A tropical forage solution to poor quality ruminant diets: A review of *Lablab purpureus*

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Abstract

The literature concerning the agronomic characteristics and nutritive value of the legume *Lablab purpureus* (Lab lab) is reviewed.

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 world wide. Staying green during the dry season, it has been known to provide up to six tonnes of dry matter/ha.

Being palatable to livestock, it is an adequate source of much needed protein and can be utilised in several different ways. It can be grazed in a pasture setting or as a companion crop to maize, cut as hay, or mixed with corn silage. In several experiments it has been observed to increase livestock weight and milk production during the dry season.

Lablab 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. Lablab can be used advantageously as a cover crop. Its dense green cover during the dry season protects the soil against the action of the sun's rays and decreases erosion by wind or rain. As green manure it provides organic matter, minerals and fixes nitrogen into the soil thereby improving crop yields in an economic and environmentally friendly manner.

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. 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. Thus helping to improve the living conditions in countries where shortages of human food and animal feedstuffs exist.

Key words: *Lablab Purpureus*, tropical legume, nutritional characteristics, review

Introduction

A major problem facing livestock producers in tropical areas is proper nutrition for their animals during the dry season when pastures, cereal residues and maize stover are limiting in nutritional quality. Normally it is during this season when problems such as sickness and weight loss due to a poor dietary profile arise. One way of improving the utilisation of such crop residues is by proper supplementation with leguminous forages (Poppi and McLennan 1995).

In recent years, the use of forage legumes in livestock production systems for ruminants in the tropics has increased. Forage legumes offer several advantages to tropical farming systems. First, leguminous cover reduces soil erosion and runoff. This cover is able to conserve soil, improve organic matter content and compete with weeds (Humphreys 1995; Schaaffhausen 1963a,b). Second, the legume-rhizomal symbiosis converts atmospheric nitrogen (N) to forms of N which plants can take up and cycled within the plant-animal-soil system. The legume-rhizobial symbiosis provides farmers with an inexpensive source of N whose production is environmentally "clean". This symbiosis does not involve the consumption of fossil fuel, as occurs in the production of fertiliser N which contributes to global warming and exacerbates the foreign exchange balance of tropical countries lacking in oil resources (Humphreys 1995; Said and Tolera 1993). As a consequence of different biochemical pathways of carbon fixation during photosynthesis, N fixing legumes have higher concentrations of cellular protein than tropical grasses (Bjorkman et al 1976). As such, tropical forage legumes are rich in protein, which is usually the most limiting nutrients in tropical animal diets.

Forage legumes can be grazed, harvested and fed fresh or stored as hay or silage (Harricharan et al 1988). A sustainable way of improving the feeding value of poor quality crop residues and pastures, especially for resource poor small holders, is through supplementation with forage legumes. Though there are several forage plants that have the capacity to produce high yields of dry matter, they contribute little to the much needed improvement of livestock production, because data on their nutritive values are scarce (Barro and Ribeiro 1983). With this in mind, the objective of this paper is to describe the tropical legume *Lablab purpureus,* summarise its nutritional characteristics and to describe its role in feeding ruminants in the Tropics.

Lablab purpureus

Table 1: Different names used for Lablab purpureus

Dolichos lablab	Lablab	Garbanzo	India Butter Bean	Bonavist Bean
Country Bean	Frijol dólicho	Hyacinth Bean	*Lablab niger*	Tonga Bean
Dolichos Bean	Caballero	Egyptian Bean	Poor-man's Bean	Sim Bean
Lablab vulgaris	Lubia Bean	Siem Bean	Chimbolo verde	Field Bean
Hierba de Conejo	Frijol jacinto	Poroto japonés	Frijol de la Tierra	Gallinita

Lablab purpureus, previously classified as *Dolichos lablab* , is known in different parts of the world by different names (Table 1). In fact, there is much disagreement in the literature as to names and varieties (Schaaffhausen 1963ab; Kay 1979). This multiplicity of names is indicative of the range of forms available globally and the fact that it has long been cultivated for human food and as green manure. The widespread use of lablab for animal grazing is more recent (Cameron 1988).

History and distribution

The wild forms of lablab are believed to have originated in India (Deka and Sarkar 1990) and were introduced into Africa from southeast Asia during the eighth century (Kay 1979). Presently, lablab is common in Africa, extending from Cameroon to Swaziland and Zimbabwe, through Sudan, Ethiopia, Uganda, Kenya and Tanzania (Skerman et al 1991). As early as 1819, seeds of lablab from Egypt were planted in the Botanical Gardens in Sydney, New South Wales. However, it was not until after the release of the forage cultivar "Rongai" in 1962, that lablab became widely used as a forage in Australia. Currently, lablab is one of the major leguminous forage and green manure crop in this area of the world (Cameron 1988).

Lablab has been widely distributed to many tropical and subtropical countries where it has become naturalised (Purseglove 1968). In South and Central America, East and West Indies, Asia, China and India, lablab is grown as an annual or a short-lived perennial (Whyte et al 1953). In these areas, the seed and immature pods are used for human food while the herbage is used as green manure, for erosion control, and as a feed supplement for cattle grazing mature pasture in the dry season (Hendricksen and Minson 1985b).

Plant Description

Lablab is a summer growing annual or short-lived perennial fodder legume sown for grazing and conservation in tropical environments with a summer rainfall. It is a vigorously trailing, twining herbaceous plant, resistant to disease and insect attack (Milford and Minson 1968; Cameron 1988). Stems are trailing to upright, reach to 3 m in length and are robust. Leaves are large and trifoliate, with the leaflets having a broad ovate-rhomboid shape measuring 7 to 15 cm long (Figure 1). The dorsal side of the leaf is smooth with the underside being hairy (Cameron 1988).

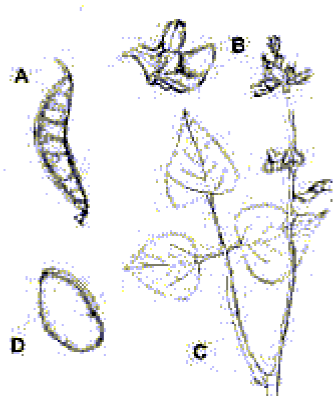

Figure 1. Diagram of *Lablab purpureus* plant fractions.
(A Pod; B. Flower; C. Stem with leaves and flowers; D. Seed.)
(Adapted from León 1987; courtesy of Sofia Colucci)

Of the two hundred types of lablab recognised, only two cultivars, Rongai and Highworth, are available commercially (Cameron 1988). Additionally, three subspecies have been identified: *ssp purpureus, ssp benghalensis* and *ssp uncinatus* (Table 2*).*

Table 2. Subspecies of *Lablab purpureus* (Cameron 1988)

[redacted]		
ssp purpureus	*ssp benhalensis*	*ssp uncinatus*
[redacted]		
- scimitar-shaped pods - cultivated as pulse crop - used as a commercial forage or green manure	- linear-oblong pods - pulse crop of Asiatic origin - used in Africa as forage crop	- wild form in Tropical Africa - pods and seeds are similar but smaller than those of *ssp purpureus* - readily eaten by livestock
[redacted]		

Rongai Cultivar

The Rongai cultivar was derived from material from the Rongai district of Kenya (Cameron 1988) and was released in New South Wales, Australia in 1962 (Wilson and Murtagh 1962). As described above, this is a summer growing, rampant and vigorously twining herbaceous annual or short-lived perennial. Stems trail, reaching 3 to 6 m in length; broad ovate-rhomboid leaflets acute at the apex, range between 7 and 15 cm and are arranged in a trifoliate manner. Leaves are almost glabrous on the upper surface and have short hairs on the lower surface. Petioles are long and slender and inflorescence lax, fascicled, of many flowered racemes on elongated peduncles. Pods are 4-5 cm in length containing 2-4 buff or pale brown seeds with a conspicuous white hilum. The brown, ovoid and laterally compressed seeds number 3600-4300 per kg (Barnard 1972). Rongai is a late maturing white flowering cultivar that will continue to grow until cut or damaged by frosts. In the absence of frost, flowering may continue for several months (Oram 1990; Cameron 1988).

Highworth Cultivar

The Highworth cultivar originated from Coimbatore, South India and is morphologically similar to Rongai. Contrasting with the green foliage, white flowers and light brown seeds of Rongai, foliage of Highworth has a purple band near the leaf axil, purple flowers and black seeds. Highworth is an early flowering line with high seed-yielding ability; it is suitable for pulse production and forage uses. It was originally intended for grain production in districts where early frosts prevented the seeding of Rongai (Oram 1990; Cameron 1988).

It should be noted that the Rongai cultivar is most prevalent in the tropical forage legume literature. The remainder of the review will deal mainly with the *Lablab purpureus* cv. Rongai.

Agronomic Characteristics

Environmental Conditions

Lablab is a legume well suited to most tropical environments as it is adaptable to a wide range of rain fall, temperature and altitude. It is reported to grow well under warm, humid conditions at temperatures ranging from 18^o to 30^o C and is fairly tolerant to high temperatures (Hendricksen and Minson 1985b; Schaaffhausen 1963ab; Kay 1979; Cameron 1988). Below 20^o C the plant will have reduced growth; leaves begin to drop at minus 2^o C but the plant can survive frost for a limited period (Kay 1979; Mayer et al 1986). Lablab is drought hardy, and has been grown in arid, semi-arid and humid regions with rainfalls between 200 and 2500 mm (Hendricksen and Minson 1985b; Cameron 1988). It needs rainfall or irrigation (minimum of 10 to 20 mm) during germination and early establishment, although once established it is extremely resistant to drought (Mayer et al 1986; Schaaffhausen 1963ab). Being a hardy plant, lablab can be found throughout the tropics and subtropics; ranging from 30^o South to 30^o North Latitude. It is normally grown from sea level up to elevations of between 1800 and 2100 metres (Cameron 1988; Hendricksen and Minson 1985b; Mayer et al 1986).

Soil

Lablab grows in a wide range of soil types, from deep sands to heavy black clays and can tolerate pH ranges of 5 to 7.5 (Kay 1979). The plant can survive short periods of flooding thus growing well in alluvial planes (Menéndez et al 1985) but needs free drainage as it does not tolerate water logging (Kay 1979). Saline conditions have been found to reduce populations and produce chlorotic leaves. Soil fertility is important; thus phosphate fertilisers may need to be applied at planting (Cameron 1988).

Forage yield

The growth period can vary from approximately 75 to 300 days (Kay 1979). Under appropriate conditions, it will produce maximum vegetative growth 130 days post germination, with additional growth possible subject to temperature (Mayer et al 1986). Once established, lablab is highly drought resistant often staying green during the dry season (Schaaffhausen 1963b). The yields of lablab grown under a range of conditions, including the yield of leaf and stem fractions for some experiments are presented in Table 3.

Table 3. Dry matter yield (kg/ha) of *Lablab purpureus (*Adapted from Hendricksen and Minson 1985b)

Mean	Whole Plant	Leaf	Stem	Variety	Conditions	Country	Reference
-	3750 - 5940	-	-	*	Various	Brazil	Schaaffhausen (1963b)
3710	-	-	-	*	Harvested at flowering	Colombia	Herrera et al (1966)
3970	-	-	-	*	Harvested at pod formation		"
12260	-	-	-	*	Harvested at maturation of pods		"
4293	3136-5040	940-1562	2196-3478	Rongai	Fields sown and harvested during autumn and winter	Australia	Milford and Minson (1968)
3241	636 - 4618	399 - 2213	237 - 2405	Rongai	Yields measured from a number of sites	Australia	Murtagh and Dougherty (1968)
962	-	-	-	Rongai	7 weeks growth under dry conditions	Australia	Philpotts (1969)
-	2039 - 2493	-	-	*	Yields measured at various stages of cut	Australia	Wetherall (1969)
2105	1778 - 2432	942-1386	836-1046	*	Fields sown in Oct/Nov and harvested during Jan/Feb	Brazil	Favoretto and Peixoto (1977)
5200	-	2230	2970	Rongai	Yields after 14 weeks growth	Australia	Hendricksen and Minson (1980)
5268	-	1946	3322	Rongai	Yields 17 weeks after sowing	Australia	Hendricksen et al. (1981)
3945	3320 - 4570	-	-	Rongai	Sown in Autumn/Winter	Australia	Wood (1983)
1860	1820 - 1900	-	-	Highworth	Harvested at flowering	"	"
6270	-	1944	4326	Rongai	Sown in January and harvested January to May	Australia	Hendricksen and Minson (1985a)
4700	-	-	-	Rongai	Grown during dry season 17 weeks after sowing	Honduras	Murphy (1998)
¶4444	**#636 -5940**	**#940 - 2230**	**#836 - 4326**				

¶ Overall mean; ## Range; * Variety not specified

Dry matter yield per hectare varies with rainfall, soil condition and time of seeding, but work in Australia suggests that 4000 kg of DM per ha with a maximum leaf production of two tonnes DM per ha is not unusual (Cameron 1988; Mayer et al 1986). The ratio of leaf to stem varies with cutting and curing procedures, from 30:70 to 45:55. When livestock are given the opportunity to graze the crop during the early stages of growth or at maturity they will select predominantly for the leaf, which has a higher protein content than the stem. However, if the plant is cured as hay or preserved as silage, animals will readily eat the whole plant (Mayer et al 1986). Lablab produces reliably under a wide range of conditions, out-yielding conventional crops such as velvet bean (*Stizolobium deeringianum*) and cowpea (*Vigna unguiculata*), particularly when grown under conditions of drought (Mayer et al 1986; Murtagh and Dougherty 1968; Wilson and Murtagh 1962). The other benefit of this legume is the versatility in feeding schemes; it adapts well to grazing when incorporated into a pasture environment. It can be fed as a good quality hay or it can be made into silage (Cameron 1988; Schaaffhausen 1963ab).

Pest and diseases

Although several diseases and pests have been associated with Lablab (Duke 1983), only a few cause serious losses. In fact, in several areas of the world, lablab is virtually free of pests and diseases (Luck 1965). In Honduras, evidence of moderate to severe insect (*Diabrotica spp.*) attack has been observed with severe attacks corresponding to dry conditions. Notwithstanding, trials have shown lablab is resistant to the insects, continuing to grow vigorously in their presence (Flores 1993).

Chemical composition

Crude protein

The levels of crude protein recorded in total plant, leaf, stem and seed fractions of lablab are summarised in Table 4.The mean crude protein content of lablab herbage was 17% with a range of 10% to 22% on a dry matter basis. Leaf crude protein varied from 14.3% to 38.5%, while the stem crude protein content ranged from 7.0% to 20.1%. Lablab follows a familiar growth pattern as protein content drops with maturity (Milford and Minson 1968). The National Research Council (1989) indicates that the minimum requirements for growth and lactation of a 400-kg cow are 119 g crude protein/kg DM and 124 g crude protein/kg DM respectively. Poppi and McLennan (1995) have suggested that a diet containing 210 g crude protein/kg digested organic matter (DOM) will provide the minimum requirement for rumen degradable nitrogen. Any soluble dietary protein in excess of this requirement will be degraded to ammonia in the rumen, and the ammonia excreted as urea in the urine. It may be calculated that these minimal requirements will be met when tropical legumes contain 115-137 g crude protein/kg DM. Thus, Lablab has the potential to supply rumen degradable nitrogen in excess of requirements. In a feeding trial, Jakhmola and Pathak (1981) found that the improved plane of nutrition resulted in a digestible crude protein intake 3 to 5 times that of the maintenance requirement.

Table 4. ***Lablab purpureus*** **crude protein content (% in DM)**
(Adapted from Hendricksen and Minson (1985b)

Whole plant	Whole plant	Leaf	Stem	Seed	References
18.0	13.6 - 22	28.0	-	25 - 28	Schaaffhausen (1963b)
19.2	-	33.5	-	-	Dougall and Bogdan (1966)
-	15.3 -19.7	-	-	-	Herrera et al. (1966)
-	-	-	-	23.0 -26.2	Kuo (1967)
14.0	10.3 - 17.1	-	-	-	Milford and Minson (1968)
-	11.8 - 17.5	-	-	-	Wetherall (1969)
-	-	26.1 - 26.4	11.9 - 16.3	-	Philpotts (1969)
16.3	10.0 - 16.88	-	-	-	McLeod and Minson (1976)
19.3	18.6 - 20.1	32.7 - 38.5	8.65 - 8.69	-	Favoretto and Peixoto (1977)
-	12.1 - 18.9	21.5 - 21.8	7.4 - 8.0	-	Jakhmola and Pathak (1981)
-	-	24.4	7.19 - 8.25	23.9 -25.3	Wood (1983)
-	-	-	-	27.2	Addison et al (1984)
-	-	21.6 - 27.9	13.9 - 20.1	-	Hendricksen and Minson (1985a)
16.0	-	15 - 33	7.0 - 8.0	-	Cameron (1988)
15.6	-	23.9	7.2 - 18.0	-	Mayer et al. (1986)
25.0	-	23.5	10.1	-	Mayer et al. (1986)
16.4	-	-	-	-	Harricharan et al. (1988)
-	15 -17	-	-	-	Ojeda et al. (1988)
-	-	14.3	10.0	-	Hendricksen et al. (1981)
-	11.3 - 19.0	14.3	11.8	-	Skerman et al. (1991)
18.6	-	-	-	-	Abule et al. (1995)
12.2	-	-	-	-	Umunna et al. (1995)
12.2	-	-	-	-	Nsahlai and Umunna (1996)
13.5	-	-	-	-	Makembe and Ndlovu (1996)
17.25	15.0 - 20.2	19.0 - 33.4	7.9 - 12.1	-	Murphy (1998)
17.0	10.0 - 22.0	14.3 - 38.5	7.0 - 20.1	23.0 - 28.0	

Note: The ranges are taken from plants at different stages of maturity. The lower the protein percentage, the more mature the plant; the higher the protein percentage indicates a less mature plant.

It has been demonstrated that tannins in temperate legumes (Barry and Blaney 1987) may protect plant proteins from ruminal digestion, and thereby provide the animal with significant sources of additional, bypass protein for absorption and utilisation. However, Schaaffhausen (1963b) indicated that lablab leaves do not contain tannins, thus providing a rapidly fermentable source of protein with little bypass protein potential. The apparent digestibility of the crude protein in lablab forage has been measured with sheep (Jakhmola and Pathak 1981) and cattle (Hendricksen et al 1981), with coefficients in the range of 54.5 to 76.1%, depending on the crude protein content. Further research is required to get a clearer understanding of the protein profile of *Lablab purpureus* and its different plant fractions.

Anti-nutritional characteristics

A major limitation to the use of legumes in animal diets is the presence of anti-nutritional factors. Schaaffhausen (1963b) reports that the leaves of lablab do not contain tannins, making them a good feed for monogastric animals. The seeds however, do contain anti-nutritional factors such as tannins, phytate and trypsin inhibitors. Activity of these compounds could be reduced by processing methods such as removing the seed coat, soaking and cooking (Lambourne and Wood 1985; Deka and Sarkar 1990). For a proper nutritional assessment of anti-nutritional factors like haemagglutinins and other toxic substances in lablab seeds, more research is required (Deka and Sarkar 1990).

Fibre

Table 5 summarises crude fibre, neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) values for the lablab plant and various fractions. The average crude fibre of the whole plant is 27.8% with the average of NDF, ADF, and ADL being 43 %, 38.6%, and 7.1% respectively (dry matter basis).

One of the challenges of growing forage in tropical environments is the effect of the environment on the nutritional characteristics of plants. High temperatures decrease the soluble carbohydrate content of plants, resulting in increased fibre content and decreased digestibility (Norton and Poppi 1995). To exacerbate this situation, crude fibre content of legumes generally increases with maturity (Minson 1990).

With recent advances in analytical techniques and a better understanding of fibre and its application to nutrition, crude fibre values are not necessarily indicative of the quality of a plant (Norton and Poppi 1995). The first issue to evaluate is the analytical technique in identifying fibre fractions. With the dawn of VanSoest's detergent system of analysis of fibre (Goering and VanSoest 1970), researchers have the capability to determine a more specific fibre profile. Defining Neutral Detergent Fibre (NDF - cell wall), Acid Detergent Fibre (ADF - ligno-cellulose) and Acid Detergent Lignin (ADL) help researchers to better understand the association of fibre and digestibility. In fact, VanSoest (1994) goes so far as to say that proximate analysis has resulted in a compilation of useless analyses.

Table 5. Fibre content of *Lablab purpureus* (% in DM)

Sample	Crude fibre	NDF	ADF	ADL	Reference
Whole plant	30.49				Dougall and Bogdan (1966)
Leaf	12.16				"
Bean (unripe)	13.9				Kuo (1967)
Seed (ripe)	4.4				"
Whole plant	28.9		39.5	8.4	McLeod and Minson (1976)
Range	26.6 - 31.7		36.5 - 41.6	7.6 - 9.5	"
Whole plant	28				Favoretto and Peixoto
Leaf	14.0 - 15.9				"
Stem	38.2 - 41.3				"
Whole plant	24				Mayer et al (1986)
Leaf	13.8				"
Stem	31.5				"
Leaf		42.5		9.4	Hendricksen et al (1981)
Stem		54.2		9.8	Hendricksen et al (1981)
Lablab hay		43.0			Umunna et al (1995)
Lablab hay		42.0	36	7	Abule et al (1995)
Whole plant		43.0			Nsahlai and Ununna (1996)
Whole plant		57.9	46.6		Makembe and Ndlovu
Whole plant		44.0	32.3	5.8	Murphy (1998)
Leaf		37.3	23.42	4.4	"
Stem		61.9	49.4	9.1	"
Average of whole plant	**27.8**	**43.0**	**38.6**	**7.1**	

One can see from Table 5 that further research is necessary to gain a better understanding of the fibre content of lablab using the more informative detergent system.

The second aspect of the fibre story is the quality of individual plant fractions. In all legumes the middle lamella is rich in pectins, and cells with only primary cell walls (mesophyll) are not lignified and pose no limit to either physical or digestive breakdown. Sclerenchyma, parenchyma (grass stems) and vascular tissues have thickened (secondary), lignified cell walls which are resistant to digestion and are the major limit to plant cell wall availability. The low digestibility of C_4 tropical grasses is associated with high proportions of these highly lignified tissues scattered throughout the leaf. A major difference between grasses and legumes is that whilst legumes often contain a higher content of lignin than grasses, only the xylem vascular tissues are lignified. In grasses, lignin is distributed throughout the plant tissue, and located in the walls of many different cell types (Wilson 1993). The fibre levels reported for leaves are lower than those reported for the whole plant. This can be significant in a grazing situation as animals tend to select for the leaf fraction (Wood 1983). This selection for immature leaves with a low cell wall content will improve nutritive value and digestibility over that indicated by a whole plant crude fibre value.

Digestibility

Digestibility of forage dry matter by the ruminant is the summation of the digestibility of the component tissues as affected by morphology, anatomy and chemical composition (Norton 1982). Table 6 summarises dry matter digestibility of lablab. The average dry matter digestibility of the studies presented is 56%. Irrespective of the method used to determine digestibility (*in vitro*, *in situ* or *in vivo*) or the species (cattle or sheep), the values of dry matter digestibility are all quite similar. As with most legumes, the dry matter digestibility of lablab declines with maturity (Milford and Minson 1968).

Table 6. Dry matter digestibility (DMD) of *Lablab purpureus* (Adapted from Minson 1990)

Sample	**DMD, %**		
	Mean	**Range**	
Lablab purpureus	55.5	50.9 - 59.2	Milford and Minson (1968)
Lablab purpureus hay	62.6	54.2 - 68.1	Thurbon et al (1970)
Lablab (*in vivo* - cattle)	55.5	50.9 - 59.2	McLeod and Minson (1976)
Lablab (*in vitro)*	55.9	52.4 - 60.0	"
Lablab hay 1st cut (sheep)	43.9		Favoretto and Peixoto (1978)
Lablab hay 2nd cut (sheep)	39.4		"
Lablab leaf (cattle)	55		Hendricksen et al (1981)
Lablab stem (cattle)	55.4		"
Lablab leaf (sheep)	55.8		"
Lablab stem (sheep)	49.4		"
Lablab - 80 growth	54.9	53.6 - 56.3	Jakhmola and Pathak (1981)
Lablab	75.0		Ojeda et al (1988)
Oat Straw + Lablab	53.1		Umunna et al (1995)
Oat Hay + Lablab	57.6		"
Lablab - ED @0.03/hr	55.4		Nsahlai and Umunna 1996
70:30 Maize:Lablab (in situ)	53.8		Makembe and Ndlovu 1996
50:50 Maize:Lablab (in situ)	55.0		
Lablab whole plant (*in*	63.0	60.9 - 67.5	Murphy (1998)
Lablab leaf (*in vitro*)	68.9	62.1 - 75.8	"
Lablab stem (*in vitro*)	54.4	49.1- 61.5	"
Average whole plant dry matter digestibility	56.1	50.9 - 68.1	

Lablab hay fed as a supplement to cattle on a basal diet of teff straw increased rumen ammonia concentration, improved straw digestibility, sped up particulate passage rate, decreased mean retention time and improved intake (Abule et al 1995). In another study involving sheep fed lablab supplements to oat straw and oat hay basal diets, it was found that rumen ammonia concentration and digestibility in the supplemented diets were improved (Umunna et al 1995). These characteristics demonstrate the potential that lablab has in alleviating nutrient deficiencies in poor quality diets.

Voluntary intake and selection

Mean voluntary intake values (Table 7) indicate satisfactory palatability of lablab at vegetative stage of growth (Jakhmola and Pathak 1981). Wood (1983) found that after flowering, the leaf was the most valuable component of a lablab crop as it not only has a much higher content of protein than the stem but it is strongly preferred by cattle. This is in accordance with an indoor feeding trial in which Hendricksen et al (1981) found that both sheep and cattle ate more leaf than stem. The higher leaf intake was associated with a shorter retention time in the rumen and was not due to differences in digestibility. In a grazing trial in Queensland, Hendricksen and Minson (1980) found that cattle strongly selected for leaf and that organic matter intakes declined as the availability of leaf fractions declined. They concluded that the desire of cattle to select leaf is so strong that stem yields should be disregarded when considering the Rongai cultivar as grazing crop. These findings need to be considered when assessing the value of lablab for grazing or as a hay crop.

Table 7. Voluntary intake of *Lablab purpureus*

Voluntary Intake (g/kg $W^{0.75}$)	Plant part	Species	BW* (kg)	DMI* (kg)	Reference
53.8 - 73.7	Hay	Sheep	50	1.01 - 1.39	Milford and Minson (1968)
60.8	Forage (vegetative stage)	Rams	50	1.14	Jakhmola and Pathak (1981)
66.3	Hay	Sheep	50	1.25	Favoretto and Peixoto (1978)
91	Leaf	Cattle	400	8.14	Hendricksen et al (1981)
51	Stem	Cattle	400	4.56	"
91	Leaf	Sheep	50	1.71	"
53	Stem	Sheep	50	.996	"
50 - 60	Forage (wet season)	Cattle			Ojeda et al (1988)
80	Forage (dry season)	Cattle			

* *Body weight (BW) and DMI (Dry matter intake) are estimated values.*

Contrary to the evidence of the leaf fraction being highly palatable, the grain fraction has been found to be the opposite. An experiment by Addison et al (1984) showed that crushed lablab grain (Highworth cultivar) was poorly accepted by steers on pasture, even during the dry season, and gave live weight responses less than its chemical analysis would suggest. The authors speculated that the presence of some heat-labile growth inhibitor decreased palatability. They concluded that the antigrowth factor was neither a protein nor a peptide but was associated with the protein component of the grain. It is interesting to note that some forms of lablab grain have been found to contain cyanogenic glucosides (Whyte et al 1953) which may also decrease palatability.

Animal production

Many conventional diets in the tropics for ruminants are poor quality roughages typified by high NDF, low nitrogen contents and slow fermentation rates. This poor dietary combination leads to decreased intake, weight loss, increased susceptibility to health risks and reduced reproductive performance. Including herbaceous legumes in these feeding regimes helps to rectify some of the problems associated with low protein and high fibre diets. Wetherall (1969) suggested that to optimise the benefits of lablab as a feed source, it should be grazed in conjunction with poor quality feedstuffs. In Thailand, Trongkongsin et al (1976) calculated that the average carrying capacity between 6 and 16 weeks for lablab was 7 animals per hectare.

In work performed in São Paulo, Brazil, weight gain of Zebu cattle yearlings grazing dry maize stalks, dry grasses and green lablab averaged 350 g per head per day during July and September. This result should be considered against the fact that cattle usually lose weight during the dry season (Schaaffhausen 1963b). During autumn and winter in Queensland, animals grazing native pastures generally lose weight. To reverse this trend Hendricksen and Myles (1980) conducted several field and pen studies with steers using lablab as a supplement. The results were positive with weight gains ranging from 93 to 1036 g per head per day depending upon the form in which lablab was fed.

In a study where lablab was used as a supplement to oat hay, average daily gain in sheep fed the supplement was almost double than that of sheep fed solely the basal diet (Umunna et al 1995). Ndlovu and Sibanda (1996) had similar results when sheep fed lablab as a supplement to Zimbabwe scrub land herbage gained a total of 3.1 kg in two months while unsupplemented sheep only gained 1.0 kg. Results from a goat study by Makembe and Ndlovu (1996), showed that maize stover diets supplemented with lablab resulted in better body weight changes of the does, higher kid birth weights, faster growth rates and more milk as compared to traditional small holder practices in which no supplementation was used. In addition, postpartum anoestrus periods were shorter for supplemented animals than in animals fed typical diets not including lablab. There were no dietary effects on carcass characteristics.

Jersey cows grazing Lablab purpureus in southeastern Queensland, Australia

In studies done by Hamilton et al (1970) in Australia, cattle consuming pure stands of lablab maintained a high level of milk production in contrast to animals eating grasses. This improved milk yield and a slower decline of yield with time was related to a higher intake. *In vitro* dry matter digestibility measurements and digestibility estimated from faecal-N regressions indicated that the diet selected by the cattle was of higher digestibility than reported literature values. This is explained by the fact that grazing cows select the leaf fraction, which is protein rich and more digestible than the stem.
A Cuban system based on pasture plus forage rations produced from inter-cropping, showed that animals on which included lablab had an increase of milk production of 3 litres/cow/day; the same response in milk production was achieved by using supplementation with soybeans. Besides improving production, the lablab system had the lowest cost/tonne of DM (Cino et al 1994). Similar results were obtained in Honduras (Sinclair 1996) in a trial comparing two forage systems (maize stover vs. maize stover/lablab). The system including lablab produced more milk per animal and per hectare than the traditional one. In addition, the cows assigned to the maize/lablab system gained more body weight than the cows in the maize system (Sinclair 1996).

Little (1976) found no oestrogenic activity caused by feeding lablab as a supplement. Documentation of detrimental impacts of feeding lablab is limited. Bloat has only been observed in animals grazing a pure stand of lablab (Hamilton and Ruth 1968).

In pasture trials, Luck (1965) determined that a limitation in using lablab is that to ensure maximum herbage regrowth, swards should only be leniently defoliated. Herrera et al

(1966) also reported that following five cuttings over a period of 294 days, the stand density of lablab declined from 7.8 to 0.75 plants /m^2. When lablab swards were grazed by sheep 10 and 16 weeks after sowing, plant density was reduced from 7.7 to 4.0 plants / m^2 (Philpotts 1969). These results suggest that to maintain sustainability using lablab in a pasture system, prudent management is required.

Comparison with other Legumes

In general, tropical legumes tend to be higher in crude lignin and protein and lower in cell wall than tropical grasses (Van Soest 1994). With an average crude protein of 17% in the dry matter (Table 4), lablab is slightly above average when compared to other tropical legumes and has considerably more protein than tropical grasses (Norton 1982). The average 28% crude fibre in dry matter of lablab (Table 5) ranks less than the majority of tropical legumes and grasses (Norton 1982). In terms of dry matter digestibility (Table 6) lablab ranks well compared to both tropical grasses and legumes (Minson and Wilson 1980). In addition to ranking well in terms of crude protein, crude fibre and dry matter digestibility, lablab makes a better recovery after grazing and demonstrates less susceptibility to disease and insect pests as compared to other tropical legumes and grasses. It is more cold tolerant growing much later into colder seasons than many other tropical legumes; while in arid environments lablab stays greener during drought periods than conventional crops (Wilson and Murtagh 1962; Luck 1965; Philpotts 1969).
When compared to 43 other tropical forage legumes in Trinidad, lablab was given an excellent production rating based on observations of the dry matter yield, adaptability, persistency, resistance to drought, pests and diseases. It is suggested however that the production rating may change according to soil types. This warrants further investigation in other areas (Harricharan et al 1988)

Agricultural applications

In addition to its potential as an enhanced nutritive feed source for livestock, *Lablab purpureus* offers many other benefits when included in tropical agriculture systems. Being a legume, lablab provides biological nitrogen (N) fixation. The natural action of converting atmospheric N into forms available for the plant-animal-soil system improves productivity in an inexpensive, environmentally friendly manner. The level of N fixation from effectively nodulated legumes depends upon the growth rate of the legume and upon soil conditions; usually 15-40 kg N is fixed for each 1000 kg dry mattr of shoots grown (Humphreys 1995). This "natural fertiliser" enables small landholders to improve the soil without exacerbating debt.

With its deep tap root, lablab is not only drought resistant, but is able to bring minerals, otherwise not available for annual crops, from the depths to the top soil (Schaaffhausen 1963a). This deep root also serves to stabilise the landscape as soil erosion and runoff are reduced by leguminous covers. This is advantageous in lay pasture systems or intercropping as during the dry season the land may lay idle at the mercy of the weather conditions. When seeded in orchards or coffee plantations, lablab not only protects the soil but acts as a natural weed control without any detrimental effects on the coffee bushes or fruit trees (Schaaffhausen 1963a).

Lablab has also been known for its use as a green manure, adding organic matter as well as N and minerals to the soil. In land destined for immediate agricultural use, as for sugar cane, the green mass is disk-harrowed before it produces ripe seed. If the land does not have to be used the same year, the plants are left to grow and are used as pasture in the dry season (Schaaffhausen 1963a). One disadvantage lablab may have however, is the fibrous stem material may break down slowly, interfering with subsequent cultivation and sowing (Wood 1983). However based on the fibre and digestibility data presented in Tables 5 and 6, this does not seem likely.

An economical method of cultivating lablab for soil improvement and for cattle feed is to sow the legume as a companion crop for maize. During the first few months lablab grows slowly competing with weeds between the maize rows, but not with the maize. When the maize begins to ripen, lablab vines start to grow more vigorously and obtain their greatest development after the maize is harvested. At this point cattle may be turned out to graze the maize stover / lablab field (Schaaffhausen 1963ab; .Sinclair 1996). This technique corrects protein deficiency in the dry season, and leads to a better use of low-protein, high-fibre crop residues. Lablab may be incorporated into pasture systems and under more advanced conditions, it can be used in controlled rotational grazing systems (Jones et al 1991). Another benefit of using lablab is that it is a viable grain producing legume for human consumption (Wood 1983). Lablab has tender pods which may be eaten green or the grain may be allowed to mature. Once the mature beans are harvested, they need only be cooked to provide nourishment for humans (Schaaffhausen 1963a; Sinclair 1996).

Conclusions

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 world wide. Staying green during the dry season, it has been known to provide up to six tonnes of dry matter/ha.

Being palatable to livestock, it is an adequate source of much needed protein and can be utilised in several different ways. It can be grazed in a pasture setting or as a companion crop to maize, cut as hay, or mixed with corn silage. In several experiments it has been observed to increase livestock weight and milk production during the dry season.

Lablab 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. Lablab can be used advantageously as a cover crop. Its dense green cover during the dry season protects the soil against the action of the sun's rays and decreases erosion by wind or rain. As green manure it provides organic matter, minerals and fixes nitrogen into the soil thereby improving crop yields in an economic and environmentally friendly manner.

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. 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. Thus helping to improve the living conditions in countries where shortages of human food and animal feedstuffs exist.

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