		Inflorescence		Leaf blade		Stem		Inflorescence	
	1st period	2nd period	1st period	2nd period	1st period	2nd period	1st period	2nd period	1st period	2nd period	1st period	2nd period
$LSD_{0.05}$ for 2 cutting frequency means (C)	–	1085.45	872.86	629.79	NY	5.30	–	673.63	6.91	–	–	–
$LSD_{0.05}$ for 2 nitrogen means (N)	1457.77	–	–	–	NY	–	–	–	–	–	–	–
$LSD_{0.05}$ for 2 C × N means	–	–	–	–	NY	–	–	–	–	–	–	–

–, Non-significant F-test at 5% probability level. The comparison is based on transformed means in parenthesis because of zero values in some instances. NY, No inflorescence yield.

This showed that the nature of growth pattern of the grass is important in determining the effect of inter-vals of cut on the tiller population. The pattern of growth in the grass used for the present study is tufted.

Results from the present study have shown that the highest yields were generally obtained with the longer cutting intervals as found by Omaliko (1980), Man and Wiktorsson (2003) and Onyeonagu (2005). Possible explanations for the observed responses to defoliation are that the more mature grasses increased leaf area and

Table 13. Dry matter yields of leaf, stem and inflorescence fractions at various periods of the year for 6- and 12- weekly intervals in 2003 and 2004.

Cutting frequency (week)	Leaf blade					Stem					Inflorescence				
	Nitrogen fertilizer (kg N ha^{-1})				Mean	Nitrogen fertilizer (kg N ha^{-1})				Mean	Nitrogen fertilizer (kg N ha^{-1})				Mean
	0	150	300	450		0	150	300	450		0	150	300	450	
2003															
June 30 to Sept. 22															
6	2494.2	2949.8	3294.9	2881.4	2905.1	39.3	193.6	609.4	636.7	369.7	3.4 (1.6)	2.7 (1.4)	16.8 (3.7)	41.4 (5.9)	16.1 (3.2)
12	2724.0	1757.6	2629.6	2112.6	2305.9	1082.0	551.2	1201.1	1335.7	1042.5	81.5 (8.9)	39.7 (5.3)	117.1 (10.6)	90.4 (9.5)	82.2 (8.6)
Mean	2609.1	2353.7	2962.2	2497.0	2605.5	560.6	372.4	905.2	986.2	706.1	42.4 (5.2)	21.2 (3.4)	67.0 (7.2)	65.9 (7.7)	49.1 (5.9)
Sept. 22 to Dec. 15															
6	1016.6	1806.9	1581.9	1632.7	1509.5	53.4	414.3	320.2	530.4	329.6	11.2 (3.0)	62.0 (7.9)	52.8 (7.3)	70.7 (8.2)	49.1 (6.6)
12	1935.3	2266.6	2176.7	1903.2	2070.5	467.7	759.3	838.9	843.1	727.3	25.3 (5.1)	44.3 (6.6)	45.8 (6.8)	49.1 (6.8)	41.1 (6.3)
Mean	1476.0	2036.8	1879.3	1767.9	1790.0	260.6	586.8	579.6	686.7	528.4	18.2 (4.0)	53.1 (7.2)	49.3 (7.0)	59.9 (7.5)	45.1 (6.5)
2004															
June 1 to Aug. 24															
6	2692.8	4060.2	4424.4	4114.2	3822.9	316.9	582.1	1034.6	801.4	683.8	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)	0.0 (0.7)
12	3638.8	5194.4	5270.1	3629.0	4433.1	1741.3	2349.5	2566.1	2558.9	2303.9	35.1 (5.7)	50.8 (6.0)	120.7 (8.7)	63.8 (7.9)	67.6 (7.1)
Mean	3165.8	4627.3	4847.2	3871.6	4128.0	1029.1	1465.8	1800.3	1680.1	1493.8	17.6 (3.2)	25.4 (3.3)	60.3 (4.7)	31.9 (4.3)	33.8 (3.9)
Aug. 24 to Nov.16															
6	2800.0	3825.0	4356.8	3216.3	3549.5	408.5	994.1	1287.5	1121.4	952.9	88.1	246.0	297.8	288.6	230.1
12	2981.7	4032.5	5353.9	3961.1	4082.3	2474.2	3167.4	3643.6	3181.6	3116.7	200.0	204.3	262.4	198.6	216.3
Mean	2890.9	3928.8	4855.3	3588.7	3815.9	1441.3	2080.8	2465.6	2151.5	2034.8	144.1	225.1	280.1	243.6	223.2

	2003						2004					
	Leaf		Stem		Inflorescence		Leaf		Stem		Inflorescence	
	1st period	2nd period	1st period	2nd period	1st period	2nd period	1st period	2nd period	1st period	2nd period	1st period	2nd period
$LSD_{0.05}$ for 2 cutting frequency means (C)	401.14	325.26	260.30	208.98	2.25	–	–	–	484.24	617.94	3.09	–
$LSD_{0.05}$ for 2 nitrogen means (N)	–	–	368.13	295.55	3.19	1.87	995.28	787.99	–	–	–	–
$LSD_{0.05}$ for 2 C × N means	–	–	–	–	–	–	–	–	–	–	–	–

–, Non-significant F-test at 5% probability level. The comparison is based on transformed means in parenthesis because of zero values in some instances.

photosynthesis, thus resulting in higher dry matter production (Man and Wiktorsson 2003). Reducing the interval between cuts reduced herbage production, the effect being greatest in the early part of the season, which concurs with the findings of Chestnutt et al. (1977) that frequent cutting reduced herbage production to a greater degree in the early part of the season. This effect has been attributed to the high growth rates associated with uninterrupted growth during the reproductive phase of growth in the early part of the season (Binnie et al., 1997).

The reduced yields of longer intervals, relative to the shorter intervals late in the 2001, 2002 and 2003 seasons as observed in the present investigation is of interest. Similar seasonal effects of harvesting intervals have been reported on perennial ryegrass by Chestnutt et al. (1977).

They attributed such seasonal effects of harvesting intervals to the inability of grass in the latter part of the season to produce any appreciable stem elongation leading to a sward which produces a dense leaf canopy with increasing senescence, lodging and a decreased net rate of dry matter accumulation as the growth interval lengthened. The results from the present investigation suggest that adopting a long interval of cut early in the season and a short interval of cut towards the end of the season may increase the annual dry matter yield compared with employing either type of regime all through the year. For example, in the case of the six-weekly cuts compared with the 12-weekly cuts in the 2001 and 2002 harvest years, or the three-weekly cuts compared with the six-weekly cuts in the 2003 harvest year, it was apparent that a combination of long (nine- or 12 -weekly) harvesting interval early in the season with the shorter (three- or six-) intervals towards the end of the season would make for an advantage in increasing the annual dry matter yield of grass herbage compared with using either of the two regimes all through the year.

Conclusion

The present information showed that cutting management and nitrogen application strongly affect yields of grasses. The results from the study suggest that adopting a longer interval of nine or 12 weeks interval of cut early in the season and a short interval of three or six weeks interval of cut towards the end of the season may increase the annual dry matter yield of pasture swards compared with employing either type of regime all through the year. Tiller production per square meter, grass dry matter production and yields of crop fractions were generally increased with incremental application of fertilizer-N in most of the periods of the years considered.

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