Asian Journal of Crop Science

ISSN 1994-7879

science alert
http://www.scialert.net

ANSInet
an open access publisher
http://ansinet.com

Asian Journal of Crop Science 4 (1): 1-11, 2012
ISSN 1994-7879 / DOI: 10.3923/ajcs.2012.1.11

Mineral Content of Lablab (*Lablab purpureus* L. Sweet) Herbage as Influenced by Phosphorus Application, Cutting Height and Age of Cutting at Samaru, Nigeria

[1,2]S.A. Ogedegbe, [1]V.B. Ogunlela, [1]O.O. Olufajo and [1]E.C. Odion
[1]Department of Agronomy, Faculty of Agriculture/Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria
[2]Department of Livestock Investigation, National Veterinary Research Institute, Vom, Nigeria

Corresponding Author: V.B. Ogunlela, Department of Agronomy, Faculty of Agriculture/Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria Tel: + 234 8037036425

ABSTRACT
As a result of the critical importance of herbage quality and danger of poor mineral nutrition of forage legumes that affect livestock feeds in Nigeria, this investigation was conducted. The experiment entailed field trials at Samaru, Nigeria over three wet seasons to evaluate the response of mineral composition of lablab (*Lablab purpureus* L. Sweet) herbage to phosphorus application and cutting treatments. The treatments were composed of factorial combinations of four rates of phosphorus application (0, 12, 24 and 36 kg P ha^{-1}), two cutting heights (10 and 20 cm) as the main plot and four cutting ages (6, 12, 18 weeks and at maturity) as the sub-plot a in split plot design with three replications. Cutting lablab to a 10 cm stubble produced significantly higher calcium and phosphorus concentrations in the dry herbage than cutting to 20 cm. The Ca:P ratio in the herbage increased as age of cutting increased but cutting height did not influence this parameter. A phosphorus application rate of 12 kg P ha^{-1} produced the highest ash concentration in lablab herbage under a 12-week cutting regime. However, the highest phosphorus concentration of lablab herbage was produced with a zero phosphorus application rate under a cutting height of 10 cm. Under the first herbage cut, ash content increased significantly with age of cutting. It is beneficial to feed lablab herbage to livestock before crop attains physiological maturity. The nutritive value of the herbage determines the most appropriate time to feed lablab herbage to livestock.

Key words: Herbage, lablab, mineral concentration, tissue analysis, cutting treatments

INTRODUCTION
Lablab (*Lablab purpureus* L.) is a climbing annual or short-lived perennial with long stems. It is a valuable feed resource for livestock production. It is a legume plant that can be grazed by both large and small ruminant animals (Muhammad *et al*., 2004). Its hay is palatable as well as being used making good silage. Forages are known to have an important role in the nutrition of ruminant animals in terms of providing energy, protein and mineral elements for chewing and rumination (Ahmad *et al*., 2000; Ranjbar, 2007). The importance is under-scored by the fact that a major constraint to livestock production in tropical Africa is the scarcity and fluctuating quality of year round forage supply (Ajayi *et al*., 2005). Furthermore, most available ruminant feeds and feedstuffs during the dry season have been described as fibrous, resulting in low digestibility and

poor livestock production (Richard *et al.*, 1994). The use of forage legumes such as lablab as feed supplements has been shown to enhance intake of poor quality roughages, improve growth rates and increase production efficiency in ruminants (Orden *et al.*, 2000).

The chemical composition and nutritive value of the grasses and legume species grown in Nigeria vary greatly, depending on the species and season of growth at which the grasses are cut or grazed (Aina and Onwukwe, 2002). Suitable legume species have the potential to ameliorate feed constraints, especially for cattle and other ruminants, during the dry season, through their higher nutritive value relative to natural fallows (Minson, 1990). Among the many introduced forage legumes that have so far been evaluated in Nigeria, lablab has been reported to be a promising crop for the northern Guinea savanna (Thomas and Sumberg, 1995; Iwuafor and Odunze, 1999; Ewansiha *et al.*, 2007). Lablab can be grazed or used for hay or silage. The foliage analysis result suggests that it had high protein content (15-30%) as well as high levels of lysine and digestibility (Valenzuela and Smith, 2002). The hay is high in crude protein (>17%), ash (>8%) and digestibility (>54%) (Murungweni *et al.*, 2004).

Phosphorus often determines the establishment and persistence of legumes (Hague *et al.*, 2008) and the importance of good re-growth, cutting height and age of pasture to its nutritive value and overall biomass production has been restated by several workers (Adjei and Gentry, 1996; Aina and Onwukwe, 2002; Odion and Singh, 2005; Ahmadi *et al.*, 2009). Smithson and Giller (2002) from their studies came to the conclusion that farm practices that address N through biological fixation should focus on soil P deficiencies, as well, simply because biological N fixation is limited by low soil P status among other factors. The concentration and balance of minerals, especially calcium and phosphorus is of paramount importance in ruminant nutrition. Consequently, it is desirable to know if more recent lablab accessions have adequate mineral compositions in their tissues (Muhammad *et al.*, 2004).

Consequently, further evaluation of lablab accession (ILRI 147) to determine the appropriate stages of growth to cut and obtain the maximum ash, calcium and phosphorus concentrations is necessary. The objective of this study therefore was to evaluate the effect of phosphorus application, cutting height and age of cutting on the mineral concentration of lablab fodder.

MATERIALS AND METHODS

Site description: Field trials were conducted during the 2006, 2007 and 2008 cropping seasons at the Institute for Agricultural Research (IAR) experimental farm, Ahmadu Bello University, Samaru (lat 11°11'N, long. 7°38'E, 686 m above sea level) in the northern Guinea savanna zone of Nigeria.

Treatments and experimental design: The lablab accession ILRI 147 which is also known as Highworth, black-seeded, was obtained from the International Livestock Research Institute (ILRI-Nigeria) and was evaluated in the study. A row spacing of 30 cm×30 cm and seed rate of 24 kg ha^{-1} which are recommended for fodder production were used in the experiment. The gross plot size was 5 m×3 m (15 m^2).

The treatments were factorial combinations of four rates of phosphorus application (0, 12, 24 and 36 kg P ha^{-1}) and two cutting height (10 and 20 cm above ground level) and four cutting ages (6 ,12 , 18 weeks after sowing(WAS) and at maturity). The experiment was a split plot design where phosphorus application × cutting height represented the main plot while cutting age was the subplot. The treatments were replicated three times.

Measurements: At each cutting age, the fodder from a gross sub-plot was cut, weighed and sub-sampled for dry weight determination in a Gallenkamp oven at 70°C. After dry weight determination, the sample was ground with a Christy and Norris laboratory mill (Christy and Norris Ltd, England) to pass through a 1 mm screen and labeled for tissue analysis of the dry herbage. The tissue analysis was carried out to determine the ash, calcium and phosphorous concentrations in the dry herbage according to the AOAC (2000) methods. For this, samples were dry-ashed at 600°C for 4 h. Phosphorus and calcium were determined by perchloric acid digestion (wet digestion) and levels were read using Atomic Absorption Spectrometer (Shimadzu AA-650 model) with the exception of P whose levels were estimated using Spetronic 20 Bausch and Lomb. Values for the Ca: P ratios were computed from the values obtained for P and Ca concentrations.

Data analysis: The data collected were subjected to one-way analysis of variance using the SAS software (SAS Institute, 2001) to determine the significance of treatment effects as described by Snedecor and Cochran (1967), while the means were separated using Duncan's multiple range test at the 5% level of probability (Steel *et al.*, 1997).

RESULTS

Table 1 shows the effect of phosphorus application, cutting height and age of cutting on lablab ash content at the 1st and 2nd herbage cuttings in 2007 and 2008 and the

Table 1: Effect of phosphorus application, cutting height and age of cutting on ash content (g kg^{-1}) of lablab herbage at the first and second cuttings in the 2007 and 2008 wet seasons and combined over both years at Samaru, Nigeria

	Ash (g kg^{-1})					
	1st cutting			2nd cutting		
Treatment	2007	2008	Combined	2007	2008	Combined
Phosphorus (kg P ha^{-1})						
0	90.7	77.9	84.3	103.1	101.0	102.1
12	90.5	77.1	83.8	102.0	104.1	103.1
24	89.2	79.9	84.5	97.0	101.0	99.1
36	98.2	84.3	91.2	102.4	99.0	101.0
SE±	4.33	5.78	3.43	3.47	3.11	2.33
Significance	NS	NS	NS	NS	NS	NS
Cutting height (cm)						
10	9.31	7.86	85.9	101.1	100.1	100.1
20	9.11	8.09	86.1	101.1	103.1	102.1
SE±	0.306	0.408	2.43	2.45	2.20	1.65
Significance	NS	NS	NS	NS	NS	NS
Age of cutting (WAS)						
6	109.3	70.2b	89.7a	100.4	103.0	102.1
12	81.8	70.7b	76.2b	104.0	101.0	102.0
18	81.5	92.2a	86.9a	102.0	100.4	100.5
Maturity	95.9	86.2b	91.0a	98.3	102.4	100.4
SE±	4.33	5.78	3.43	3.47	3.11	2.33
Significance	**	*	*	NS	NS	NS

Means within a column of any set of treatments followed by different letter are significantly different at 5% level of probability according to the Duncan's multiple range test, NS = not significant, *, ** = Significant at 5% and 1% levels of probability, respectively, WAS = weeks after sowing

Table 2: Interaction between phosphorus rate and age of cutting on ash content (g kg^{-1}) of lablab herbage at the second cutting combined over 2007 and 2008 wet seasons at Samaru, Nigeria

	Age of cutting (WAS)			
Phosphorus (kg P ha^{-1})	6th	12th	18th	Maturity
0	103ad	97bcd	107abc	98ad
12	102ad	111a	103ad	94cd
24	105abc	99ad	91d	99ad
36	95cd	98ad	99a d	109ab
SE ±		4.6		

Means followed by similar letter(s) in same row or column are not significantly different at 5% level of probability according to the Duncan's multiple range test, WAS = weeks after sowing

combined means for both years. Phosphorus application and cutting height did not affect ash content at any period of sampling.

With respect to age of cutting, ash concentration in lablab herbage was affected significantly (p = 0.05) only at the 1st cutting in 2008 and in the combined analysis. In 2008, cutting at 18 weeks produced the highest ash concentration of 92.2 g kg^{-1} that was significantly more than those for the other ages of cutting, i.e. 70.2-86.2 g kg^{-1}, all of which were at par. However, in the combined analysis, the lower ash content was obtained when lablab was cut at 12 weeks while the other ages of cutting produced similar ash contents that were at par.

The phosphorus rate × age of cutting interaction of the combined data for ash content at the 2nd cutting was significant (Table 2). When age of cutting is held constant and phosphorus rates are varied, at the 6th week age of cutting ash content was similar for all P rates. At the 12 week age of cutting, a phosphorus application rate of 12 kg P ha^{-1} produced significantly (p = 0.05) higher ash content (111 g kg^{-1}) than the zero P control (97 g kg^{-1}), while it was at par with the two higher P rates. At 18 weeks, the zero P control produced significantly higher ash content (107 g kg^{-1}) in lablab than the 24 kg P ha^{-1} application rate (91 g kg^{-1}) , while under the maturity stage cutting, application of 36 kg P ha^{-1} produced more ash (109 g kg^{-1}) than for the 12 kg P ha^{-1} rate i.e. 94 g kg^{-1}. When phosphorus application rate was held constant, while varying age of cutting, it was observed that at the zero P ha^{-1} rate of application, ash contents were similar for all the ages of cutting. When an application rate of 12 kg P ha^{-1} was considered, cutting at 12 weeks produced more ash than cutting at the maturity stage; whereas at 24 kg P ha^{-1} the ash content (105 g kg^{-1}) at the 6-week age of cutting was significantly (p = 0.05) higher than what was obtained from cutting lablab herbage at 18th weeks i.e 91 g kg^{-1}. Finally, at 36 kg P ha^{-1} the lablab herbage cut at maturity contained significantly more ash (109 g kg^{-1}) than that cut at 6 weeks i.e. 95 g kg^{-1}.

Table 3 shows the effect of phosphorus application, cutting height and age of cutting on calcium concentration in lablab herbage at the 1st and 2nd cuttings in 2006 and 2007 and the means of the two years. Phosphorus application significantly affected calcium concentration at the 2nd cutting in 2006. At this sampling period, lablab herbage accumulated significantly (p = 0.05) more calcium (11.7 g kg^{-1}) in its tissue when 36 kg P ha^{-1} was applied compared to the application rates of 0 and 24 kg P ha^{-1} (9.6-10.3 g kg^{-1}). Cutting height effect on calcium concentration of lablab was significant in the combined analysis. Lablab cut to a stubble height of 10 cm accumulated more calcium compared to that cut to a stubble height of 20 cm.

Table 3: Effect of phosphorus application, cutting height and age of cutting on calcium concentration (g kg^{-1}) of lablab herbage at the first and second cuttings in the 2006 and 2007 wet seasons and combined over both seasons at Samaru, Nigeria

	Calcium (g kg^{-1})					
	1st cutting			2nd cutting		
Treatment	2006	2007	Combined	2006	2007	Combined
Phosphorus (kg P ha^{-1})						
0	11.1	12th.9	12th.1	10.3bc	10.9	10.6
12th	11.4	13.8	12th.6	11.0ab	12th.0	11.5
24	11.9	13.7	12th.8	9.6c	12th.6	11.1
36	11.1	12th.1	11.6	11.7a	11.3	11.5
SE±	0.49	0.80	0.48	0.45	0.65	0.39
Significance	NS	NS	NS	**	NS	NS
Cutting height (cm)						
10	11.5	13.4	12th.4	11.0	12th.2	11.6a
20	11.3	12th.9	12th.1	10.3	11.2	10.8b
SE±	0.35	0.57	0.34	0.32	0.46	0.28
Significance	NS	NS	NS	NS	NS	*
Age of cutting (WAS)						
6	10.3b	10.9c	10.6c	9.4c	10.3b	9.8b
12th	13.4a	12th.3bc	12th.8ab	11.8a	10.4b	11.1a
18th	11.6b	15.5a	13.6a	11.2ab	12th.2ab	11.7a
Maturity	10.3b	13.9ab	12th.1b	10.3bc	14.0a	12th.1a
SE±	0.49	0.80	0.48	0.45	0.65	0.39
Significance	**	**	**	**	**	**

Means within a column of any set of treatments followed by different letter are significantly different at 5% level of probability according to the Duncan's multiple range test, NS = not significant,*, ** = Significant at 5% and 1% levels of probability, respectively, WAS = weeks after sowing

Age of cutting caused significant differences in calcium concentration at each of the sampling dates. However, there was no clear picture as the pattern of response was not consistent. In 2006, lablab cut at 12 weeks produced significantly more calcium than those cut at the other ages of cutting, all of which were at par. In 2007, cuttings at the 18 week favoured calcium concentration over cutting at 6 or 12 weeks whereas in the combined analysis cutting at 18 weeks produced more calcium in lablab herbage than cutting at either 6 weeks or at maturity.

At the 2nd cutting, the differences in calcium concentration of lablab due to age of cutting were significant in both years and in the combined analysis. In 2006, cutting at 12 weeks produced calcium concentration (11.8 g kg^{-1}) that was statistically superior to lablab cut at 6 WAS (9.4 g kg^{-1}) or at maturity (10.3 g kg^{-1}). In 2007, lablab cut at maturity contained significantly more calcium (14.0 g kg^{-1}) than lablab cut at either 6 or 12 weeks (10.3 or 10.4 g kg^{-1}). However, in the combined analysis, the calcium concentrations of lablab cut at either 12, 18 weeks or at the maturity were similar but significantly higher than the calcium concentration of lablab cut at 6 weeks. The cutting height × age of cutting interaction for calcium concentration at the 2nd cutting in 2006 was statistically significant.

Table 4 shows the effect of phosphorus application, cutting height and age of cutting on phosphorus concentration of lablab at the 1st and 2nd cuttings in 2006, 2007 and their combined data. Phosphorus application did not affect phosphorus content in either year or age of cutting.

Table 4: Effect of phosphorus application, cutting height and age of cutting age on the phosphorus concentration of lablab herbage at the first and second cuttings in 2006 and 2007 wet seasons and combined both seasons at Samaru, Nigeria

	Phosphorus (g kg^{-1})					
	1st cutting			2nd cutting		
Treatment	2006	2007	Combined	2006	2007	Combined
Phosphorus (kg P ha^{-1})						
0	4.5	3.7	4.1	2.9ab	1.6	2.3
12th	5.2	3.8	4.5	2.6ab	1.8	2.2
24	5.1	4.6	4.9	2.5b	1.8	2.1
36	5.1	4.0	4.5	3.0a	1.6	2.3
SE±	0.37	0.39	0.47	0.15	0.17	0.11
Significance	NS	NS	NS	*	NS	NS
Cutting height (cm)						
10	5.1	4.1	4.6	2.9	1.8	2.3a
20	4.8	4.1	4.4	2.7	1.6	2.1b
SE±	0.26	0.28	0.33	0.11	0.12th	0.08
Significance	NS	NS	NS	NS	NS	*
Age of cutting (WAS)						
6	4.2b	5.9a	5.1a	2.3b	1.8	2.1b
12th	6.3a	4.6b	5.5a	2.6b	1.6	2.1b
18th	5.8a	4.1b	5.1a	2.7b	1.7	2.2ab
Maturity	3.4b	1.6c	2.5b	3.4a	1.6	2.5a
SE±	0.37	0.39	0.47	0.15	0.17	0.11
Significance	**	**	**	**	NS	*

Means within a column of any set of treatments followed by different letters are significantly different at 5% level of probability according to the Duncan's multiple range test. NS = not significant, *,** = Significant at 5% and 1% levels of probability, respectively, WAS = weeks after sowing

Cutting height however influenced phosphorus content in the combined data of the 2nd cutting. The lower cutting height (10 cm) produced significantly (p = 0.05) higher phosphorus content (2.4 g kg^{-1}) in the dry herbage than the higher cutting height of 20 cm i.e. 2.1 g kg^{-1}.

Age of cutting significantly (p = 0.05) influenced phosphorus content of lablab herbage in the 1st cutting in 2007 and in the combined data of the same cutting stage as well as at the 2nd cutting in 2006 and in the combined data of that cutting stage. Generally, the P content of lablab herbage cut at the 1st stage was 109.1% greater than that cut at the 2nd stage. At the 1st cutting in 2007, phosphorus content of lablab cut at 6 weeks (5.9 g kg^{-1}) was significantly higher than that cut at 12 and 18 weeks (4.1-4.6 g kg^{-1}) both of which were at par and significantly higher than the phosphorus content produced when lablab was cut at maturity i.e. 1.6 g kg^{-1}. In the combined data of the 1st cutting stage, phosphorus content of lablab cut at 6, 12 and 18 weeks was similar and significantly higher than the P content of lablab cut at maturity.

At the 2nd cutting in 2006, cutting lablab at 6, 12 and 18 weeks produced similar phosphorus contents which were significantly (p = 0.05) lower than the phosphorus content of lablab cut at maturity. Similarly, in the combined data of the 2nd stage of cutting, phosphorus content of lablab cut maturity (2.5 g kg^{-1}) was significantly higher than those obtained from herbage cut at 6, 12 and 18 weeks i.e. 2.1-2. g kg^{-1} which produced similar phosphorus contents. However, the P content of lablab herbage cut at 18 weeks was also at par with that cut at maturity.

Table 5: Interaction between phosphorus rate and cutting height on phosphorus concentration (g kg^{-1}) in lablab herbage at the second cutting combined over 2006 and 2007 wet seasons at Samaru, Nigeria

	Cutting heights (cm)	
Phosphorus (kg P ha^{-1})	10	20
0	2.7a	1.9b
12th	2.2b	2.3ab
24	2.2b	2.1b
36	2.4ab	2.2b
SE ±	0.16	

Means followed by similar letter(s) in the same row or column are not significantly different at 5% level of probability according to the Duncan's multiple range test, WAS = weeks after sowing

The interaction between phosphorus rate and cutting height for phosphorus concentration in the combined analysis at the 2nd cutting was significant (Table 5). Holding cutting height constant and varying phosphorus application rates, at 10 cm stubble height, the zero P control was significantly higher (2.7 g kg^{-1}) than the other P rates of application with respect to P concentration (2.2 g kg^{-1}), except for the 36 kg P ha^{-1} rate (2.4 g kg^{-1}) which had a similar phosphorus concentration as the zero P control. Under the 20 cm stubble height, all rates of P application were at par regarding the phosphorus concentration of lablab herbage. Holding the P rate constant and varying cutting height, at the zero P control, the 10 cm cutting height produced a statistically higher phosphorus concentration (2.7 g kg^{-1}) than the 20 cm cutting height i.e. 1.9 g kg^{-1} while the other P rates produced similar phosphorus concentrations irrespective of the cutting height of lablab.

Table 6 presents the effect of phosphorus application, cutting height and age of cutting on the Ca: P ratio of lablab herbage at the 1st and 2nd cuttings in 2006, 2007 and their combined data. Under the 1st cutting, phosphorus application influenced Ca: P ratio in 2007 and in the combined analysis in the same manner. Phosphorus application rates of 0 and 12th kg P ha^{-1} favoured the Ca: P ratio of lablab herbage i.e. 3.8-3.9 g kg^{-1} over the highest phosphorus rate of 36 kg P ha^{-1} i.e. 3.0 g kg^{-1}, with enhancement in Ca:P ratio being within the range of 37.1-42.9% for 2007 and 26.7-30.0% for the combined data.

Age of cutting affected the Ca:P ratio of lablab herbage significantly (p = 0.05) in both years at the 1st cutting but only in 2006 at the 2nd cutting. Generally, lablab herbage cut at maturity had significantly a higher Ca: P ratio than lablab cut at the earlier age of cutting and in addition, Ca: P ratio of lablab increased as age of cutting increased. The older the age of cutting, the higher the Ca: P ratio was.

DISCUSSION

General: Mineral nutrients are believed to be important to the proper nutrition of both ruminant and non-ruminant animals. Many minerals, most especially Ca, P and Na, are essential for small ruminants for optimum productivity (Ghazanfar *et al*., 2011). It is important to know the minerals contained in feed resources, their strengths and weaknesses, especially for goats where browse plays such an important role. In a related issue, Norton (1994) reported that Ca is rarely limiting in forage diets although legumes and browses have been indicated to have more concentration of Ca than the grasses.

Table 6: Effect of phosphorus application, cutting height and age of cutting on calcium: phosphorus ratio in lablab herbage at the first and second cuttings in the 2006 and 2007 wet seasons and combined over both seasons at Samaru, Nigeria

	Calcium: Phosphorns ratios					
	1st cutting			2nd cutting		
Treatment	2006	2007	Combined	2006	2007	Combined
Phosphorus (kg P ha^{-1})						
0	3.1	4.8a	3.8a	4.1	9.3	6.6
12th	2.7	5.0a	3.9a	4.7	10.2	7.4
24	2.6	4.2ab	3.4ab	4.3	7.7	6.1
36	2.5	3.5b	3.0b	4.3	8.3	6.3
SE±	0.28	0.37	0.23	0.36	1.04	0.55
Significance	NS	*	**	NS	NS	NS
Cutting height (cm)						
10	2.6	4.6	3.6	4.4	8.6	6.5
20	2.9	4.2	3.6	4.3	9.1	6.7
SE±	0.20	0.26	0.16	0.26	0.74	0.39
Significance	NS	NS	NS	NS	NS	NS
Age of cutting (WAS)						
6	2.2b	2.5c	2.9b	3.1b	7.8	6.1
12th	2.2b	3.1bc	2.7b	4.4a	8.8	7.1
18th	3.1a	4.0b	3.1b	4.7a	9.1	6.9
Maturity	3.3a	8.0a	5.5a	5.1a	9.8	6.4
SE±	0.28	0.37	0.23	0.36	1.04	0.55
Significance	**	**	**	**	NS	NS

Means within a column of any set of treatments followed by different letter are significantly different at 5% level of probability according to the Duncan's multiple range test, NS = not significant,*,** = Significant at 5% and 1% levels of probability, respectively, WAS = weeks after sowing

Response to phosphorus: Lablab tissue P content is adequate proper nutrition of ruminant animals. This is because the range of lablab tissue P concentration values in the present study (4.0-5.0 g P kg^{-1}) was within the range of the National Research Council (NRC) recommendation (1.2-4.8 g kg^{-1}) for some classes of ruminants as reported by Cullison (1979). Follett and Wilkinson (1985) noted that the critical P concentration in forages may range from 0.14 to over 0.3%, values which are below the range obtained for lablab in the present study. However, Mupangwa *et al.* (2006) obtained phosphorus concentration values of 1.2, 1.4 and 1.1 g kg^{-1} DM at 8, 14 and 20 weeks, respectively. This difference may be ascribed to factors such as discrepancies in age of cutting, rainfall, soil pH (i.e. 4.9 vs. 5.5) and the analytical procedures that were adopted for P determination (i.e. optical density (OD) in spectrophotometer vs. inductively coupled plasma (ICP) emission spectrometer) at Samaru vs. Zimbabwe, respectively.

The lack of response of lablab tissue P concentration to phosphorus application is an indication that lablab is able to extract soil phosphorus to achieve equal tissue phosphorus content sufficient for ruminant requirement irrespective of the phosphorus application rate, especially in soils that contain medium to high soil P levels. This result contradicts the findings by Malami and Abdullahi (2007) from their study conducted in semi-arid Nigeria where positive responses by lablab to phosphorus application were recorded. According to Griffith (1974), legumes are able to extract phosphorus in low soil available concentrations, especially in low production situations. This implies that resource-poor farmers may grow lablab with little or no phosphorus fertilizer and still meet the P requirements of ruminants.

Response to cutting height: The lower cutting height (10 cm) produced significantly higher calcium and phosphorus concentration in the present study. This condition may have resulted because of the slower re-growth rate of lablab which probably enabled these elements to accumulate over time. This is in addition to the fewer leaves relative to stems in this cutting treatment (10 cm) which may have skewed the analysis results for P content.

Response to age of cutting: The results of this study suggest that timely consumption of lablab herbage will ensure quality nutrition for ruminants. In the present study, the calcium concentration of lablab fell within the range of 9.4 to 15.5 g kg^{-1} which is similar to the values (9.0 to 19.8 g kg^{-1} DM) reported by Gohl (1981). The calcium concentration in dry herbage increased with maturity but declined between 18 weeks and maturity stage at the first cutting stage. Mupangwa *et al.* (2006) associated a similar calcium increase in the forage legumes they studied, lablab inclusive, with increased calcium accumulation in plant tissues associated with plant support. Nonetheless, lablab can adequately cater for the recommended (1.9 to 4.0 g kg^{-1} DM) calcium requirements of livestock, since the values obtained in the present study were in excess of the recommended Agricultural Research Council (ARC, 1984) values.

Generally, the values for Ca: P ratios recorded for lablab are adequate for various species of ruminant animals. The Ca: P ratio for lablab in the current study ranged between 2.7 and 5.5 at the 1st cutting and from 6.1 to 7.1 at the 2nd cutting. The recommended Ca: P ratio in ruminant feeds is 2:1 (Buxton, 2008). The Ca:P ratio of lablab was more favourable at the earlier age of cutting (6, 12 and 18 weeks) compared to the uncut control. However, the trend at which the Ca: P ratio changed between the 1st and 2nd cuttings was similar to results obtained in an earlier study. Collins (1989) reported that the Ca: P ratio of alfalfa increased from 5.3 at the first sampling date for alfalfa to 7.5 on the last date while that of birdsfoot trefoil (*Lotus comiculatus*) had Ca:P ratios of 3.5 and 4.7 on the first and last sampling dates, respectively.

Phosphorus × age of cutting interaction: A phosphorus application rate of 12 kg P ha^{-1} produced the highest ether extract, ash and proximate dry matter concentration in lablab when cutting intervals were at 6, 18 weeks and the uncut control, respectively. This result contradicts the findings reported by Ahmadi *et al.* (2009) for harvest frequency for dry matter yield in *Medicago scutellata*. The highest phosphorus concentration of lablab was obtained with an application rate of zero P ha^{-1} under a cutting height of 10 cm in this study.

CONCLUSION

Lablab should be developed into a ley (temporary) pasture in the farming systems of northern Nigeria and utilized for ruminant livestock feeding preferably before attainment of physiological maturity for optimum mineral nutrient contents in the dry herbage.

ACKNOWLEDGMENTS

The postgraduate degree training of the principal author was made possible through a study leave granted by the management of the National Veterinary Research Institute, Vom, Plateau

State, Nigeria. The research facilities provided by the Institute for Agricultural Research, Samaru and the Department of Agronomy, Ahmadu Bello University, Zaria, Nigeria for the research work are gratefully acknowledged.

REFERENCES

AOAC, 2000. Official Methods of Analysis. 15th Edn., Association of Official Analytical Chemists, Washington, DC.

ARC, 1984. The Nutrient Requirements of Ruminant Livestock. Suppl. No. 1. Commonwealth Agricultural Bureaux, Farnham Royal, UK.

Adjei, M.B. and T.G. Gentry, 1996. Forage characteristics of lablab beans in semi-arid tropics. Agron Abstr, Annual Meeting 1996, pp: 42.

Ahmad, Z., A. Ghafoor and A. Ali, 2000. Evaluation of three exotic legume species for fodder potential. Pak. J. Biol. Sci., 3: 2079-2081.

Ahmadi, A.H.A., M.R. Chaichi and M. Mirabzade, 2009. Effects of nitrogen fertilizing system and harvest frequencies on forage dry matter yield and quality of snail medic (*Medicago scutellata* var. Robinson). Asian J. Plant Sci., 8: 160-165.

Aina, A.B.J. and S.C. Onwukwe, 2002. Estimation of nutrient contents of some selected grasses as affected by age of cuttings. Proceedings of the 7th Annual Conference of Animal Science Association of Nigeria (ASAN), September 16-19, 2002, University of Agriculture, Abeokuta, Nigeria, pp: 212th-214.

Ajayi, D.A., J.A. Adeneye and F.T. Ajayi, 2005. Intake and nutrient utilization of West African Dwarf goats fed mango (*Mangifera indica*), ficus (*Ficus thionningii*), gliricidia *Gliricidia sepium*) foliages and concentrates to basal diet of guinea grass (*Panicum maximum*). World J. Agric. Sci., 1: 18th4-18th9.

Buxton, D.R., 2008. Growing quality forages under variable environmental conditions. http://www.wcds.ca/proc/1995/wcd9512th3.htm.

Collins, M., 1989. Mineral concentrations in whole crop and pressed forage of three forage legumes. Agron. J., 81: 901-906.

Cullison, A.E., 1979. Feeds and Feeding. 2nd Edn., Reston Publishing Company, Virginia, USA.

Ewansiha, S.U., U.F. Chiezey, S.A. Tarawali and E.N.O. Iwuafor, 2007. Potential of *Lablab purpureus* accessions for crop-livestock production in the West African savanna. J. Agric. Sci., 145: 229-238.

Follett, R.F. and S.R. Wilkinson, 1985. Soil Fertility and Fertilization of Forages. In: Forages: The Science of Grassland Agriculture, Heath, M.E., R.F. Barnes and D.S. Metcalfe (Eds.). 4th Edn. The Iowa State University Press, Ames, Iowa, pp: 304-317.

Ghazanfar, S., A. Latif, I.H. Mirza and M.A. Nadeem, 2011. Macro-mineral concentrations of major fodder tree leaves and shrubs of District Chakwal, Pakistan. Pak. J. Nutr., 10: 480-484.

Gohl, B., 1981. Tropical Feeds: Feed Information Summaries and Nutritive Values. Food and Agriculture Organization of the United Nations, Rome, Italy, Pages: 18th6.

Griffith, W.K., 1974. Satisfying the Nutritional Requirements of Established Legumes. In: Forage Fertilization, Mays, D.A. (Ed.). American Society of Agronomy, Madison, WI., USA.

Hague, I., L.A. Nnadi and M.A. Mohamed-Saleem, 2008. Phosphorus management with special reference to forage legumes in Sub-Saharan Africa. Food and Agriculture Organization, http://www.fao.org/wairdocs/ilri/x5488e/x5488e0a.htm.

Iwuafor, E.N.O. and A.C. Odunze, 1999. Performance of Selected Legume Cover Crops in an Arid Zone of Nigeria. In: Cover Crops for Natural Resource Management in West Africa, Carsky, R.J., A.C. Eteka, J.D.H. Keatinge and V.M. Manyong, (Eds.). International Institute of Tropical Agriculture, Cotonou, Benin. pp: 209-213.

Malami, B.S. and I.A. Abdullahi, 2007. Preliminary investigations on Egyptian bean (*Lablab purpereus* L.) for fodder in semi-arid Nigeria effects of phosphorus fertilizer on growth components and herbage yield. Int. J. Agric. Res., 2: 971-975.

Minson, D.J., 1990. Forage in Ruminant Nutrition. Academic Press, New York, USA.

Muhammad, I.R., S.A.S. Olorunju, S.W. Hena and E.C. Agishi, 2004. Forage yield, crude protein, *in vitro* dry matter digestibility and mineral content of three cultivars of lablab (*Lablab purpureus*). J. Anim. Prod. Res., 19: 51-59.

Mupangwa, J.F., N.T. Ngongoni and H. Hamudikuwanda, 2006. The effect of stage of growth and method of drying fresh herbage on chemical composition of three tropical herbaceous forage legumes. Trop. Subtrop. Agroecosyst., 6: 23-30.

Murungweni, C., O. Mabuku and G.J. Mangawu, 2004. Mucuna, Lablab and Paprika Calyx as Substitutes for Commercial Protein Sources Used in Dairy and Pen-Fattening Diets by Smallholder Farmers of Zimbabwe. In: Tropical Legumes for Suitable Farming System in Southern Africa and Australia, Whitbread, A.M. and B.C. Pengelly, (Eds.)., ACIAR Proceedings No. 115. Australian Centre for International Agricultural Research, Canberra, pp: 12th6-135.

Norton, B.W., 1994. The Nutritive Value of Tree Legumes. In: Forage Tree Legumes in Tropical Agriculture, Gutteridge, R.C. and H.M. Shelton (Eds.). CAB International, UK., pp: 177-191.

Odion, E.C. and B.B. Singh, 2005. Production of dual purpose cowpea varieties at two clipping heights in the Sudan savanna of Nigeria, 2. Pod and grain production in pure stand. J. Arid Agric., 15: 15-19.

Orden, E.A., S.A. Abdulrazak, E.M. Cruz, M.E. Orden, T. Ichinohe and T. Fujihara, 2000. *Leucaena leucocephala* and *Gliricidia sepium* supplementation in sheep fed with ammonia treated rice straw: Effect on intake, digestibility, microbial protein yield and live-weight changes. Asian-Aust. J. Anim. Sci., 13: 1659-1666.

Ranjbar, G.A., 2007. Forage and hay yield performance of different berseem clover (*Trifolium alexandinum* L.) genotypes in mazandaran conditions. Asian J. Plant Sci., 6: 1006-1011.

Richard, D.E., W.F. Brown, G. Ruegsegger and D.B. Bates, 1994. Replacement value of tree legume for concentrates in forage based diets. I: Replacement value of *Gliricidia sepium* for growing goats. Anim. Feed Sci. Technol., 46: 37-51.

SAS Institute, 2001. Statistical Analysis System (SAS) User's Guide. SAS Institute Inc., North Carolina, USA.

Smithson, P.C. and K.E. Giller, 2002. Appropriate farm management practices for alleviating N and P deficiencies in low-nutrient soils of the tropics. Plant Soil, 245: 169-18th0.

Snedecor, G.W. and W.G. Cochran, 1967. Statistical Methods. 6th Edn., Iowa State University, Ames, Iowa, pp: 456.

Steel, R.G.D., J.H. Torrie and D.A. Dickey, 1997. Principles and Procedures of Statistics: A Biometrical Approach. 3rd Edn., McGraw-Hill Co., New York, USA., ISBN: 9780070610286, Pages: 666.

Thomas, D. and J.E. Sumberg, 1995. A review of the evaluation and use of tropical forage legumes in Sub-Saharan Africa. Agric. Ecosyst. Environ., 54: 151-163.

Valenzuela, H. and J. Smith, 2002. Cooperative Extension Service publication. University of Hawaii at Manoa, Honolulu, United States.