Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension
Volume 9 Number 2 May 2010 PP. .111 – 124
ISSN 1119-7455

EFFECT OF SWARD TYPE, CUTTING FREQUENCY AND FERTILIZER-N APPLICATION ON PASTURE ESTABLISHMENT, GROWTH AND YIELD IN GUINEA GRASS-VERANO STYLO PASTURES.

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ABSTRACT

This experiment was a 3 x 3 x 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 weeks, 8 weeks and 12 weeks) and two nitrogen fertilizer rates (0 and 300 kg N ha^{-1}). Increasing the interval between harvests increased the number of branches per plant, number of leaves per legume plant, and heights of grass and legume species. The application of N increased heights of grass and legume plants, with no effect on the number of leaves per plant and number of branches per legume plant. Fertilizer effects on height of grass and legume plants were generally, not significant during the later periods of 2006 and 2007. There were significant reductions in the height, number of nodules per plant, length of longest root per plant, number of branches per plant, number of leaves per plant, and dry matter yields of leaf, stem and root fractions per verano stylo plant in the grass-legume mixed swards when compared with the pure legume swards.

Key words: Interval between cuts, nitrogen, grass-legume mixture

INTRODUCTION

A lot of experimental work has been conducted on the response of tropical sown pastures to cutting management and nitrogen fertilization (Haggar, 1971; Humphreys, 1980; Bamikole *et al*., 2004). However, little is known on how verano stylo (*Stylosanthes hamata*) grown with or without guinea grass (*Panicum maximum*) in the derived savanna will respond to different N-fertilizer application rates and different cutting regimes.

Cutting management is critical to stand longevity (Guay, 2001). Grass stands are weakened if cutting intervals are too frequent, leading to a decline in the stand because of insufficient energy reserves for regrowth (Jung *et al*., 1994). Infrequent cutting can also weaken the stand through reduced seedling and tiller survival, due to excessive shading from the forage canopy (Jung *et al*., 1994). The value of the addition of legumes to a stand of grass is well known (Guay, 2001; Casler and Walgenbach, 1990). Maintenance of legume in pastures is imperative in terms of sustainability of mixed species swards (Turner *et al*., 1998). Nitrogen fertilization has been found to reduce the legume content in mixture with grass (Guay, 2001). therefore, the influence of nitrogen application on the legume component needs to be investigated. Variations in growth habit, regrowth, and physiological growth requirements make management of grass/legume mixtures difficult (Casler, 1988). It is generally accepted that grasses normally have a competitive advantage over legumes (Wong and Wilson, 2005); however, pasture management techniques such as fertilization and cutting management, are utilized in order to secure a desirable balance (Rhodes and Stern, 1978). This study was designed to evaluate the effect of sward type, cutting frequency and nitrogen application on the establishment, growth and yield in guinea grass and verano stylo pastures.

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 06^0 $52^{'}$ N and longitude 07^0 $24^{'}$ E, and on altitude of 447.2m above sea level. The experiment was a 3 x 3 x 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 (4weeks, 8 weeks and 12 weeks) and two nitrogen fertilizer rates (0 and 300 kg N/ha). These gave eighteen treatment combinations. In May 2006, an area of land 37.8 meters long by 13m meters wide with an area of 491.4m^2 was ploughed and marked out into three blocks of 37.8 x 3 meters each.

Each block was further divided into 18 plots of 3 x 2.1 meters each with a sampling area of 0.9 x 1.8 meters. 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 *Panicum maximum* with height of 15cm were planted after land preparation at 20cm x 30cm spacing. The seeds of *Stylosanthes 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 effect of type of sward treatment alone on establishment was considered during the first 8 weeks after planting (17 June to 12 August 2006) before the first general cut.

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 x 1.8 meters sample area. The fresh herbage harvested was separated into grass and legume fractions which were weighed separately. A sub-sample 100g each of the grass species and legume per plot were put in paper envelops and dried in a forced air oven set at 80^{o}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 components. Records on plant height, number of branches per plant and number of leaves per plant were taken using the mean of three readings taken at random from the sample area in each plot.

Soil samples were collected at random from twelve representative locations of the field by augering to the depth of 0 - 20cm. These were bulked together to form a composite sample from which a sub-sample was taken for soil analysis to determine the physical and chemical characteristics of the site. Meteorological data of rainfall, rain days, ambient temperature, soil temperature, solar radiation, relative humidity, and day length were collected from the Department of Crop Science, University of Nigeria, Nsukka Meteorological Station. All data collected were statistically analysed using the procedure outlined by Steel and Torrie (1980) for factorial experiment in 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.). Group t-test was in addition used to compare two sward types during establishment. The 4 and 8 weeks intervals of cut each spanning the yearly harvest period were analysed and compared for effect of season as done by Omaliko (1980). The first, second and third harvest periods, represent the first 8 weeks, second 8 weeks and third 8 week-harvest periods, respectively.

RESULT

The total annual rainfall was higher at 1613mm with 129 rain days in 2006 than at 1570mm with 112 rain days in 2007 (Table 1). The distribution pattern was always bimodal in both years with the heaviest rainfalls in June, August, or October. Rains fell more frequently from July to September. The minimum air temperatures ranged from 17.90 – 23.33^{o}C and 20.03 – 23.19^{o}C for 2006 and 2007 seasons, respectively. The maximum air temperatures were generally highest in the months of November to March or April. The average relative humidity observed was highest during the rainy season in both years from April to October.

The soil of the experimental site (Table 2) was sandy in texture and acidic in reaction. The soil had low amounts of nitrogen content, potassium, magnesium, organic matter, and base saturation at the beginning of the experiment. The soil was low in cation exchange capacity and in available phosphorus.

Plant height, number of leaves per plant, number of nodules per plant, length of the longest root per plant, dry matter yields of leaf, stem and root fractions per verano stylo plant were significantly higher under Verano stylo swards than in the guinea grass/verano stylo mixed swards at 8-weeks after planting (Table 3).

The verano stylo swards produced significantly lower dry matter yield compared with the guinea grass (*Panicum maximum*) swards or with guinea grass/verano stylo mixed swards at 8 weeks after planting in 2006 (Table 4). The guinea grass sward produced higher dry matter yield than Verano sylo sward but had similar effect with the guinea grass/verano stylo mixed swards.

The height of verano stylo plant was higher in plots with pure legume sward compared with where verano stylo was in mixture with guinea grass in 2006 (Table 5). The type of sward had no effect on plant height in 2007. Plant height increased significantly with increase in interval between cuts and with nitrogen fertilizer application in 2006 and 2007.

During the establishment year (2006), verano stylo height was significantly higher at

Table 1: Meteorological Data for Nsukka*

Month	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec	Total rain fall (mm)	Total rain days
2006														
Rain fall (mm)	36.32	4.06	103.12	51.05	243.83	259.60	213.86	195.58	190.50	313.94	1.52	0.00	1613.38	129
Rain days	1	2	4	5	16	16	21	19	25	19	1	0		
Max. Air temp. (^oC)	33.16	33.61	33.10	35.53	30.55	29.90	28.65	27.84	28.17	29.94	31.77	32.65		
Min. Air t emp. (^oC)	23.06	23.25	22.84	23.33	21.35	21.20	21.58	20.81	21.33	21.29	18.97	17.90		
Soil Temp (^oC)	28.54	29.39	28.36	30.39	27.19	26.71	25.91	25.06	25.53	26.65	27.64	26.51		
Solar radiation ($Cal/cm^2/day$)	796.5	779.2	857.4	866.6	736.0	779.6	655.2	554.4	651.2	879.1	998.1	987.3		
Relative humidity (%)	75.29	76.00	73.65	74.84	77.90	77.67	79.68	80.00	79.07	76.94	65.47	57.23		
2007														
Rain fall (mm)	0.00	9.91	39.12	121.66	193.55	327.66	62.99	323.60	169.67	267.20	55.12	0.00	1608.06	107
Rain days	0	1	4	8	11	16	14	17	19	18	4	0		
Max. Air temp. (^oC)	33.29	35.07	35.13	32.67	31.13	29.37	28.50	27.65	28.27	29.32	30.40	31.61		
Min. Air temp. (^oC)	20.87	22.64	23.19	22.97	21.90	21.83	21.20	21.87	21.37	20.71	21.30	20.03		
Soil Temp (^oC)	26.54	29.26	30.55	29.21	27.67	26.90	26.23	25.23	25.89	26.19	27.25	27.49		
Solar radiation ($Cal/cm^2/day$)	1045.5	845.4	894.5	902.3	893.4	753.3	705.8	525.4	728.0	935.1	921.2	1026.6		
Relative humidity (%)	54.55	71.93	69.45	74.53	76.32	77.53	78.74	69.06	78.07	76.61	76.33	69.39		

University of Nigeria, Nsukka, Meteorological Centre, about 200m from the experimental site.

Table 2: Soil physical and chemical properties of the experimental site

Mechanical Properties	
Coarse sand (%)	40.0
Fine sand (%)	54.0
Clay (%)	4.0
Silt (%)	2.0
Textural Class	Sandy soil
Chemical Properties	
pH in water	3.6
pH in KCl	3.0
Organic carbon (%)	0.97
Organic matter (%)	1.68
Total nitrogen (%)	0.15
Total phosphorus (ppm)	35.82
Base Saturation	0.89
Exchangeable Cation ($cmol\ kg^{-1}$)	
Potassium	0.27
Magnesium	2.2
Calcium	1.8
Sodium	3.18
Hydrogen	3.2
Aluminium	0.8
C.E.C.	8.4

Table 3: Effect of type of sward on morphological development and dry matter yield (g) of verano stylo (*Stylosanthes hamata*) at weeks after planting (June 17 August 12, 2006).

Type of sward	Plant height (cm)	No. of leaves plant^{-1}	No. of nodules plant^{-1}	Length of longest root plant^{-1} (cm)	Leaf DM plant^{-1} (g)	Stem DM plant^{-1} (g)	Root DM plant^{-1} (g)
Verano stylo	20.1	35.5	112.7	14.3	0.23	0.21	0.15
Verano stylo in mixture	13.2	8.1	24.9	11.2	0.04	0.04	0.03
Variance T-value	8.43	11.29	6.85	3.96	10.23	8.54	6.83
Pooled d.f.	34	34	34	34	34	34	33
2-tail probability	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Table 4: Effect of type of sward on the total herbage yield (kg ha^{-1}) at 8 weeks after planting (June 17 - August 12, 2006).

Type of sward	Total herbage yield
Pure grass	2760.0
Pure legume	468.0
Grass-Legume mixture	2435.2
Mean	1887.7
s.e.d between 2 sward type means	189.46

Table 5: Effects of sward type, cutting frequency and fertilizer-N application on height (cm) of verano stylo (*Stylosanthes hamata*) in 2006 and 2007

		Cutting frequency (weeks)			
Sward type	Fertilizer-N (kg ha^{-1})	4	8	12	Mean
			2006		
Verano stylo	0	19.27	32.40	55.17	35.61
	300	21.60	33.73	61.10	38.81
	Mean	20.43	33.07	58.13	37.21
Verano stylo in mixture	0	17.77	25.67	38.60	27.34
	300	22.47	26.03	47.03	31.84
	Mean	20.12	25.85	42.82	29.59
Cutting Frequency Mean		20.28	29.46	50.48	33.40
Fertilizer Mean	0kg Nha^{-1} = 31.48		300kg Nha^{-1} = 35.33		
			2007		
Verano stylo	0	23.1	31.5	49.5	34.7
	300	24.2	35.4	44.6	34.7
	Mean	23.6	33.4	47.1	34.7
Verano stylo in mixture	0	22.6	34.7	48.4	35.2
	300	24.9	36.5	48.8	36.8
	Mean	23.8	35.6	48.6	36.0
Cutting Frequency Mean		23.7	34.5	47.8	35.3
Fertilizer Mean	0kg Nha^{-1} =35.0		300kg Nha^{-1} = 35.7		

	2006	2007
S.e.d. between 2 Sward Type means (S) =	1.711	1.69
S.e.d. between 2 Cutting Frequency means (C) =	2.096	2.07
S.e.d. between 2 Nitrogen means (N) =	1.711	1.69
S.e.d. between 2 S X C means =	2.964	2.93
S.e.d. between 2 S X N means =	2.420	2.39
S.e.d. between 2 C X N means =	2.964	2.93
S.e.d. between 2 S X C X N means =	4.192	4.14

the 8-weekly interval between cuts compared with the 4 weeks at the first period of the year (Table 6). Cutting intervals had no effect on verano stylo height during the second period. Fertilizer-N application significantly increased the height of verano stylo at the first period but had no effect on plant height at the second period of the year when compared with where no nitrogen was applied. During the first period of the year, the pure verano stylo swards produced taller plants compared to where verano stylo was grown in mixture with guinea grass. Verano stylo plants appeared to be taller at the early period than at later period.

The height of the legume component was increased with the higher cutting interval of 8 weeks in all the periods of the year 2007 compared with where the frequent interval of 4 weeks was used (Table 7). Application of nitrogen fertilizer significantly increased plant height only at the early period of the year. Cutting every 8-week with 300 and 0 kg N ha^{-1}, gave the tallest plants in grass-legume-mixed swards at the first and last periods, respectively, while the tallest plant was produced in pure

Table 6: Effect of Sward type, cutting frequency and fertilizer N application on height of verano stylo plant (cm) at two periods of 2006

Sward type	Fertilizer N (kg ha^{-1})	Cutting frequency (weeks) 4	8	Mean
	August 12 – October 7 (1st 8-weeks period)			
Verano stylo	0	22.1	42.7	32.4
	300	24.6	47.2	35.9
	Mean	23.4	45.0	34.2
Verano stylo in mixture	0	17.7	30.1	23.9
	300	19.3	35.0	27.2
	Mean	18.5	32.6	25.6
Cutting Frequency mean		20.9	38.8	29.9
Fertilizer Mean:	0kg Nha^{-1} = 28.2		300 kg Nha^{-1} =31.6	
	October 7 – December 2 (2nd 8-weeks period)			
Verano stylo	0	16.5	22.0	19.3
	300	18.7	20.2	19.4
	Mean	17.6	21.1	19.4
Verano stylo in mixture	0	17.8	21.1	19.5
	300	25.6	17.0	21.3
	Mean	21.7	19.1	20.4
Cutting Frequency Mean		19.6	20.1	19.9
Fertilizer Mean:	0kg Nha^{-1} = 19.4		300 kg Nha^{1} =20.4	

	1st period	2nd period
S.e.d. between 2 Sward Type means (S) =	1.35	1.88
S.e.d. between 2 Cutting Frequency means (C) =	1.35	1.88
S.e.d. between 2 Nitrogen means (N) =	1.35	1.88
S.e.d. between 2 S X C means =	1.91	2.65
S.e.d. between 2 S X N means =	1.91	2.65
S.e.d. between 2 C X N means =	1.91	2.65
S.e.d. between 2 S X C X N means =	2.69	3.75
S.e.d. between 2 S X C X N means =	2.69	3.75

legume swards during the second period, when fertilizer application was combined with the 8-weekly interval of cuts. Plant height appeared to decrease with advancement in season.

The height of guinea grass plant increased significantly with increasing interval between cuts in 2006 and 2007 (Table 8). Sward type did not affect guinea grass height in both years. Fertilizer-N treatments did not influence height of grass plant in 2006 but increased it in 2007. Height of guinea grass plant was not affected by sward type x cutting interval x nitrogen application interaction in both years.

The 8-weekly interval of cut always increased the height of guinea grass plant in each of the two periods in the 2006 harvest season compared to the 4-weekly interval of cut (Table 9). Sward type had no significant effect on the plant height in any of the periods. Fertilizer application increased guinea grass height over where N was not applied only in the first period of the year. For similar cutting frequencies, average guinea grass height was always doubled during the first period compared with the second period of the harvest schedule.

During the second year, the height of the grass plant was significantly increased with increase in interval between cuts in all the harvest periods. Fertilizer application increased plant height in the first and second periods of the year (Table 10). Plant height did not differ significantly among the different sward types during the first and third periods of the year. Pure grass swards produced taller plants than grass-legume-mixed swards at the second period of the year. Tallest plants were obtained in grass-legume mixed swards when cutting was done at the longer interval of 8 weeks with fertilizer application during the first and third periods while cutting at 8 weeks interval gave the tallest plants when fertilizer was applied in pure grass swards at the second period. The height of grass plant appeared to increase with season.

Table 7: Effect of Sward type, cutting frequency and fertilizer N application on height of verano stylo plant (cm) at various periods of the year 2007

		Cutting frequency (weeks)		
Sward type	Fertilizer N (kg ha^{-1})	4	8	Mean
		May 29 – July 24 (1st 8 weeks period)		
Verano stylo	0	25.5	35.8	30.6
	300	28.5	44.7	36.6
	mean	27.0	40.2	33.6
Verano stylo in mixture	0	25.4	40.3	32.9
	300	28.0	47.1	37.5
	mean	26.7	43.7	35.2
Cutting Frequency mean		26.8	42.0	34.4
Fertilizer mean:	0kg Nha^{-1} = 31.7		300 kg Nha^{-1} = 37.1	
		July 24 – September 18 (2nd 8 weeks period)		
Verano stylo	0	21.4	30.8	26.1
	300	21.8	33.5	27.7
	mean	21.6	32.2	26.9
Verano stylo in mixture	0	19.2	31.7	25.4
	300	20.7	32.4	26.6
	mean	19.9	32.1	26.0
Cutting Frequency mean		20.8	32.1	26.5
Fertilizer mean:	0kg Nha^{-1} = 25.8		300 kg Nha^{-1} = 27.1	
		September 18 – November 13 (3rd 8 weeks period)		
Verano stylo	0	22.4	27.9	25.1
	300	22.2	27.9	25.1
	mean	22.3	27.9	25.1
Verano stylo in mixture	0	23.1	32.1	27.6
	300	26.3	30.1	28.2
	mean	24.7	31.1	27.9
Cutting Frequency mean		23.5	29.5	26.5
Fertilizer mean:	0kg Nha^{-1} = 26.4		300 kg Nha^{-1} = 26.6	

	1st period	2nd period	3rd period
S.e.d. between 2 Sward Type means (S) =	1.22	0.89	1.13
S.e.d. between 2 Cutting Frequency means (C) =	1.22	0.89	1.13
S.e.d. between 2 Nitrogen means (N) =	1.22	0.89	1.13
S.e.d. between 2 S X C means =	1.72	1.26	1.60
S.e.d. between 2 S X N means =	1.72	1.26	1.60
S.e.d. between 2 C X N means =	1.72	1.26	1.60
S.e.d. between 2 S X C X N means =	2.43	1.78	2.27

Table 8: Effects of sward type, cutting frequency and fertilizer-N application on height (cm) of guinea grass (*Panicum maximum*) in 2006 and 2007

		Cutting frequency (weeks)			
Sward type	Fertilizer-N (kg ha^{-1})	4	8	12	Mean
			2006		
Guinea grass	0	50.5	105.9	200.0	118.8
	300	60.2	106.1	198.8	121.7
	Mean	55.4	106.0	199.4	120.2
Guinea grass in mixture	0	49.8	107.1	200.2	119.0
	300	56.4	121.2	203.9	127.1
	Mean	53.1	114.1	202.0	123.1
Cutting Frequency mean		54.2	110.1	200.7	121.7
Fertilizer Mean	0kg Nha^{-1} = 118.9		300kg Nha^{-1} =124.4		
			2007		
Guinea grass	0	38.7	84.8	136.6	86.7
	00	45.6	93.5	141.6	93.6
	Mean	42.1	89.2	139.1	90.1
Guinea grass in mixture	0	37.0	83.3	142.2	87.5
	300	51.8	97.0	140.4	96.4
	Mean	44.4	90.2	141.3	92.0
Cutting Frequency mean		43.3	89.7	140.2	91.0
Fertilizer Mean	0kg Nha^{-1} =87.1		300kg Nha^{-1} = 95.0		

	2006	2007
S.e.d. between 2 Sward Type means (S) =	3.50	2.98
S.e.d. between 2 Cutting Frequency means (C) =	4.29	3.64
S.e.d. between 2 Nitrogen means (N) =	3.50	2.98
S.e.d. between 2 S X C means =	6.06	5.15
S.e.d. between 2 S X N means =	4.95	4.21
S.e.d. between 2 C X N means =	6.06	5.15
S.e.d. between 2 S X C X N means =	8.57	7.29

Table 9: Effect of Sward type, cutting frequency and fertilizer N application on height of guinea grass plant (cm) at two periods of 2006

		Cutting frequency (weeks)		
Sward type	Fertilizer N (kg ha^{-1})	4	8	Mean
	August 12 – October 7 (1st 8 weeks period)			
Guinea grass	0	68.8	134.1	101.4
	300	86.9	141.3	114.1
	Mean	77.8	137.7	107.8
Guinea grass in mixture	0	66.6	139.8	103.2
	300	78.6	154.7	116.6
	Mean	72.6	147.2	109.9
Cutting Frequency mean		75.2	142.5	108.8
Fertilizer Mean:	0kg Nha^{-1} =102.3		300 kg Nha^{-1} =115.4	
	October 7 – December 2 (2nd 8 weeks period)			
Guinea grass	0	32.2	77.6	54.9
	300	33.5	70.8	52.1
	Mean	32.8	74.2	53.5
Guinea grass in mixture	0	33.2	74.4	53.8
	300	34.2	87.6	60.9
	Mean	33.7	81.0	57.4
Cutting Frequency mean		33.2	77.6	55.4
Fertilizer Mean:	0kg Nha^{-1} =54.3		300 kg Nha^{1} = 56.5	

	1st period	2nd period
S.e.d. between 2 Sward Type means (S) =	3.38	2.80
S.e.d. between 2 Cutting Frequency means (C) =	3.38	2.80
S.e.d. between 2 Nitrogen means (N) =	3.38	2.80
S.e.d. between 2 S X C means =	4.78	3.96
S.e.d. between 2 S X N means =	4.78	3.96
S.e.d. between 2 C X N means =	4.78	3.96
S.e.d. between 2 S X C X N means =	6.76	5.60

In the 2006 harvest year, infrequent cutting interval of 12 weeks produced significantly the highest number of leaves per verano stylo plant compared with the other intervals (Table 11). The number of leaves per plants increased significantly with increase in intervals between cuts up to the 8-weekly interval in 2007. Number of leaves per plant remained the same for the 4 weeks compared with 8-week intervals of cuts in 2006. Four and 12 weekly intervals of cut had similar effects on the number of leaves per plants in 2007. Fertilizer-N application had no effect on the number of leaves per plant in both years. Plots with verano stylo swards produced significantly greater number of leaves than where verano stylo was in mixture with guinea grass in 2006. In 2007, verano stylo grown in mixture with guinea grass had significantly greater number of leaves per plant compared with pure verano stylo swards. Harvesting every 12 weeks gave significantly the highest number of leaves per plant under pure legume swards in 2006. The number of leaves per legume plant was not affected by sward type x cutting interval x nitrogen application interaction in both years.

The legume plant produced greater number of leaves per plant when cutting was done every 8 weeks than 4 weeks at the first period of the year 2006 (Table 12). The number of leaves per plant was not affected at any cutting interval during the second period. Fertilizer-N application did not influence the number of leaves per plant at any of the periods. Pure legume swards consistently produced greater number of leaves per plant at both periods when compared with where the legume plant was grown in mixture with grass. The number of leave per plant appeared to increase with season.

The infrequent cutting interval of 8-weeks consistently produced significantly greater number of leaves in all the periods in 2007 than the 4 weeks (Table 13). Fertilizer-N application had no effect on the number of leaves per plant in any of the periods. Greater number of leaves per plant was produced in legume plants grown in mixture with grass compared to those grown alone during the first and second periods. Type of sward treatment did not influence the number of leaves per plant at the third period. The number of leaves appeared to decrease with increase in season.

Table 10: Effect of Sward type, cutting frequency and fertilizer N application on height of grass plant (cm) at various periods of the year 2007

Sward type	Fertilizer N (kg ha^{-1})	Cutting frequency (weeks) 4	8	Mean
		May 29 – July 24 (1st 8 weeks period)		
Guinea grass	0	29.0	74.9	51.9
	300	42.7	89.5	66.1
	mean	35.9	82.2	59.0
Guinea grass in mixture	0	33.0	80.0	56.5
	300	53.9	94.5	74.2
	mean	43.4	87.2	65.3
Cutting Frequency mean		39.7	84.7	62.2
Fertilizer mean:	0kg Nha^{-1} = 54.2		300 kg Nha^{-1} = 70.2	
		July 24 – September 18 (2nd 8 weeks period)		
Guinea grass	0	29.0	72.4	50.7
	300	41.3	87.0	64.2
	mean	35.1	79.7	57.4
Guinea grass in mixture	0	31.2	62.0	46.6
	300	37.5	86.1	61.8
	mean	34.4	74.0	54.2
Cutting Frequency		34.8	76.9	55.8
Fertilizer mean:	0kg Nha^{-1} = 48.6		300 kg Nha^{-1} = 63.0	
		September 18 – November 13 (3rd 8 weeks period)		
Guinea grass	0	54.6	107.2	80.9
	300	52.8	104.0	78.4
	mean	53.7	105.6	79.6
Guinea grass in mixture	0	46.8	107.9	77.3
	300	63.9	110.4	87.1
	mean	55.4	109.1	82.2
Cutting Frequency mean		54.5	107.4	80.9
Fertilizer mean:	0kg Nha^{-1} = 79.1		300 kg Nha^{-1} = 82.8	

	1st period	2nd period	3rd period
S.e.d. between 2 Sward Type means (S) =	5.40	2.87	7.15
S.e.d. between 2 Cutting Frequency means (C) =	5.40	2.87	7.15
S.e.d. between 2 Nitrogen means (N) =	5.40	2.87	7.15
S.e.d. between 2 S X C means =	7.64	4.06	10.11
S.e.d. between 2 S X N means =	7.64	4.06	10.11
S.e.d. between 2 C X N means =	7.64	4.06	10.11
S.e.d. between 2 S X C X N means =	10.80	5.76	14.29

The infrequent cutting interval of 12 weeks produced significantly the highest number of branches per verano stylo plant compared with the other intervals of cuts during the establishment year (Table 14). Four and 8-weeks intervals of cut did not differ in their effects on the number of branches per plant. Eight weekly interval of cut produced greater number of branches than the 4-weekly interval but had similar effect with the 12 week interval of cuts in 2007. Fertilizer-N application had no effect on the number of branches per plant in both years. Greater number of branches per plant was produced in pure verano stylo swards in 2006 compared with where verano stylo was grown in mixture with guinea grass. In 2007, verano stylo plants grown in mixture with guinea grass produced significantly greater number of branches compared with pure verano stylo swards. Cutting every 12 weeks gave significantly the highest number of branches per plant when verano stylo plants were grown alone in 2006. Cutting interval, sward type and fertilizer application did not interact significantly to produce differential number of branches per plant in 2007.

Table 11: Effects of sward type, cutting frequency and fertilizer-N application on number of leaves per Verano stylo plant in 2006 and 2007

		Cutting frequency (weeks)			
Sward type	Fertilizer-N (kg ha^{-1})	4	8	12	Mean
			2006		
Verano stylo	0	127.6	108.7	221.2	152.5
	300	114.3	150.0	330.2	198.2
	Mean	121.0	129.4	275.7	175.3
Verano stylo in mixture	0	61.3	54.1	115.5	77.0
	300	54.0	67.4	97.3	72.9
	Mean	57.7	60.8	106.4	74.9
Cutting Frequency Mean		89.3	95.1	191.1	125.1
Fertilizer Mean	0kg Nha^{-1} = 114.7		300kg Nha^{-1} =135.5		
			2007		
Verano stylo	0	70.8	92.3	105.6	89.6
	300	87.8	112.9	74.7	91.8
	Mean	79.3	102.6	90.1	90.7
Verano stylo in mixture	0	87.8	155.1	123.9	122.2
	300	110.5	147.7	142.7	133.6
	Mean	99.2	151.4	133.3	127.9
Cutting Frequency Mean		89.2	127.0	111.7	109.3
Fertilizer Mean	0kg Nha^{-1} =105.9		300kg Nha^{-1} =112.7		

	2006	2007
S.e.d. between 2 Sward Type means (S) =	16.08	7.13
S.e.d. between 2 Cutting Frequency means (C) =	19.70	8.73
S.e.d. between 2 Nitrogen means (N) =	16.08	7.13
S.e.d. between 2 S X C means =	27.86	12.35
S.e.d. between 2 S X N means =	22.74	10.08
S.e.d. between 2 C X N means =	27.86	12.35
S.e.d. between 2 S X C X N means =	39.39	17.46

Table 12: Effect of Sward type, cutting frequency and fertilizer N application on number of leaves per Verano stylo plant at various periods of the year 2006

		Cutting frequency (weeks)		
Sward type	Fertilizer N (kg ha^{-1})	4	8	Mean
	August 12 – October 7 (1st 8-weeks period)			
Verano stylo	0	97.6	138.6	118.1
	300	131.1	196.2	163.7
	mean	114.3	167.4	140.9
Verano stylo in mixture	0	52.2	60.7	56.4
	300	48.3	58.3	53.3
	mean	50.3	59.5	54.9
Cutting Frequency mean		82.3	113.5	97.9
Fertilizer mean:	0kg Nha^{-1} = 87.2		300 kg Nha^{-1} = 108.5	
	October 7 – December 2 (2nd 8-weeks period)			
Verano stylo	0	278.9	78.9	178.9
	300	97.5	103.7	100.6
	mean	188.2	91.3	139.7
Verano stylo in mixture	0	70.5	47.3	58.9
	300	59.7	76.4	68.1
	mean	65.1	61.9	63.5
Cutting Frequency mean		126.6	76.6	101.6
Fertilizer mean:	0kg Nha^{-1} = 118.9		300 kg Nha^{1} = 84.3	

	1st period	2nd period
S.e.d. between 2 Sward Type means (S) =	13.80	34.97
S.e.d. between 2 Cutting Frequency means (C) =	13.80	34.97
S.e.d. between 2 Nitrogen means (N) =	13.80	34.97
S.e.d. between 2 S X C means =	19.51	49.45
S.e.d. between 2 S X N means =	19.51	49.45
S.e.d. between 2 C X N means =	19.51	49.45
S.e.d. between 2 S X C X N means =	27.59	69.93

Table 13: Effect of Sward type, cutting frequency and fertilizer N application on number of leaves per Verano stylo plant at various periods of the year 2007

		Cutting frequency (weeks)		
Sward type	Fertilizer N (kg ha^{-1})	4	8	Mean
		May 29 – July 24 (1st 8 weeks period)		
Verano stylo	0	87.5	66.6	77.0
	300	96.1	110.7	103.4
	mean	91.8	88.6	90.2
Verano stylo in mixture	0	103.3	179.1	141.2
	300	102.9	170.0	136.5
	mean	103.1	174.6	138.8
Cutting Frequency mean		97.5	131.6	114.5
Fertilizer mean:	0kg Nha^{-1} = 109.1		300 kg Nha^{-1} =119.9	
		July 24 – September 18 (2nd 8 weeks period)		
Verano stylo	0	64.8	134.7	99.8
	300	92.4	96.3	94.3
	mean	78.6	115.5	97.0
Verano stylo in mixture	0	80.2	161.8	121.0
	300	138.9	146.9	142.9
	mean	109.5	154.3	131.9
Cutting Frequency mean		94.1	134.9	114.5
Fertilizer mean:	0kg Nha^{-1} = 110.4		300 kg Nha^{-1} =118.6	
		September 18 – November 13 (3rd 8 weeks period)		
Verano stylo	0	67.9	75.8	71.9
	300	74.9	132.3	103.6
	mean	71.4	104.1	87.8
Verano stylo in mixture	0	79.9	124.3	102.1
	300	89.7	126.2	108.0
	mean	84.8	125.3	105.0
Cutting Frequency mean		78.1	114.7	96.4
Fertilizer mean:	0kg Nha^{-1} = 87.0		300 kg Nha^{-1} =105.8	

	1st period	2nd period	3rd period
S.e.d. between 2 Sward Type means (S) =	12.68	13.88	13.31
S.e.d. between 2 Cutting interval means (C) =	12.68	13.88	13.31
S.e.d. between 2 Nitrogen means (N) =	12.68	13.88	13.31
S.e.d. between 2 S X C means =	17.94	19.63	18.82
S.e.d. between 2 S X N means =	17.94	19.63	18.82
S.e.d. between 2 C X N means =	17.94	19.63	18.82
S.e.d. between 2 S X C X N means =	25.37	27.76	26.61

During the first period of the year 2006, the infrequent cutting interval of 8 weeks significantly produced greater number of branches per legume plant compared with the 4 weeks (Table 15). Cutting interval did not influence the number of branches per plant at the second period. Fertilizer-N application showed no effect on the number of branches per plant at both periods. Greater number of branches was obtained in pure legume swards compared with where legume was in mixture with grass at both periods. The number of branches per plant appeared to increase with season.

Cutting interval treatment had a significant effect on the number of branches per legume plant only at the third period of 2007; where the 8 weeks interval produced greater number of branches than the 4 weeks (Table 16). Fertilizer-N application did not influence the number of branches per plant at any period. The legume plants grown in mixture with grass produced significantly greater number of plant branches than where legume was grown alone during the first two periods. Sward type had no effect on the number of branches at the third period of the year.

Table 14: Effects of sward type, cutting frequency and fertilizer-N application on number of the branches per Verano stylo plant in 2006 and 2007

		Cutting frequency (weeks)			
Sward type	Fertilizer-N (kg ha^{-1})	4	8	12	Mean
			2006		
Verano stylo	0	38.1	40.1	90.2	56.1
	300	31.8	44.2	115.1	63.7
	Mean	35.0	42.1	102.7	59.9
Verano stylo in mixture	0	17.1	18.3	36.2	23.9
	300	20.1	18.2	29.2	22.5
	Mean	18.6	18.2	32.7	23.2
Cutting Frequency Mean		26.8	30.2	67.7	41.6
Fertilizer Mean	0kg Nha^{-1} = 40.0		300kg Nha^{-1} = 43.1		
			2007		
Verano stylo	0	17.9	24.3	25.5	22.6
	300	22.2	30.9	23.8	25.6
	Mean	20.1	27.6	24.6	24.1
Verano stylo in mixture	0	22.6	36.9	33.4	31.0
	300	29.5	37.2	39.3	35.3
	Mean	26.1	37.0	36.3	33.1
Cutting Frequency Mean		23.1	32.3	30.5	28.6
Fertilizer Mean	0kg Nha^{-1} =26.8		300kg Nha^{-1} =30.5		

	2006	2007
S.e.d. between 2 Sward Type means (S) =	7.00	2.74
S.e.d. between 2 Cutting Frequency means (C) =	8.58	3.35
S.e.d. between 2 Nitrogen means (N) =	7.00	2.74
S.e.d. between 2 S X C means =	12.13	4.74
S.e.d. between 2 S X N means =	9.90	3.87
S.e.d. between 2 C X N means =	12.13	4.74
S.e.d. between 2 S X C X N means =	17.15	6.71

Table 15: Effect of Sward type, cutting frequency and fertilizer N application on the number of branches per Verano stylo plant at various periods of the year 2006

		Cutting frequency (weeks)		
Sward type	Fertilizer N (kg ha^{-1})	4	8	Mean
	August 12 – October 7 (1st 8-weeks period)			
Verano stylo	0	25.9	42.3	34.1
	300	28.7	45.3	37.0
	mean	27.3	43.8	35.5
Verano stylo in mixture	0	12.9	14.9	13.9
	300	15.7	13.8	14.8
	mean	14.3	14.3	14.3
Cutting Frequency mean		20.8	29.1	24.9
Fertilizer mean:	0kg Nha^{-1} =24.0		300 kg Nha^{-1} =25.9	
	October 7 – December 2 (2nd 8-weeks period)			
Verano stylo	0	50.3	37.8	44.1
	300	35.0	43.1	39.0
	mean	42.7	40.5	41.6
Verano stylo in mixture	0	21.4	21.7	21.5
	300	24.4	22.6	23.5
	mean	22.9	22.1	22.5
Cutting Frequency mean		32.8	31.3	32.0
Fertilizer mean:	0kg Nha^{-1} =32.8		300 kg Nha^{1} =31.3	

	1st period	2nd period
S.e.d. between 2 Sward Type means (S) =	2.53	6.75
S.e.d. between 2 Cutting Frequency means (C) =	2.53	6.75
S.e.d. between 2 Nitrogen means (N) =	2.53	6.75
S.e.d. between 2 S X C means =	3.57	9.54
S.e.d. between 2 S X N means =	3.57	9.54
S.e.d. between 2 C X N means =	3.57	9.54
S.e.d. between 2 S X C X N means =	5.05	13.50

Table 16: Effect of Sward type, cutting frequency and fertilizer N application on the number of branches per Verano stylo plant at various periods of the year 2007

		Cutting frequency (weeks)		
Sward type	Fertilizer N (kg ha^{-1})	4	8	Mean
		May 29 – July 24 (1st 8 weeks period)		
Verano stylo	0	21.9	17.2	19.5
	300	25.3	23.8	24.5
	mean	23.6	20.5	22.0
Verano stylo in mixture	0	22.0	30.6	26.3
	300	25.6	39.4	32.5
	mean	23.8	35.0	29.4
Cutting Frequency mean		23.7	27.7	25.7
Fertilizer mean:	0kg Nha^{-1} = 22.9		300 kg Nha^{-1} = 28.5	
		July 24 – September 18 (2nd 8 weeks period)		
Verano stylo	0	14.1	29.5	21.8
	300	21.2	22.0	21.6
	mean	17.6	25.8	21.7
Verano stylo in mixture	0	26.0	42.1	34.1
	300	35.7	37.4	36.6
	mean	30.9	39.8	35.3
Cutting Frequency mean		24.3	32.8	28.5
Fertilizer mean:	0kg Nha^{-1} = 27.9		300 kg Nha^{-1} = 29.1	
		September 18 – November 13 (3rd 8 weeks period)		
Verano stylo	0	17.8	26.2	22.0
	300	20.1	46.8	33.4
	mean	18.9	36.5	27.7
Verano stylo in mixture	0	20.8	38.1	29.4
	300	27.3	34.7	31.0
	mean	24.0	36.4	30.2
Cutting Frequency mean		21.5	36.4	29.0
Fertilizer mean:	0kg Nha^{-1} = 25.7		300 kg Nha^{-1} = 32.2	

	1st period	2nd period	3rd period
S.e.d. between 2 Sward Type means (S) =	2.89	4.22	6.37
S.e.d. between 2 Cutting Frequency means (C) =	2.89	4.22	6.37
S.e.d. between 2 Nitrogen means (N) =	2.89	4.22	6.37
S.e.d. between 2 S X C means =	4.09	5.97	9.01
S.e.d. between 2 S X N means =	4.09	5.97	9.01
S.e.d. between 2 C X N means =	4.09	5.97	9.01
S.e.d. between 2 S X C X N means =	5.79	8.45	12.74

DISCUSSION

The significant reductions in the height, number of branches and number of leaves per legume plant occasionally observed in grass-legume mixed swards in the present work had earlier been shown as some morphogenetic changes; which are presumably mechanisms for individual plants to adapt to changes in light resource availability (Ballare *et al*., 1995). Changes in sward structure resulting from fragmentation and loss of individuals or species had been shown to alter light environment and further influenced competitive interactions among plants (Ballare *et al*., 1995).

The significant increase in heights of grass and legume species with increase in interval between cuts and with nitrogen application has also being reported earlier by Wilman and Asiegbu (1982). Working with perennial ryegrass (*Lolium perenne*) in a perennial ryegrass-white clover swards, these authors obtained the highest plant height with 8 – 12 weeks interval of cuts and the lowest with 3-weekly interval. They also reported that plant height increased with incremental application of fertilizer N, indicating that higher plant height with increasing application of N could partly be explained with the propensity for greater leaf area with increasing N rates.

Nitrogen application has been shown to stimulate grass growth and conversely reduce legume growth in a mixed sward (Brunet *et al.*, 1990; Aydin and Uzun, 2005). To encourage stylo in mixture with guinea grass and maintain a balance in the growth and proportions of grass and legume in mixture, one needs to take into account, the adverse effect of defoliation as well as of the potential benefit of defoliation in terms of reduced competition from grass; when grass is not competing strongly, the stylo may benefit from a period of uninterrupted growth, whereas, when the grass is competing strongly and over-

growing the stylo, defoliation may provide some net benefit to the stylo. Wilman and Asiegbu (1982) showed that reduction in grass tiller density of perennial ryegrass (*Lolium perenne*) in a perennial ryegrass-white clover swards; as a result of increasing the interval between harvests, favoured the legume whereas the greater difference in height between the grass and the legume with the longer intervals acted against the legume. This could account for the reduction in height, number of leaves per plant and number of branches per legume plant in mixture with grass as observed in the present work.

The low dry matter yields of herbage obtained at 8 weeks after planting apparently resulted from the poor nutrient status of the soil. The soil of the experimental site of the present study was low in nitrogen, potassium, magnesium, and base saturation and was acidic in reaction. The observed nutrient deficiencies of the site could partly account for the low productivity.

The general reduction in plant growth obtained during the dry season had been recognized for tropical pastures (Onyeonagu and Asiegbu, 2005). Increases in plant height, number of leaves per plant and number of branches per plant obtained in the present study followed the rainfall patterns in 2006 and 2007 seasons. Whether for 4 or 8 weeks interval of cuts, the October-December or September-November periods generally had the least values of the above parameters compared with the May-October periods. This could be partly attributed to reduced moisture and nutrient availability and uptake at the dry periods of 2006 and 2007.

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