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Effect of Planting Patterns and Age at Harvest of Two Cultivars of *Lablab purpureus* in *Andropogon gayanus* on Agronomic Characteristic and Quality of Grass/Legume Mixtures

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ABSTRACT

Research was conducted to investigate the contribution of two legume cultivars of *Lablab purpureus* cv. Highworth (early maturing) and *Lablab purpureus* cv. Rongai (late maturing) to total fodder productivity and nutritive value when intercropped with Gamba grass (*Andropogon gayanus* cv. Kunth). There were nine treatments in all consisting of monocultures of grass, legumes and grass-legume mixtures in the ratios 1:1, 1:2 and 1:3 for each cultivar. The total dry matter yield, Relative yield (RY), land equivalent ratio (LER) and competitive ratio (CR) of the grass and legumes were estimated at 10 and 15 weeks after planting before flowering. Overall total herbage yield of the mixtures was higher than those of grass. In all the mixtures, incorporation of *L. purpureus* cv. Rongai in *A. gayanus* gave higher ($P>0.05$) CP than Highworth. The mixture of *A. gayanus* with double rows of *L. purpureus* cv. Rongai gave the highest ($P<0.05$) mineral contents while the least were recorded in sole *A. gayanus*. It was concluded that double rows of *L. purpureus* were recommended as the most compatible combination to improve the forage quantity and quality of *A. gayanus*.

Keywords: Cultivars, grass-legume, highworth, relative yield, rongai

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INTRODUCTION

In most developing tropical countries, animal production from pastures is low compared to developed countries. Pasture grasses (mainly C4) frequently contain

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crude protein levels of 8% or less, which are inadequate for animal production (Humphreys, 1991). During the low-rainfall season (dry season), there is a drastic decrease in the nutritional quality of tropical grasses, which is reflected by low crude protein (CP) and increased lignin content in the cell wall (Paulino *et al.,* 2008). The limited CP availability provides the critical threshold for adequate microbial growth on the fibrous carbohydrates in basal forage (Lazzarini *et al.,* 2009). This CP deficiency implies poor utilisation of potentially degradable cell wall by microorganisms and results in decreased intake and animal performance (Paulino *et al.,* 2008). Introduction of forage legumes is one of the strategies for improvement of grassland productivity. The benefits of legume-grass association can be expressed, among others, in terms of the enhanced dry matter yield, nitrogen content of herbage, animal intake of forage and animal productivity. Grass-legume mixtures are a means of improving productivity compared to monocultures without any additional investment. Yields are generally higher in mixtures because of more efficient light utilisation and transfer of symbiotically fixed nitrogen to grasses (Ledgard, 1991). Baba *et al*., (2013) reported in an experiment that a Guinea-Arachis mixture gave higher cumulative dry matter yield than pure guinea grass.

Of the species (*Andropogon gayanus, Brachiaria spp* and *Panicum maximum*) that are well adapted to a wide range of relevant environmental conditions, only *Andropogon gayanus* (Gamba grass) grows reasonably well in both the wet season and long into the dry season Phengsavanh, 1997). Gamba grass has soft leaves and grows well on infertile, acid soils in hot climates and in a wide range of climates, but is particularly useful in areas with a long dry season. Gamba grass stays green long into the dry season when most other grasses are already dry, is easy to cut and can tolerate grazing. Gamba provides palatable forage when young but feeding value declines rapidly with age and decreasing leaf/stem ratio. Mineral content is low (0.08 P and 0.27 Ca in DM) (Ajiji *et al*., 2013). Agishi (1985) reported that gamba grass is available in abundance in almost all ecological zones in Nigeria. The problem with gamba, like other tropical grasses, is the rapid decline in crude protein and soluble carbohydrate with age. This is coupled with a progressive increase in crude fibre and lignin (Lambert & Litherland, 2000)

Lablab purpureus combines a great number of qualities that can be used successfully under various conditions. Its first advantage is its adaptability; not only is it drought resistant, it is able to grow in a diverse range of environmental conditions worldwide. Staying green during the dry season, it has been known to provide up to six tonnes of dry matter/ha (Murphy & Colucci, 1999). Being palatable to livestock, it is an adequate source of much-needed protein and can be utilised in several different ways. In several experiments it has been observed to increase livestock weight and milk production during the dry season. *L. purpureus* with its ability to out-yield conventional crops, especially during the dry season, and its enhanced nutritive value, is a fodder crop of great significance for the tropics.

Though lablab is known in many countries and has the capability of being an outstanding resource for agricultural systems in the tropics, it is not being used to its full potential (Evans, 2002). In many areas where lablab could be beneficial, ability to buy seed is restricted by economic constraints, and producers' willingness to take the risk in trying a new practice is guarded by traditional paradigms. Effort must be devoted to conducting more research to extend both technical and practical knowledge about lablab so that its full potential may be achieved.

The objectives of this study is to evaluate the potential of Andropogon as one of the tropical grasses with rapidly declining crude protein and the solube carbohydrate content in intercrops with different cultivars of lablab, which has a different growth pattern.

MATERIALS AND METHODS

Experimental Sites

The experiment was conducted from May 2011 to May 2012 at the Muturu Paddock of the IFSERAR Farm, Federal University of Agriculture, Abeokuta. The experimental site lies within the savanna agro-ecological zone of South Western Nigeria (latitude: 7°N, longitude 3.5°E, (Google earth, 2011). With an average annual rainfall of 1037mm Abeokuta has a bimodal rainfall pattern that typically peaks in July and September with a break of two to three weeks in August. The relative humidity in the rainy (late March-October) and dry (November-early March) season ranges between 63-96% and 55-84% respectively (Fig.1). The temperature of the soil ranges from 24.5 to 31.0°C (Ogun-

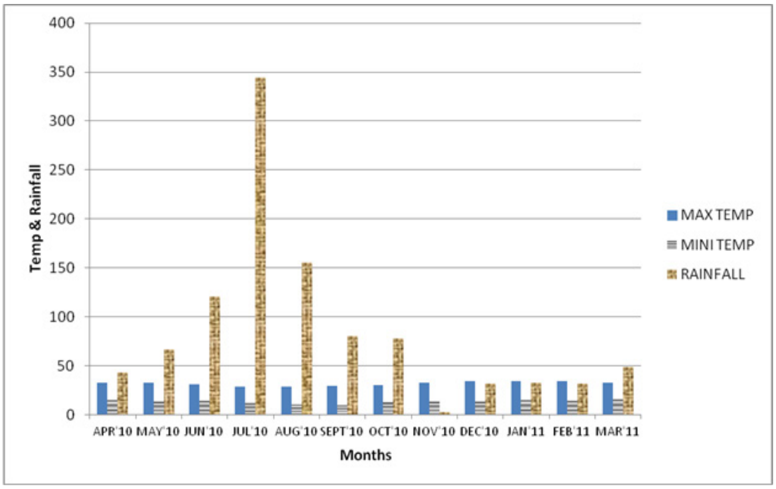

Fig.1: Temperature (^oC) and Rainfall (mm) for the experimental period (April 2010 to March 2011)

Source: Ogun-Osun River Basin Development Authority, Abeokuta, Nigeria

Osun River Basin Development Authority, Abeokuta, Nigeria).

Procedure

A land area of 0.15 ha was ploughed, harrowed and levelled before plots layouts. The land was divided into three blocks to cater for the topography of the experiment site and each block represented a replicate. Three core samples of soil (0–15cm) were randomly collected from the plots before planting. These were bulked for each block and analysed for physical (particle size) and chemical properties (pH, total N, organic carbon, C: N ratio, available P, available N, cation exchange capacity and acidity The total nitrogen of the soil was 0.11%, the organic carbon was 1.29 % and the available phosphorus was 53.87mg.kg^{-1}. Exchangeable cations, namely sodium, was 0.80cmol.kg^{-1} and potassium was 0.20cmol. kg^{-1} while calcium and magnesium were 2.77 and2.72cmol.kg^{-1} respectively.

Each block was later divided into nine plots of 7x7m^2 each, representing the number of treatments. The experiment was a randomised complete block design. The trial comprises two cultivars of *L. purpureus*, namely Rongai and Highworth, planted as single, double and triple rows between *A. gayanus* with each legume and grass planted sole to give nine treatments as summarised: single rows of *L. purpureus* cv. Rongai between *A. gayanus* rows, double rows of *L. purpureus* cv. Rongai between *A. gayanus* rows, triple rows of *L. purpureus* cv. Rongai between *A. gayanus* rows, single rows of *L. purpureus* cv. Highworth between *A. gayanus* rows, double rows of *L. purpureus* cv. Highworth between *A. gayanus* rows, triple rows of *L. purpureus* cv. Highworth between *A. gayanus* rows, and sole *A. gayanus*, *L. purpureus* cv. Rongai and sole *L. purpureus* cv. Highworth.

The crown splits of the *A. gayanus* were sourced from previously established plots because the Andropogon seeds were not readily available. The grasses were planted at the spacing of 1m between and within rows on 14^t May 2010, giving 7 rows each with 7 stools and an overall population equivalent to 10,000 stools per ha. The legumes were sowed at 20kg/ha and 6plants/m^2 giving an equivalent of 60,000 plants/ha. The single rows of legumes were drilled in the middle of the grass rows (50cm from the rows of grasses) while in the double and triple row treatments, the legumes were sown at 30cm from the rows of grasses and 40cm apart and 30cm from the grasses and 20cm apart respectively.

The seed of *L. purpureus* var. Highworth (early maturing with purple flowers and white seeds) and *L. purpureus* var. Rongai (late maturing with white flowers and light brown seeds) were obtained from the National Animal Production Research Institute (NAPRI), Zaria and planted at the recommended rate of 15kg/ha two weeks after planting the grass (28 May) to allow the grass to recover and become established as legume grows faster than grass and so it was critical to avoid competition . The plots were free of weeds throughout the period of study.

Data Collection

Plant growth measurement was taken at two-week intervals throughout the experimental periods while specific measurements were taken six and 10 weeks after planting to estimate the effect of time of harvest. The estimations of tiller density were carried out by counting the number of tillers within two randomly located 1m^2 quadrats at every harvesting time throughout the experimental period. Estimations of the height of the grass and legumes were carried out by measuring from the base of the plant to where the last leaf on the stem emerged with the aid of a metre rule on 10 randomly selected stands per plot at every harvesting time.

The estimation of total yield, relative yield (RY), land equivalent ratio (LER) and competitive ratio (CR) was carried out by harvesting the herbage materials within the range of two randomly located 1mx1m quadrat at different ages before the flowering of Andropogon at the 10th and 15th weeks after planting. The quadrat was thrown three times per replicate. The dry matter percentage was estimated as dry matter yield (DMY) = dry matter percentage x fresh sample from 1m^2, which afterwards was extrapolated in tonnes per hectare. Relative yield (RY), land equivalent ratio (LER) and competitive ratio (CR) were determined following the equations of Ghosh *et al.* (2006) as:

RY = RYab = DMYab/DMYaa,
RYba = DMYba/DMYbb
LER = RYab + RYba

In the equation, the following definitions apply: ab refers to performance of *A. gayanus* (a) mixed with either *L. purpureus* cv. Rongai or *L. purpureus* cv. Highworth (b); ba is the performance of either of the legumes (b) mixed with *A. gayanus*; aa is the performance of *A. gayanus* in monoculture and bb is the performance of either of the legumes as a monoculture.

Chemical compositions. Forage samples were harvested at the 10th and 15th weeks after planting, which coincided with 50% and 100% flowering of Andropogon so as to evaluate the effect of legume inclusion when the quality of the grass was declining.

Proximate composition: The contents of dry matter, crude protein, ether extract and ash were determined according to A.O.A.C. (1995). Fibre fraction analysis: Neutral detergent fibre (NDF); acid detergent fibre (ADF); acid detergent lignin (ADL) (Van Soest *et al*., 1991); cellulose was taken as the difference between ADF and ADL while hemicellulose was calculated as the difference between NDF and ADF.

Mineral determination: The samples of the grasses were dried in a forced draught oven at 105^{o}C for 24 hours and were analysed for some macro minerals (Ca, P, K, Na and Mg). The concentration of potassium (K) was estimated with a flame photometer after wet digestion in nitric acid and per chloric acid. Concentration of calcium and phosphorus were determined with atomic absorption spectrophotometry (Fritz & Schenk, 1979).

Statistical Analysis

The data collected was subjected to a two-way analysis of variance (ANOVA), SAS (1999). Duncan's means separation procedure was used to test the level of significance among the means (Duncan, 1955).

RESULTS

Plant growth

The height of the grass in all the mixtures increased as the rows of legume increased to double in each plot (Table 1). Andropogon was tallest ($P<0.05$) when planted with double rows of Highworth but lowest in both varieties when the rows were tripled. Sole grass was comparable in height with mixture except in the triple rows of legumes.

The height of grass increased with age both in cultivars and all planting patterns. Andropogon produced a higher ($P<0.05$) tiller number (15.3) when planted with double rows of *L. purpureus* cv. Highworth than when planted in the sole plot, while the tiller number was similar in the other mixtures

The height of both Rongai and Highworth in the sole plot was higher ($P<0.05$) than in the mixed plots. Within the mixed plots, the height of the Rongai increased from the single to the double rows; however, Highworth reduced ($P<0.05$) in height as its rows in the mixed plots increased. Both cultivars of lablab increased ($P<0.05$) in height with advancing age.

Relative Yield

Planting both legume cultivars in single or double rows had no significant effect on the relative yield of Andropogon in the mixed culture. However, the RY of Andropogon reduced ($P<0.05$) when the rows of Rongai were tripled. The mean RYs of the components of the mixtures throughout the experiment presented in Table 3 shows that the mean RYs of both grasses and legumes were less than unity except for the double rows of Rongai. This indicated that the DM yields of both grasses and legumes in the mixtures were less than those for pure stands; however, all exceeded 0.5 (Table 1). The RY increased in grass as the age at harvest increased but were similar in legume in both harvests. The mean LERs of all grass-legume mixtures in the experimental periods were greater than 1 and ranged between 1.21 and 1.78, demonstrating higher yields in the mixtures than the average of the pure stands.

Dry Matter Yield

Dry matter forage yields of the grass and legumes in the sole and mixed plots were significantly influenced by different planting patterns and age at harvest (Table 1). The dry matter yield of grass increased from the single row to double rows of the legumes and then declined in the triple rows. Planting double rows of legumes with grasses produced higher ($P<0.05$) grass forage. However, these yields were comparable with the yield recorded when grass was planted as a sole plant.

TABLE 1
Plant Growth, Biological Indices and Herbage Yield of Grass-Legume Mixtures as Influenced by Planting Pattern, Cultivars and Age at Harvest

	Plant height (cm)		Grass tiller	Relative yield			Dry matter Yield (t/ha)		Total Dry matter
Mixture of *A. gayanus* with	Grass	Legume	number	Grass	Legume	LER	Grass	Legume	yield (t/ha)
Single rows of *L. purpureus* cv. Rongai	103^{b}	49.3^{c}	13.4^{ab}	0.83^{a}	0.87^{b}	1.70^{b}	5.11^{b}	6.25^{ab}	11.4^{c}
Double rows of *L. purpureus* cv. Rongai	122^{ab}	57.4^{b}	9.25^{ab}	0.89^{a}	0.81^{b}	1.70^{b}	6.20^{a}	7.22^{ab}	13.4^{a}
Triple rows of *L. purpureus* cv. Rongai	94.8^{c}	51.4^{b}	10.8^{ab}	0.19^{b}	1.02^{a}	1.21^{d}	5.45^{b}	5.69^{b}	11.1^{c}
Single rows of *L. purpureus* cv. Highworth	115^{ab}	73.2^{ab}	11.9^{ab}	0.80^{a}	0.97^{a}	1.77^{a}	5.21^{b}	7.18^{ab}	12.4^{b}
Double rows of *L. purpureus* cv. Highworth	135^{a}	39.9^{cd}	15.3^{a}	0.81^{a}	0.97^{a}	1.78^{a}	6.59^{a}	7.20^{ab}	13.8^{a}
Triple rows of *L. purpureus* cv. Highworth	83.2^{c}	15.6^{d}	10.2^{b}	0.83^{a}	0.83^{b}	1.66^{c}	4.94^{b}	6.06^{ab}	11.0^{c}
Sole *A. gayanus*	107^{ab}	-	7.63^{b}	-	-	-	6.23^{a}	-	6.20^{e}
Sole *L. purpureus* cv. Rongai	-	88.4^{a}	-	-	-	-	-	7.12^{ab}	7.12^{d}
Sole *L. purpureus* cv. Highworth	-	87.3^{a}	-	-	-	-	-	7.78^{a}	7.48^{d}
SEM	7.63	5.93	0.97	0.01	0.02	0.05	0.13	1.36	1.12
Age									
6 weeks after planting	62.2^{b}	28.3^{b}	6.55^{b}	0.53^{b}	0.73	1.26^{b}	3.28^{b}	5.76^{b}	9.04^{b}
10 weeks after planting	108^{a}	75.8^{a}	10.9^{a}	0.89^{a}	0.85	1.74^{a}	5.55^{a}	6.29^{a}	11.8^{a}
SEM	7.63	5.93	0.97	0.33	0.04	0.23	3.93	3.35	3.04

In columns: values with same letters as superscripts do not differ significantly by DMRT at $P<0.05$

Sole *L. purpureus* cv. Highworth gave the highest ($P<0.05$) legume dry matter yield (7.78t/ha) while the least was recorded when triple rows of Rongai were planted in Andropogon plots. The dry matter yield of *L. purpureus* cv. Highworth was similar to that of *L. purpureus* cv. Rongai when both were planted in a single row within Andropogon. Similar results were recorded when both legume cultivars were planted in double and triple rows within Andropogon. Dry matter yield of grass, legumes and their mixtures in the first harvest were generally lower than in the second harvest.

Quality

The proximate composition of the forage mixture and their sole was affected ($P<0.05$) by legume cultivars, planting pattern and age at harvest (Table 2). The DM content of the mixtures and their sole ranged from the highest value of 950g.kg^{-1} DM in the mixtures *A. gayanus* and double rows of *L. purpureus* cv. Highworth to the least value of 903g.kg^{-1} DM from sole Highworth. The mixture of *A. gayanus* with Highworth gave a higher DM than Rongai, while in both cultivars, an increase in row ratio gave similar dry matter. The DM content of the forages in sole or when mixed at both ages was similar.

The crude protein (CP) of the mixtures of *A. gayanus* and each of the cultivars of *L. purpureus* increased ($P< 0.05$) as the row ratios of the legume increased from single to double and then declined ($P>0.05$) as the row ratio tripled. The highest CP content was recorded from the sole plots of both legume cultivars while the least (70.9g.kg^{-1} DM) was recorded from the sole grass plot. The CP content of the forages in the mixture and sole reduced ($P<0.05$) as the age at harvest advanced.

The EE content trend was similar to that of the CP content with *L. purpureus* cv. Rongai in *A. gayanus* but was reversed with cv. Highworth. Sole Rongai contained the highest EE content of 73.9g.kg^{-1} DM while the EE content was similar in both ages.

The ash content values ranged between 90.2g.kg^{-1} DM in the mixture of *A. gayanus* with single rows of *L. purpureus* cv. Rongai and 124g.kg^{-1} DM in the sole *L. purpureus* cv. Rongai. The ash content of each legume cultivar was similar in mixture to *A. gayanus* in the double and triple row ratios.

Intercropping Rongai and Highworth in a single row with Andropogon had no significant effect on the NDF content of the mixtures, which were comparable ($P>0.05$) with NDF content of the sole grass, while the NDF content (425g.kg^{-1} DM) was least in the sole plot of *L. purpureus* cv. Highworth.

When intercropped in triple rows with Andropogon, the NDF content of the mixed sward reduced significantly ($P<0.05$). The NDF content increased in all treatments with advanced age at harvest (Table 2).

The ADF contents of the mixed sward reduced ($P<0.05$) with increased rows of the legume *L. purpureus* cv. Highworth. ADL content of the mixed sward decreased ($P<0.05$) as both legumes were intercropped with Andropogon from the single row to double rows and then increased as the

TABLE 2
Proximate and Fibre Composition (g.kg-1 DM) of the Grass-Legume Mixture as Influenced by Planting Rows, Legume Cultivars and Age at Harvest

Mixture of *A.gayanus* with	Dry matter	Crude protein	Ether extract	Ash	Neutral Detergent Fibre	Acid Detergent Fibre	Acid Detergent Lignin
Single rows of *L. purpureus* cv. Rongai	927^{bc}	121^{c}	42.1^{b}	90.2^{b}	606^{a}	384^{a}	135^{b}
Double rows of *L. purpureus* cv. Rongai	930^{bc}	146^{b}	58.9^{ab}	119^{ab}	596^{a}	368^{ab}	123^{c}
Triple rows of *L. purpureus* cv. Rongai	920^{bcd}	129^{bc}	58.8^{ab}	119^{ab}	577^{ab}	362^{ab}	130^{b}
Single rows of *L. purpureus* cv. Highworth	938^{ab}	119^{d}	54.3^{ab}	115^{ab}	597^{a}	340^{b}	126^{bc}
Double rows of *L. purpureus* cv. Highworth	950^{a}	128^{bc}	49.2^{ab}	109^{b}	553^{ab}	313^{c}	116^{c}
Triple rows of *L. purpureus* cv. Highworth	952^{a}	125^{bc}	43.1^{b}	101^{b}	513^{b}	297^{d}	125^{ab}
Sole *A. gayanus*	925^{bcd}	70.9^{d}	54.0^{ab}	104^{b}	637^{a}	473^{a}	160^{a}
Sole *L. purpureus* cv. Rongai	913^{cd}	157^{a}	73.9^{a}	124^{a}	474^{c}	341^{b}	120^{c}
Sole *L. purpureus* cv. Highworth	903^{d}	153^{a}	55.5^{ab}	116^{ab}	425^{d}	317^{c}	128^{bc}
SEM	0.31	0.47	0.38	0.3	2.87	2.1	0.95
Age							
10 weeks after planting	92.89^{a}	129^{a}	58.0	91.5^{a}	729^{b}	501^{a}	182^{a}
15 weeks after planting	92.78^{a}	107^{b}	56.8	86.0^{b}	761^{a}	528^{b}	195^{b}
SEM	0.31	0.89	0.26	0.3	1.9	1.82	0.95

a, b, c, d indicates different superscripts in the same column differ significantly (P<0.05) rows tripled. Both ADF and ADL content increased ($P<0.05$) as the age at harvest increased.

The calcium content of the mixtures showed the same trend in both cultivars as they increased ($P<0.05$) from a single row of legumes to double rows but also decreased as the rows increased from double to triple (Table 3). In all the treatments, the mixture of *A. gayanus* with double rows of *L. purpureus* cv. Rongai gave the highest ($P<0.05$) calcium, sodium, phosphorus and magnesium contents while the least mineral contents were recorded when *A. gayanus* was planted sole.

DISCUSSION

The height of the Andropogon as a sole crop could be attributed to penetration of light, circulation of air and comparatively more nutritional area available to the sole crop under competition in the free environment. However, the reduction noted in the plant height of Andropogon due to intercropping at binary rows with legume was consistent with the report of Rashid and Himayatullah (2003).

In both double and triple rows of lablab, Rongai was taller than Highworth. This was primarily due to differences in growth habit that are genetically controlled. Highworth has a prostrate with a low growth habit of twining while Rongai is an erect bush type of plant (Hector & Smith, 2002). The reduction in the RY of the grass when the rows of Rongai were tripled may be due to a higher population of legumes resulting in higher competition for soil resources than showed by the grass (Baba *et al*., 2011). The mean LERs for the mixtures indicated a yield advantage of 21-78% over that from an average of pure stands of the different species (grass and legumes). This implies that sole crops would require 21-78% more land to achieve the yields obtained by the intercrops. This may indicate N contribution to the grass through nitrogen fixation by the legumes and its transfer from the legume component to the grass. This situation could be attributed to the efficient utilisation of plant growth factors by species in the mixture due to either temporal or spatial differences of their demands.

Relative yield total or LER value well above 1 suggests partial or no competition among species in the mixtures, probably made possible by the contribution of the legumes to the environment of the grass via nitrogen fixation (Tessema & Baar, 2006) or simply the mixtures avoided competition due to a different rooting pattern, which may have prevented the uptake of resources from the same soil strata.

Dry matter production is a function of the nature of competition among the various species in a mixture. The higher dry matter yield recorded when grasses and legumes were planted in 1:2 row ratio might have been due to better utilisation of space, light, nutrients and moisture than other planting patterns. Similar results were also obtained by Singh *et al*. (1983) and Dwivedi (1986). This implies that Andropogon benefited from double rows of legumes by producing high herbage although it was not significantly higher than

TABLE 3
Mineral Composition (g.kg-1 DM) of the Grass-Legume Mixture as Influenced by Planting Rows, Legume Cultivars and Age at Harvest

Mixture of *A.gayanus* with	Calcium	Sodium	Potassium	Phosphorus
Single rows of *L. purpureus* cv. Rongai	2.11^{d}	0.32^{b}	2.10^{c}	0.34^{e}
Double rows of *L. purpureus* cv. Rongai	14.3^{a}	3.26^{a}	24.1^{a}	3.48^{a}
Triple rows of *L. purpureus* cv. Rongai	8.56^{bc}	2.65^{a}	16.7^{ab}	2.72^{ab}
Single rows of *L. purpureus* cv. Highworth	9.69^{b}	3.59^{a}	18.3^{ab}	2.8^{ab}
Double rows of *L. purpureus* cv. Highworth	11.4^{ab}	3.65^{a}	19.2^{ab}	1.72^{c}
Triple rows of *L. purpureus* cv. Highworth	5.77^{c}	2.78^{a}	19.1^{ab}	2.39^{b}
Sole *A. gayanus*	2.01^{d}	0.28^{b}	2.00^{c}	0.25^{f}
Sole *L. purpureus* cv. Rongai	12.8^{ab}	3.27^{a}	11.8^{b}	1.13^{d}
Sole *L. purpureus* cv. Highworth	10.3^{ab}	3.20^{a}	17.1^{ab}	1.19^{d}
SEM	0.83	0.22	1.33	0.18
Age				
10 weeks after planting	11.8a	2.24	6.66b	1.47
15 weeks after planting	16.8b	2.72	9.81a	1.97
SEM	0.83	0.22	1.33	0.18

Values with same letters as superscripts do not differ significantly ($P<0.05$)

the sole grass. However, the combined total DM yield for grass/legumes intercrops was significantly high. Intercropping has been reported to increase light interception in the intercrops, reduce water evaporation and improve conservation of the soil moisture, resulting in higher DM compared with monocropping (Ghanbari *et al*., 2010). The high dry matter yields of grass in mixtures, which was comparable to the sole plot, could be due to the vigorous nature of grass growth and its ability to rapidly utilise the nitrogen in the soil, which is released following cultivation (Tessema & Baar, 2006). The rapid establishment of the grass may have had a profound effect on the root system that enabled it to extract growth resources from the soil (Kechero, 2008). This result implies that Andropogon can associate well with *L. purpureus*.

Generally, intercrops gave higher forage DM yield than the monocrops. Intercrops with maize, maize/Rongai produced more dry matter than maize pure stands while the yield of maize/Highworth was not significantly different from that of maize in the pure stands (Haque 1989).

The total dry matter yield of forages either in the mixed swards or sole cropping was higher when harvested at 5 weeks after planting than the harvest at 10 weeks after planting. This may be seen in the light of the fact that harvesting at 15 weeks after planting, both grass and legumes were relatively more established and thus able to utilise soil resources better for maximum growth. As both forages advanced to reproductive stage, DM accumulation tends to increased. Njarui *et al*. (2007) reported lower yield when grass-legumes were harvested early because the forages had not developed longer roots to compete for both nutrients and water.

The observed DM yield of grass in the double rows of both legume cultivars was higher than for both single and triple rows and was different from that of Ezenwa and Aken'ova (1996) where grass DM yield was higher with the single than double rows of verano planted between rows of guinea grass. Njarui *et al*. (2007) also recorded no difference in the DM yield of grass either in single or double rows of Seca and Sirato. This could be attributed to the species and their different growth habits and, most importantly, the plant population.

Generally the herbage yield recorded for Lablab in this study was higher than for those reported in Zimbabwe (Jingura *et al*., 2001) but lower than 10.2t/ha, which was obtained at 18 weeks in Zaria Nigeria (Ogedegbe *et al*., 2011). However, the yield recorded in the experiment suggests that both cultivars of lablab have the potential to supply adequate forage quantity for ruminant livestock in sub-Saharan Africa.

The highest CP content recorded when both cultivars were planted sole was lower than what Aganga and Autlwetse (2000) reported (16.4%) for whole plant lablab but was similar to within the range (12.7-14.1%) reported by Evan (2002) for whole plant. Legumes fix atmospheric nitrogen and, therefore, have a higher protein and feed value than associated grasses (Schwenke

& Kerridge, 1990). This contributed to the higher CP content recorded in both legume cultivars when planted sole.

The high CP content of the sole legume was reduced in the intercrop due to the dilution effect of the grass incorporation. However, when two rows of Rongai were incorporated into a single row Andropogon, the CP content was higher than in the other intercrop row ratios. The improvement in quality of forage in the 1:2 row ratios of grass-legume mixed pasture may possibly be the result of the fixation of a higher amount of nitrogen, either by direct excretion from the legume nodule root system or by decomposition of the nodule and root debris. These findings are in conformity with the result obtained by Singh *et al*. (1983).

The CP content of the sole *A. gayanus* obtained from this study was below the recommended CP level (8%) for optimum ruminant performance (Norton, 2003), but was improved by intercropping, which confirmed several reports. The crude protein yield, dry matter yield and ash content of maize forage increased by intercropping with legumes compared with the maize monoculture (Javanmard *et al*., 2009). Increasing the CP content in the diet has been reported to consistently enhance the concentration of NH_3–N in the rumen (Amole *et al*., 2013). It is evident from this study that intercrops of grass with legumes can substantially increase forage quantity and quality and decrease the requirements for protein supplements compared with sole grass.

The NDF content is important in ration formulation because it reflects the amount of forage that can be consumed by animals (Bingol *et al*., 2007). As NDF percentage increases, dry matter intake decreases (Van Soets , 1994). Intercropping Andropogon with three rows of Highworth reduced the NDF concentration. Lauriault *et al*. (2004) noted a similar report that intercropping with peas decreased NDF in all cereals. Thus, addition of lablab to Andropogon reduced the NDF and ADF concentrations, indicating potential for increasing forage intake. Dahmardeh *et al*. (2009) reported that maximum ADF (31.85%) was recorded by sowing maize alone while increasing the proportion of cowpea seeds to 50% in intercropping with maize, resulting in the lowest ADF (25-89%). Both NDF and ADF contents followed generally linear increase with advancing maturity. Similar results were reported by Turgut *et al*. (2008). As plants mature, photosynthetic products are more rapidly converted to structural components, thus having the effect of decreasing protein and soluble carbohydrate and increasing the structural cell wall components (Ammar *et al*., 2004).

Calcium is the most abundant and needed mineral in the animal body and it primarily functions as a component of the skeletal system. It is also involved in vital functions such as blood clotting, transmission of nerve impulse, muscle contractions and cardiac regulation (NRC 2001), *A. gayanus* with double rows of *L. purpureus* cv. Rongai supply the required calcium content without the need of supplementation.

Legumes are said to contain more mineral concentrations including calcium than grass species (Aregheore, 2002.) The mineral concentrations were adequate and sufficiently higher than the requirements of ruminants (NRC, 2001). Legume inclusion increased the sodium content of *A. gayanus*, thus confirming previous reports (Evitayani *et al*., 2004). K content also increased with lablab inclusion, which falls within the recommended range of 1 to 4% of DM in the diet by NRC (2001). The phosphorus content of Andropogon with double rows of *L. purpureus* cv. Rongai is the highest in this study and this can meet the dietary requirements of animals that are fed *A. gayanus* grass because phosphorus is vital for differentiation as a component of RNA and is also responsible for the formation of organic bone matrix in farm animals (NRC, 2001).

CONCLUSION

Gamba grass stays green long into the dry season when most other grasses are already dry, is easy to cut and can tolerate grazing, but there is rapid decline in crude protein and soluble carbohydrate and feeding value with age and low mineral content. It was concluded that *A. gayanus* formed a better association with *L. purpureus* cv. Rongai than with *cv. Highworth.* Double rows of *L. purpureus* are recommended as the most compatible combination to improve the forage quantity and quality of *A. gayanus*. The use of cereal-legume combinations may be attractive to organic meat or milk producers.

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