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Full Length Research Paper

Effects of leaf harvest on crude protein and mineral contents of selected early maturing lines of lablab (*Lablab purpureus*)

B. M. Baloyi[1], V. I. Ayodele[1] and A. Addo-Bediako[2]*

[1]Department of Soil Science, Plant Production and Agricultural Engineering, University of Limpopo, Private Bag X1106, Sovenga, 0727, South Africa.
[2]Department of Biodiversity, University of Limpopo, Private Bag X1106, Sovenga, 0727, South Africa.

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The crude protein and mineral elements of the tropical legume *Lablab purpureus* leaves were determined in eight different lines to evaluate the effect of leaf harvest on the contents of crude protein and mineral elements. Leaves of the eight lablab lines were harvested at 6, 8 and 10 weeks after planting (WAP) for the study. The crude protein and mineral contents were found to be higher at the early harvest stages than at a later stage. At 15 WAP, leaves were harvested from defoliated plants and non-defoliated plants to determine the effect of leave harvest on crude protein and mineral contents. There was no significant difference in crude and mineral contents between leaves from defoliated plants and non-defoliated plants.Thus leaf harvest at the vegetative stage did not compromise the crude protein and mineral element contents of lablab as a vegetable crop. The results show leaves can be harvested at early stage and yet have little or no effect on the crude protein and mineral contents in leaves at a later growth (e.g. flowering) phase.

Key word: Crude protein, Lablab lines, leaf harvesting, mineral elements.

INTRODUCTION

Lablab purpureus is a widespread food crop especially in Africa and Asian. It produces edible leaves, pods and seeds. The tenderer leaves are usually consumed by humans and the older leaves for forage. Hay from the whole plant (if cut at a young, leafy stage) is nutritionally comparable to alfalfa, although somewhat less digestible. The consumption of legume products has been proved to reduce the risk of a number of chronic diseases (Gossalau and Chen, 2004; Gundgaard et al., 2003).

Lablab is a prolific food crop and thrives on relatively soils of low fertility. It improves the land's nitrogen content through the action of the highly active beneficial bacteria in the root nodules. The plant is simple to establish and easy to manage under subsistence conditions. It gives high yields and resists droughts that usually affect leguminous crops. It is commonly preferred due to the high biomass (forage) yields in drought conditions (Murphy and Colucci, 1999) prevailing in these regions than cowpeas (*Vigna unguiculata* L.). It can be grown alone, inter-planted with field crops, or included in crop rotations as it can be used as a cover crop.

Lablab has a high nutritional value with the crude-protein contents of 20 to 28%. In addition, amino acids are moderately well balanced, with especially high lysine content (6 to 7%), which means that lablab seeds complement cereal diets well. The seeds, in addition to contributing relatively good quality protein, are also a good source of energy. Among legumes, lablab is one of the best sources of iron (155 mg/100 g of leaves dry weight) ((Deka and Sarkar, 1990; Norton and Poppi, 1995). Lablab leaves are known not to contain tannins (Murphy and Colucci, 1999), making them a good feed for monogastric animals (Agishi, 1991). Lablab hay may improve and increase live weight and milk yield of cattle

*Corresponding author. E-mail: abe.addo-bediako@ul.ac.za.

(Beckmann and Clements, 2002)

Harvesting of the leaves for human consumption is becoming common in many areas where the crop is grown. Nevertheless, the effect of defoliation on the overall performance of the plants is not known. The response of plants to defoliation depends on the intensity or extent, frequency and timing of foliage removal (Salisbury and Ross, 1992; Saidi et al., 2010). Leaf harvesting procedures have the potential to reduce the yield of essential components of the crop (Rahman et al., 2008).

The aim of the study was to determine and compare crude protein and mineral elements contents in different lablab lines at different harvesting stages. In addition, the study was to ascertain the most appropriate stage to harvest the leaves in order to derive optimum crude protein and mineral elements for human and livestock consumption.

MATERIALS AND METHODS

The field trial was conducted at the Horticultural Skills Centre, University of Limpopo, South Africa (23°53'10"S, 29°44'15"E) during 2010/11 summer growing season. A randomized complete block design (RCBD)with four replications consisting of factorial combinations of two leaf harvest regimes (no leaf harvest, leaf harvest) and five entries (CPI60795, Q6880B, CPI52554, CPI52506, CPI52513, CPI81364, CQ3620, and CQ52552) was used. Each experimental plot was 3 × 4 m (12 m²). Two or three lablab seeds were sown at 30 cm between plants and 60 cm between rows.

The seedlings were thinned to one, two weeks after planting. Mechanical weed control with hand hoe was also regularly done first at three weeks after planting (WAP) and subsequently once during the vegetative stage and close to crop maturity. Supplemented irrigation with horse pipe was carried out during the trial.

Young leaves were harvested from five plants tagged at the middle rows per plot. Data were collected from six weeks after planting at two-weekly interval (6, 8 and 10), and then flowering at 15 WAP. The fully frown but succulent leaves were harvested since the older leaves of legumes are not used by humans as vegetable (Karikari and Molatakgosi, 1999). Harvested leaves were washed with distilled water and dried in ventilated oven at 65°C to a constant weight for mineral content. Dried leaves were then stored in brown paper bag at room temperature and were sent to the laboratory for chemical analysis.

The chemical analysis of leaf samples was conducted at Cedara Feed Laboratory in Kwa Zulu-Natal, South Africa. The dried leaves were ground into powder using a milling machine and then sieved through 20 mesh sieves. Proximate analysis was carried out using the methods recommended by Association of Official Analytical Chemists International (AOAC, 1990). The following parameters were determined: Crude protein, calcium (Ca), iron (Fe), potassium (K), zinc (Zn), phosphorus (P), sodium (Na) and magnesium (Mg). All analyses were carried out duplicate and reported as mean values on a dry weight basis.

The samples were analysed based on nitrogen analysis utilizing the Kjeldahi system according to AOAC for crude protein content. The crude protein was calculated using a nitrogen conversion factor of 6.25 (AOAC, 1990). The Na and K content were determined by flame photometry and P was determined calorimetrically with a Jemway 6100 spectrophotometer. The other mineral elements were determined after wet digestion with a mixture of nitric acid, sulphuric acid and hydrochloric acid using Atomic Absorption Spectrophotometer (AAS Model SP9) (Dada and Oworu, 2010).

All data were subjected to analysis of variance (ANOVA), using SAS software programme (2001). The differences between means were assessed and compared using the least of significant difference (LSD) and significant level of 0.05.

RESULTS

Crude protein

The analysis of variance showed a significant difference in crude protein among the lablab lines at 6 WAP (the first harvest). The mean crude protein (CP) ranged from 24.7% in Q6880B to 30.3% in CP152513at 6 WAP. At 8 WAP (second harvest), the mean crude protein values were higher than those at 6 WAP and ranged from 28.0% in Q6880B to 33.5% in CQ3620.However, the values decreased at 10 WAP (third harvest) and ranged from 22.8% in Q6880B to 28.5% in CP160795 (Table 1).

At 15 WAP, lower crude protein contents were observed in lablab leaves as compared to the earlier stages. The grand mean crude protein at 6, 8 and 10 WAP (vegetative stage) were 27.7, 30.1, and 26.9% respectively, while at 15 WAP the grand mean was 22.7%. At 15 WAP, there was no significant difference in crude protein between leaves from defoliated plants and those of the control (non-defoliated plants) ($p > 0.05$). Thus, leaf harvest had no significant effect on the crude protein contents of the lablab leaves.

Mineral content

There were variations in the mineral content among the different harvesting stages. The highest Ca content of 1.43% was recorded in CP160795 at 6 WAP. Mg content was highest (0.34%) was in CP181364 at 6 WAP. K highest content of 2.41% was in CP181364 at 8 WAP. Na highest content of1.84% was in CQ3620 at 10 WAP. The highest P content of 0.65%% was found in CP152513 at 8 WAP (Table 1).

The highest Mn content of 139.5 ppm was in CQ3620 at 6 WAP. Cu content was highest (9 ppm) in CP152506 at 8 WAP. Fe highest content of 427.5 ppm was in CP160795 at 6 WAP and the highest Zn content of 156.5 ppm was recorded in CQ3620 at 6 WAP (Table 2). All the mineral contents with the exception of Na content were highest at either 6 or 8 WAP. The mean Fe and Ca contents were significantly higher at 6 WAP than the other two stages ($p<0.05$); however, P, and Zn were higher at 8 WAP than other harvesting stages, though the difference was not significant. Meanwhile, Na content was significantly higher at 10 WAP than at 6 WAP and 8 WAP ($p<0.05$). There were significant differences in interaction between Lablab lines and harvesting stages in K and Na.

Table 1. Crude protein and mineral contents of lablab leaves on 100%DM basis at three harvesting stages (6, 8 and 10 WAP).

Lines	Crude protein (%)			Ca (%)			Mg (%)			K (%)			Na (%)			P (%)		
	Harvest stages (WAP)																	
	6	8	10	6	8	10	6	8	10	6	8	10	6	8	10	6	8	10
CPI60795	25.2^{bc}	29.5	28.5	1.43	0.90^{a}	0.90^{ab}	0.26^{ab}	0.20^{ab}	0.20^{b}	2.0^{bc}d	2.06^{ab}	1.90^{a}	0.03	0.01^{ab}	0.03^{c}	0.42	0.58	0.40^{ab}
Q6880B	24. 7^{c}	28.0	22.8	1.13	0.82^{ab}	0.90^{bc}	0.25^{ab}	0.20^{ab}	0.20^{b}	1.80d	2.07^{ab}	1.40^{c}	0.03	0.01^{ab}	0.01^{c}	0.43	0.57	0.30^{c}
CPI52554	26.8^{abc}	29.6	28.2	1.15	0.69^{ab}	0.70^{bc}	0.22^{b}	0.20^{ab}	0.20^{b}	1.86^{cd}	2.20^{a}	2.00^{a}	0.02	0.02^{a}	0.02^{c}	0.50	0.63	0.50^{a}
CPI52506	29.6^{ab}	28.2	28.1	1.17	0.69^{ab}	0.90^{ab}	0.28^{ab}	0.20^{b}	0.20^{b}	2.20^{a}	1.89^{ab}	1.90^{ab}	0.03	0.01^{ab}	0.01^{c}	0.55	0.59	0.50^{a}
CPI52513	30.3^{a}	31.1	28.0	1.25	0.60^{b}	0.8^{bc}	0.24^{ab}	0.20^{b}	0.20^{b}	2.23^{a}	1.98^{ab}	1.80^{ab}	0.02	0.01^{ab}	0.02^{c}	0.57	0.65	0.50^{ab}
CPI81364	28.9^{abc}	31.0	26.9	1.41	0.82^{ab}	1.16^{a}	0.34^{a}	0.30^{a}	0.30^{a}	1.9^{bc}d	2.41^{a}	1.80^{ab}	0.03	0.01^{ab}	1.81^{a}	0.49	0.61	0.50^{ab}
CQ3620	30.1^{a}	33.5	27.8	1.33	0.58^{b}	0.80^{bc}	0.28^{ab}	0.20^{b}	0.20^{b}	2.0^{abc}	1.49^{b}	1.80^{ab}	0.02	0.01^{ab}	1.84^{a}	0.56	0.64	0.40^{ab}
CQ52552	26.1^{abc}	29.5	24.9	0.83	0.63^{ab}	0.61^{c}	0.22^{b}	0.20^{b}	0.20^{b}	2.08^{ab}	1.89^{ab}	1.60^{bc}	0.01	0.01^{ab}	1.63^{b}	0.51	0.51	0.40^{bc}
Mean	27.7	30.1	26.9	1.21	0.72	0.84	0.26	0.22	0.21	2.01	2.00	1.80	0.02	0.01	0.67	0.50	0.59	0.44
LSD (0.05)	4.7	ns	ns	ns	0.29	0.26	0.12	0.06	0.05	0.20	0.67	0.24	ns	0.01	0.15	ns	ns	0.09
Significance																		
L		**			**			**			**			ns			**	
HS		**			**			**			**			ns			**	
L X HS		ns			ns			ns			**			**			ns	

L = Lablab lines; HS = harvesting stages; means followed by the same letter(s) within a column are not significantly different at *p*< 0.05 among the *Lablab* lines. ** F-test significant at p < 0.05. ^{NS}, not significant.

Similar to the crude proteins, at 15 WAP there were no significant differences in Na and Zn contents of leaves from defoliated plants and those from non-defoliated plants among the lablab lines (p > 0.05). Although in most lines, higher mineral contents were recorded in leaves from non-harvested plants than those from harvested plants, the differences were insignificant (Table 3).

DISCUSSION

Crude protein

There were obvious differences in variation and distribution of crude protein among the lablab lines. It implied that the genotypic variations provided opportunities to select materials with high contents of crude protein. In the present experiment, the crude protein contents in CPI52513, CPI81364 and CQ3620 were high and could be selected after considering other factors. The crude protein content is found to be higher at the early stages of growth (vegetative phase) than at the later stage (15 WAP), indicating importance to harvest the leaves at early stages to derive most of the crude protein. This supports the finding of Miller-Cebert et al. (2009) in canola leaves where significantly higher protein content was found at pre-bolting stage than rosette and blooming growth stages. The lower protein content of leaves at the final harvest (15 WAP) for both harvested and non-harvested plants is an indication that there is a decline in protein content (nutrient) with the age of the plant.

Mineral content

There was a genetic variation in mineral composition among lablab lines as observed in the crude protein content. This variation has also been reported in other crops such as cassava (Ravindran and Rajaguru, 1988; Dada and Oworu, 2010) and kenaf (Hossain et al., 2011).

At the vegetative phase (6, 8 and 10 WAP) generally there was a decline in mineral contents with successive leaf harvest. This suggests that

Table 2. Mineral contents of lablab leaves on 100% DM basis at three harvest stages (6, 8 and 10 WAP).

Lablab line	Mn (ppm)			Cu (ppm)			Fe (ppm)			Zn (ppm)		
	Harvest stages (WAP)											
	6	8	10	6	8	10	6	8	10	6	8	10
CPI60795	73.0	69.5	127.0^{a}	7.5	7.0	7.5^{ab}	427.5	221.0^{a}	174.5^{ab}	54.0	60.0	64.5^{ab}
Q6880B	105.5	92.5	76.5^{b}	8.0	8.0	6.5^{ab}	364.0	218.5^{ab}	137.0^{ab}	93.0	103.5	56.0^{ab}
CPI52554	59.0	49.0	51.0^{b}	7.0	7.0	6.5^{ab}	370.5	217.5^{ab}	132.0^{ab}	55.5	47.5	47.5^{ab}
CPI52506	57.5	88.5	96,0^{ab}	6.5	9.0	8.0^{a}	365.5	186.0^{bcd}	206.5^{a}	45.5	102.5	88.5^{ab}
CPI52513	105.5	68.5	68.0^{b}	6.5	6.5	6.0^{b}	335.5	162.5^{d}	127.0^{b}	63.5	51.5	32.5^{b}
CPI81364	58.5	52.0	50.5^{b}	7.5	7.5	7.0^{ab}	420.0	171.0^{cd}	145.0^{ab}	67.5	68.0	50.5^{ab}
CQ3620	139.5	58.5	75.0^{b}	8.0	7.5	6.0^{b}	354.5	204.0^{abc}	167.5^{ab}	156.5	97.0	89.0^{a}
CQ52552	61.5	114.0	134.5^{a}	6.0	7.0	6.0^{b}	338.5	166.5^{d}	198.0^{ab}	52.0	79.0	89.0^{a}
Mean	82.5	74.1	84.8	7.1	7.4	6.7	372.0	193.4	161.0	73.4	76.1	62.3
LSD (0.05)	ns	ns	46.1	ns	ns	1.8	ns	34.9	77.6	ns	ns	56.3
Significance												
L		ns			**			ns			**	
HS		**			**			**			**	
L × HS		ns			ns			ns			ns	

L, Lablab lines; HS, harvesting stages; Means followed by the same letter(s) within a column are not significantly different at $p< 0.05$ among the *Lablab* lines; ** F-test significant at $p < 0.05$; ^{NS}, not-significant.

Table 3. Effects of leaf removal on crude protein and mineral element contents of lablab at final harvest (15 WAP).

Lablab line	Treatment	CP	Ca	Mg	K	Na	P	Mn	Cu	Fe	Zn
		%						ppm			
CP160795	LH	22.6	2.59^{a}	0.40^{ab}	1.49^{ab}	0.03	0.24^{b}	131.5^{a}	6.50^{ab}	653.0^{a}	100.0
	NLH	22.6	2.71^{a}	0.36^{bcd}	1.52^{ab}	0.07	0.25^{b}	122.5^{a}	6.00^{ab}	571.0^{ab}	79.50
Q6880B	LH	20.9	2.26^{c}	0.39^{abc}	1.28^{b}	0.02	0.23^{b}	111.0^{a}	6.50^{ab}	378.0^{b}	105.0
	NLH	21.2	2.07^{d}	0.39^{abc}	1.53^{ab}	0.02	0.29^{ab}	107.5^{a}	7.00^{ab}	460.0^{a}	96.0
CP152554	LH	22.8	2.34^{b}	0.35^{bcd}	1.56^{ab}	0.02	0.29^{ab}	131.5^{a}	6.50^{ab}	529.0^{a}	102.5
	NLH	23.5	2.20^{c}	0.32^{bcd}	1.51^{ab}	0.02	0.29^{ab}	119.0^{a}	6.50^{ab}	525.5^{a}	91.5
CP152506	LH	21.9	2.30^{b}	0.40^{ab}	1.63^{ab}	0.01	0.30^{ab}	131.0^{a}	6.00^{ab}	475.0^{a}	124.5
	NLH	23.3	2.30^{b}	0.47^{a}	1.52^{ab}	0.02	0.28^{b}	120.5^{a}	7.50^{a}	569.5^{a}	140.0
CP152513	LH	23.2	2.34^{b}	0.37^{bcd}	1.56^{ab}	0.02	0.28^{b}	103.0^{a}	6.00^{ab}	515.5^{a}	71.0
	NLH	23.4	2.36^{a}	0.34^{bcd}	1.44^{ab}	0.02	0.26^{b}	121.5^{a}	6.00^{ab}	534.0^{a}	73.0
CP181384	LH	22.4	2.23^{c}	0.40^{ab}	1.44^{ab}	0.02	0.26^{b}	96.0^{b}	5.50^{b}	383.5^{b}	81.5
	NLH	23.8	2.76^{a}	0.47^{a}	1.53^{ab}	0.02	0.22^{b}	99.0^{b}	7.50^{a}	656.0^{a}	112.5
CQ3620	LH	22.8	2.20^{d}e	0.37^{bcd}	1.41^{ab}	0.02	0.27^{b}	125.5^{a}	6.50^{ab}	608.5^{a}	114.5
	NLH	22.9	2.25^{cd}	0.34^{bcd}	1.55^{ab}	0.02	0.28^{b}	140.0^{a}	6.50^{ab}	664.0^{a}	152.5
CQ52552	LH	23.7	2.07^{d}e	0.32^{bcd}	1.52^{ab}	0.02	0.30^{ab}	126.0^{a}	5.50^{ab}	493.0^{a}	95.5
	NLH	22.5	1.81e	0.35^{bcd}	1.74^{ab}	0.02	0.36^{a}	151.5^{a}	6.00^{ab}	550.0^{a}	132.5
Grand mean		22.9	2.73	0.36	1.51	0.02	0.27	121.1	6.38	535.3	104.5
LSD (0.05)		ns	0.42	0.09	0.07	ns	0.09	46.68	1.98	267.7	ns
CV (%)		8.60	6.29	11.14	12.23	40.12	15.54	18.09	14.60	23.48	53.67

LH, Leaf harvested; NLH, No leaf harvested; ns, not significant; Means followed by the same letter within a column are not significantly different at $p< 0.05$among the *Lablab* lines.

leaves harvested at the early stage of lablab growth contained more of the minerals than those harvested at a later stage of the vegetative phase. Thus the nutritive value of legumes declined as the plant matures (Deka and Sarkar, 1990). However, there were no significant differences among the harvesting stages.

At 15 WAP, there was no consistent trend in mineral content; Ca, Mg, Mn, Fe and Zn contents were slightly higher than the contents recorded at the vegetative phase, while K, Na, P and Cu contents declined slightly from the vegetative phase. In cassava, a decrease in Na, K, Ca and P composition of cassava leaf with an increase in the age of the crophas been reported (Dada and Oworu, 2010).It has also been reported in *Amaranthus* that the nutritional composition of leaves declines with the age of the plant (Modi, 2007). These suggest that absolute nutrient potential derivable from the leaf of the crop may not be fully exploited at the maturity phase.

Conclusion

The nutritional value of lablab leaves does not only depend on the variety (line) but also the stage of the leaf harvest. Leaves harvested at the early stage had higher protein and some of the mineral contents than those harvested at a later growing stage (flowering).There were no significant changes in crude protein and mineral contents between leaves from plants with harvested leaves and those with non-harvested leaves. Lablab with its high crude protein and mineral content at both vegetative and flowering phases could be employed more often in tropical and sub-tropical agricultural production systems, to improve nutrition, boost food security, and foster rural development.

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