

PRODUCTIVITY OF *LABLAB PURPUREUS* [L. SWEET] CV.
RONGAI AND ITS FEEDING VALUE AS A SUPPLEMENT
FOR LACTATING DAIRY COW

By

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A THESIS SUBMITTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN AGRICULTURE
OF MAKERERE UNIVERSITY

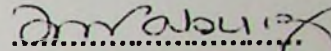
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DECLARATION

I declare that the work presented in this thesis is my own and that it has not been submitted for a degree in any other University.

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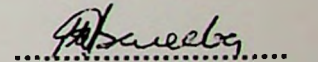
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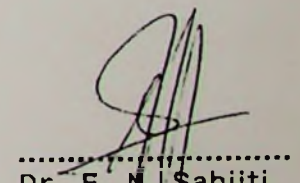
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DEDICATION

This work is dedicated to my Parents: Margaret and Eria; my children: Michael, Edward and Margaret and to all fellow smallholder dairy farmers in Uganda.

ACKNOWLEDGEMENTS

I am greatly indebted to Assoc. Prof. Dr. F.B. Bareeba, Head of Animal Science Department and Assoc. Prof. Dr. E. N. Sabiiti, Dept. of Crop Science and Dean, Faculty of Agriculture and Forestry, Makerere University, Kampala (MUK), for accepting to supervise this work and for their personal interest and criticism during the period the study was being conducted.

The technical assistance of Mr. J. Kigongo and Miss A. Namagembe of Namulonge Agricultural and Animal Production Research Institute (NAARI) and Mrs R. Mubiru of MUK, is greatly appreciated. Many thanks go to: Mrs. S. Mubiru; Drs. J.S. Tenywa and C. Ebong for their useful comments on this manuscript. Special thanks go to Drs. I.V. Nsahlai, P.O. Osuji and Mr. D. Mpairwe of the International Livestock Research Institute (ILRI), Debre-Zeit, Ethiopia for their comments and suggestions and to Ato Getahum Kifle, for allowing me to use the institute facilities. I am also grateful to my casual labourers who worked wholeheartedly to ensure availability of fresh fodder throughout the study. Thanks are owed to Mr. J. B. Mubiru, Director, Extension, Ministry of Agriculture, Animal Industry and Fisheries; Prof. J.S. Mugerwa; Mr. W. Ndyanabo; Mr. F. Tibayungwa; Mr. Oduru and all those friends who provided reading materials.

Finally, I wish to thank the Director General, National Agricultural Research Organization (NARO) for accepting to provide funds for this study. Special thanks go to Drs. M. Kalunda, Deputy Director General, NARO, for his relentless advice and T. Sengooba (Mrs), Director, NAARI for allowing me to use the station facilities and her motherly encouragement throughout the study period.

Last, but not least, thanks go to my children for their moral support; Mrs. Sandra Mwebaze and Ms. Sarah Kasule for their moral and spiritual encouragement. May God bless you all.

ABSTRACT

Evaluation of Lablab (*Lablab purpureus* [Sweet]) cv Rongai as a supplementary forage legume for lactating dairy cows (Friesian x Zebu) fed on elephant grass (*Pennisetum purpureum*), was done at Namulonge Agricultural and Animal Production Research Institute. The effect of stage of maturity on the herbage dry matter yield (DMY), *in vitro* organic matter digestibility (IVOMD) and chemical composition of Lablab was assessed in Experiment I. As plant age advanced, herbage biomass DMY, spread and stem fraction increased significantly ($P \leq 0.05$). Lablab biomass DMY was 6.6, 10.9 and 12.2 Mt ha⁻¹, for the vegetative, flowering and pod-ripening stages of growth (75, 110 and 140 days post-planting respectively). The leaf fraction decreased ($P \leq 0.05$) with increasing plant age starting from FS to PS. Likewise, crude protein (CP) content decreased ($P \leq 0.05$) with increasing plant age. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) increased with plant age while, acid detergent lignin (ADL) remained constant. *In vitro* organic matter digestibility of the leaf and stem fractions also declined over the growth period by 12 and 19.5%, respectively. Calcium (Ca) and phosphorus (P) contents remained unchanged during the study period.

The performance of lactating dairy cows fed elephant grass based diets supplemented with Lablab hay was studied in Experiment II. Four cross-bred Friesian (Friesian x Zebu), were used in a 4 x 4 Switch-over Latin square design. The animals had a mean milk yield of 9.5 kg day⁻¹ and average live weight of 405.5 (S.D= ± 15 kg).

Addition of Lablab hay significantly increased elephant grass DMI. The optimum supplement level was 3 kg day⁻¹ (as fed), beyond which there was a substitution effect. Sole feeding on elephant grass resulted in lower ($P \leq 0.05$) total dry matter intake (TDMI) than when lablab hay was included as a supplement. Daily milk yield was significantly ($P \leq 0.05$) increased by lablab hay supplementation: 9.1; 9.8 and 10.8 kg day⁻¹ for levels: 0; 2 and 3 kg day⁻¹ respectively of lablab hay but decreased to 10.7 kg day⁻¹ at a level of 4 kg day⁻¹. The decrease was not significant. Milk composition was not affected by supplementation. Animal live weight decreased with sole elephant grass feeding. Supplementation with Lablab, however significantly ($P \leq 0.05$) increased live weight of the animals but there were no differences among the different supplement levels. A level of 3 kg day⁻¹ of lablab hay was sufficient to maintain milk yields and improve animal live weight.

Experiment III evaluated the effect of supplementing a concentrate to elephant grass-lablab hay basal diets. The experimental design and animal management were similar to those used in Experiment II. Mean milk yield was 8.5 kg day⁻¹ and mean liveweight was 384.5 (± 15 kg).

Supplementing a basal diet of elephant grass and 3 kg day⁻¹ of lablab hay with a concentrate, in Experiment III impaired the intake of elephant grass although TDMI increased significantly ($P \leq 0.05$). Daily milk yield was increased ($P \leq 0.05$) by supplementing: 9.8; 10.4 and 11.3 for levels 0; 1 and 2 kg day⁻¹ of a concentrate but there was no significant ($P < \pm 0.05$) differences beyond the level of 3 kg day⁻¹. Milk composition, on the other hand, was not affected by concentrate supplementation. Both supplemented and unsupplemented animals gained weight. However, the difference in live weight gains was not significant ($P \leq 0.05$).

A simple cost benefit analysis showed an increase of 5% in gross margin when lablab was further supplemented with a concentrate.

In Uganda, utilization of elephant grass accompanied by Lablab hay with a concentrate for lactating dairy cattle is a new intervention which has not now been documented especially. This practice certainly needs to be encouraged in light of the results of this study.

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ABBREVIATIONS

ADF: Acid detergent fibre

ADL: Acid detergent lignin

A.O.A.C.: Official methods of analysis of the association of official analytical chemists

BW: Body weight

CP: Crude protein

DE: Digestible energy

DM: Dry matter

DMD: Dry matter digestibility

DMI: Dry matter intake

DMY: Dry matter yield

FCM: Fat corrected milk

IVOMD: *in vitro* Organic matter digestibility

$\text{kgW}^{0.75}$: Metabolic body weight

MAURIK: Makerere University Agricultural Research Institute, Kabanyolo.

Mcal: Mega calories

m.a.s.l.: meters above sea level

NAARI: Namulonge Agricultural and Animal Production Research Institute

NARO: National Agricultural Research Organization

NDF: Neutral detergent fibre

N.R.C.: Nutrient requirement of cattle; TDMI: Total dry matter Intake

CHAPTER 1

INTRODUCTION

1.1 Background

All-year-round forage supply is probably the most pressing constraint in smallholder production systems in Uganda. Lack of adequate arable land for both livestock and crop production has played a major role. Generally, smallholder land-use systems accord food production top priority; fodder production is barely left to the marginally productive fringes such as rangelands, roadside and occasionally in fallowed arable fields. These forage sources rarely meet livestock requirements adequately (Ogwang, 1974; Mugerwa, 1975).

Under tropical conditions, low forage quality is caused by the unique rapid growth and maturation of forage plants with the onset of rains (Demarquilly, 1989). Paralleled with this is a rapid deposition of fibrous components (Van Soest, 1965), a decline in nitrogen and soluble carbohydrates (Milford and Minson, 1968) and a rise in the stem to leaf ratio (Karachi, 1988). High fibre levels and low crude protein content impair the functionality of the rumen ecosystem, thus causing inefficient utilization of feeds (Reid *et al.*, 1973; Ngwa and Tawah, 1992).

In Uganda, dairy production is currently among the most rapidly developing industries in the agricultural sector. It contributes approximately 9% of the gross domestic product (GDP) and about 30% of the overall agricultural sector (MFEP, 1995). It has been estimated that out of a total of a population of about 4.5 million heads of cattle in Uganda, 85% is indigenous Zebu, 13% intermediate crosses with *Bos indicus* and 2%

exotic breeds (Anon, 1994). The majority of Uganda smallholder dairy farmers use elephant grass (*Pennisetum purpureum*) as the basal diet for their cattle (Boonman, 1993; Nsubuga, 1994). Unfortunately, this species unduly declines in nutritive value with maturation (Ogwang and Mugerwa, 1976). Bredon and Horrell (1962) characterized the chemical composition and nutritive value of various grasses in Uganda. Metabolizable energy (ME) and CP appeared to be sufficient for maintenance requirements of cattle throughout the year. However, ME and digestible crude protein values were low and generally inadequate for milk production over 5-6 months period. Specific reports characterizing the performance of dairy cows fed on elephant grass *per se* or with supplements and/or concentrates are still scanty, especially as related to Uganda.

A number of management strategies have been suggested for the improvement of pasture quality, intake and digestibility. These include controlled rotational grazing (Mugerwa, 1975), bush and weed control (Wendt *et al.*, 1970), oversowing improved pastures species into the natural swards (Sabiiti, 1979) and irrigation and fertilizer application (Stobbs, 1965). These options appear inappropriate for most small-scale farmers who own small holdings or communal land and are financially disadvantaged. In addition, positive results from these options may not be achievable in the short term. One alternative that has had some degree of success in the cut and carry system in Uganda at the smallholder level, is the cultivation of improved leguminous fodder plants such as green leaf Desmodium (*D. intortum*), Centro (*C. pubescens*), Siratro (*M. atropurpureum*) and Stylo (*S. guyanensis*) and Lablab (*L. purpureus* cv. Rongai) (Ndyanabo, 1992; Sabiiti, 1993; Sabiiti *et al.*, 1994; Livestock Services Annual Report, MAAIF, 1994).

Lablab is more popular among the smallholder dairy farmers in Uganda because of its high biomass yield relative to other forage legumes (Sabiiti and Lusembo, 1990).

The rainfall pattern in central and southern Uganda is bimodal, with a period of long rains (3-4 months) separated by a dry spell from a period of short rains (2 to 3 months). During the growing seasons, Lablab herbage yield is often in excess of immediate livestock requirements. This excess herbage could be harvested and preserved either as hay or silage to serve as a cheap source of protein, expand the feed base and ensure a year-round supply of good quality fodder.

A complementary strategy, that of nutrient balancing through supplementation with concentrates, could also be adopted to optimize the efficiency of transforming absorbed nutrients into milk products (Archibald, 1984). Ruminants from a nutritional standpoint are considered to consist of two entities with different nutritional requirements (Smith, 1993). First, the requirements of the rumen which need to be met to ensure a functional ecosystem that will result in a maximum breakdown of the fibrous component of the diet by the resident microbes. The second entity is the whole animal component which requires true protein, other than the non-protein nitrogen utilized by the rumen microbes plus the glycogenic energy precursors. Hence, there is a need for supplying by-pass nutrients, energy and protein, in order to meet these requirements of the animal component (Smith, 1993). All the above options can only be developed and tested through well-designed studies both *in vitro* and *in vivo*, under specific environmental conditions and management regimes.

1.2 Justification

The use of elephant grass as a basal diet for lactating dairy cows is a well-established practice on most smallholder dairy farms in Uganda. The major problem associated with it is that it matures rapidly, becomes coarse and stemmy, and therefore has low CP content for a greater part of the year resulting in low apparent protein digestibility (Bredon and Horrell, 1962; Mpairwe, 1994). Animals subsisting solely on it during the dry season are often on a diet almost void of digestible crude protein and in many cases may even show a negative nitrogen balance (Crowder and Chheda, 1982). Low protein content also causes a reduction in overall digestibility of herbage dry matter, total digestible energy content and voluntary intake of dry matter. The end result of reduced voluntary intake and lower digestibility is a sharp decline in the total intake of digestible energy.

L. purpureus cv Rongai provides a cheap source of protein for animals in Uganda. It has been observed that the majority of smallholder dairy farmers in Uganda are using Lablab fodder as a protein supplement to elephant grass. Lablab crop has been reported to produce high dry matter yield compared to other sister forage legumes used by the smallholder dairy farmers in Uganda (Sabiiti *et al.*, 1994). Herbage availability during the wet season often exceeds animal requirements; however the accumulated forage loses most of its nutritive value with maturity (Karachi, 1988). The excess herbage harvested at optimum nutritive value could be conserved for dry season feeding.

Very little research work has been done on this crop in Africa (Rowland, 1993). Some research on it has been reported from India (mainly

as a food crop) (Jakhmola and Pathak, 1981; Thomas and Dabas, 1982), Australia (Hendericksen *et al.* 1981; Hendericksen and Minson, 1985; Wood, 1983), Brazil (NAS, 1979) and Kenya (Karachi, 1988). Lablab therefore suffers from the research disincentives common to many minor forage legumes (Rowland, 1993). Sabilti *et al.*, (1993) working on Lablab as a pasture crop in Uganda suggested that Lablab like any other new forage legume should be evaluated further to determine its potential in terms of milk and beef production. This kind of research would lead to a comprehensive package of integrating forages into crop/livestock production systems in the country.

Forage which forms the bulk of the feed may be available in sufficient quantity but of inadequate quality to support optimum milk production. It therefore becomes necessary to supplement the diet with concentrates to ensure maximum milk production. To reduce competition between man and animals for cereal grains, it is necessary to determine the optimal rate of concentrate supplementation for lactating cows in accordance with efficient utilization of available forages.

1.3 Objectives

- (i) To determine the effect of stage of maturity on the productivity and feeding value of *Lablab purpureus* cv. Rongai.
- ii) To study the effect of supplementing a basal diet of *Pennisetum purpureum* var. P.99 with Lablab hay, on the performance of lactating dairy cows.
- iii) To determine an optimum level of concentrate supplementation for dairy lactating cows fed on elephant grass-lablab hay based diets.

CHAPTER II

LITERATURE REVIEW

2.1 Role of forage legumes in pastures

Forage legumes are desirable components of pastures and grazing lands where: nitrogen is a limiting factor for optimal growth of associated grasses; a need exists for increased crude protein in herbage available for grazing; extended grazing into the dry season is desired and stability of the pasture system is given high priority (Crowder and Chheda, 1982).

2.1.1 Livestock production and productivity

It is generally accepted that pasture is the foundation for economical beef and milk production because: it is the cheapest source of feed (Wendt *et al.*, 1970) and it requires minimum labour once it is established properly. When conserved, it can be cheaper than most feedstuffs (Musangi, 1967). The productivity of pastures can be greatly increased by the use of high yielding pasture legumes (Stobbs, 1969; Reid *et al.*, 1973; Muinga *et al.*, 1992; Kusekwa *et al.*, 1992; Koume *et al.*, 1992); fertilization (Ogwang and Mugerwa, 1976) and efficient pasture management (Davison *et al.*, 1985; Skerman *et al.*, 1988). These attributes are also known to have a considerable impact on the nutritional quality of the pastures (Otim, 1973, 1975; Ochodomuge, 1978; Skerman *et al.*, 1988; Kiflewahid and Mossimanyana, 1992; Kang *et al.*, 1990; Mpairwe, 1994). Forage legume supplements have been reported to promote voluntary intake and therefore animal production (Rees and Minson, 1976; Muinga *et al.*, 1992; Tayeb and Takla, 1992) although Kiflewahid and Mosimanyana (1992), reported a depressing effect

in voluntary intake of maize stover when lactating dairy cows were supplemented with *Dolichos Lablab* (*Lablab purpureus*) in Botswana. Mpairwe (1994) reported a depressing effect on elephant grass fodder DM intake by mature sheep with *Gliricidia* supplementation although total DM intake was elevated.

As opposed to pure stands of grass, an increase of 11–49% in live weight of fattening steers has been reported in Uganda from grass-legume mixtures of *Hyperthysanella rufa* and *Stylosanthes guyanensis* (Stobbs, 1969) and *Panicum* (*Panicum maximum*) with Siratro (*M. atropurpureum*), *S. guyanensis* with *C. pubescens* (Otim, 1973).

Improved animal performance is not only expressed and measured in terms of higher live-weight gains per head but also in improved milk yields, carrying capacity (two to six fold), and improved pre-weaning growth rates (Ruiz, 1983; Jennings and Holmes, 1985; Boonman, 1993). For high milk production, dairy cattle need high quality feedstuffs. The amount of feed required to produce 1 kg liveweight gain per day is equal to that needed to produce 8–9 kg of milk per day (Crowder and Chheda, 1982). In addition to maintenance requirements, lactating cows require about 1.3 Mcal day⁻¹ of DM intake day⁻¹ and 0.08 kg of protein kg⁻¹ of milk containing 4.0% fat as recommended by ARC (1980). High milk production has been obtained from cows grazing *Leucaena leucocephala* (Muinga *et al.*, 1992). *Gliricidia* has been shown to be a useful supplement to elephant grass in the diet of sheep (Mpairwe, 1994).

Milk production and composition from sub-tropical pastures may be influenced by the legume species (Hamilton *et al.*, 1970; Sabiiti and Mwebaze, 1989; Lascano and Avilo, 1993). Stobbs (1977), showed that the solid non-fat

content of milk was lower from Siratro (*M. atropurpureum*) than Desmodium (*D. intortum*). Boonman (1993) noted that when the milk yield is depressed due to a low intake of digestible energy, butterfat content increases and protein content decreases. A depressing effect on milk yield from Desmodium and Siratro was reported by Stobbs (1971). Less milk was obtained from cows grazing on pure stands of either *D. intortum* or Siratro than on N-fertilized Pangola grass. This was attributed to reduced intake of digestible energy caused by the morphology of the plants. Grazing time on trailing legumes has been shown to be excessively long due to low sward density.

Fibrous residues constitute an important source of animal feed especially at the beginning of the dry season. Their nutritive value could be improved by supplementing with forage legumes and this has been shown to improve digestibility of poor quality roughage and their intake (Kimambo *et. al.* 1002).

In some instances, the introduction of legumes into native pastures has substantially increased animal production without fertilizer input (Rees and Minson, 1976). In evaluating the economics of improved pastures at Serere Research Station, Uganda, Stobbs (1969), reported that although nitrogen applications produced increases in herbage and beef production, the excellent pastures produced were uneconomic when the price of beef was considered. The grass-legume treatment provided the greatest profit margin. Long *et al.*, (1972) in their survey of 13 dairy farms in eastern Uganda, reported that the dominant pasture species included *Chloris gayana*, *H. rufa*, *P. maximum*, *Pennisetum purpureum*, *Centrocema pubescens* and *S. gracilis*. The pastures contained adequate amounts of nitrogen,

potassium, magnesium and sulphur and where legumes were present the pasture supplied adequate amounts of calcium and manganese for a 500kg cow giving 10 kg milk daily. Sodium and zinc were deficient and supplementation with these 2 elements was recommended. The amount of phosphorus was marginal and some supplementation was considered necessary. Copper supplementation was not considered advisable until definite deficiency is reported.

2.2 Effect of stage of growth on dry matter yield of forage legumes

Daily dry matter intake of an animal appears to be the most important factor controlling the nutritional value of tropical pastures (Mugerwa, 1975; Stobbs, 1976; Sabiiti, 1979; Minson, 1982). An understanding of plant reaction to defoliation in terms of dry matter production is necessary as a basis for devising forage management systems. Management involves altering the botanical composition in a particular way or adjusting pasture growth rate to some specified animal needs so as to utilize nutrients produced by the pastures.

The effect of maturity on dry matter yield of forage legumes has been extensively reviewed by (Minson, 1982; Norton, 1982; Hendericksen and Minson, 1985; Karachi 1988; Karuaichamy and Oaliwal (1993); Mpairwe (1994). Ochodomuge (1978), in his investigations on the effect of age and dry matter yield of *D. intortum*, *M. atropurpureum* and *S. guyanensis*, reported that advancing maturity generally increased dry matter production, *Desmodium* being a better yielder than Siratro. Sabiiti (1979) reported the highest dry matter yield per hectare of legumes to be usually at near 10% bloom. Cutting investigations based on stage of development have shown

that harvesting or grazing at 10% bloom is the best stage for obtaining the most acceptable herbage and nutrient yield.

Decline in leaf to stem ratio with maturity has been reported by Jakhmola and Pathak (1981); Karachi (1988); Mpairwe (1994). This is partly attributed to increased leaf abscission and fall off the plant.

Plant maturity and DM yield of a species depends on rainfall and location. It varies from year to year so that cutting based on regular cutting intervals does not take into account the physiological stage of the plants (Karuaichamy and Oaliwal, 1993). They reported a positive relationship between above-ground plant biomass and the amount of monthly rainfall in the annual cycle for a tropical grassland and the Himalayan grassland.

2.3 Effect of stage of growth on nutritive value of forage legumes

2.3.1 Crude protein content

The effect of age on the protein content of forages has been extensively reviewed by (Ogwang, 1974; Ogwanga and Mugerwa, 1976; Ochodomuge, 1978; Sabiiti, 1979; Minson, 1982; Hendericksen and Minson, 1985; Mpairwe, 1994). The protein content of forage legumes declines only slowly with maturation, the older leaves showing the greatest decrease (Crowder and Chehda, 1982). A decrease in crude protein content with increasing maturity has been observed for *D. uncinatum* (Milford 1967), *M. atropurpureum*, and *L. purpureus* (Milford and Minson 1968; Hendericksen and Minson, 1985; Karachi, 1988), *I. hirsuta* (Sabiiti, 1979) and *S. humilis* (Ochodomuge, 1978). The variation between legume species in protein content also probably reflects the effectiveness of rhizobial nitrogen

fixation under different environmental conditions (Wendt *et al*, 1970).

It has been reported that with advancing maturity, the decline in protein content is slower in leaves than in stems (Karachi, 1988). Protein content at maturity is determined by species differences, initial protein levels in vegetative tissue, the rate and extent of decline and the final proportions of leaf and stem in the mature plant (Reid *et al*. 1973; Laredo and Minson, 1973); Demarquilly and Jarrige (1973); Minson (1982). Ochodomuge (1978) working with *Siratro* and *Desmodium* reported that advancing maturity was negatively correlated with CP content, intake and digestibility of herbage, but not positively correlated with fibre content. Sabiiti (1979) reported that flowering in *I. hirsuta* is not completely associated with large changes in nutritive value despite leaf loss through senescence. The age and season at which the pasture is grazed influences the quantity of milk produced from the pasture. Milk production has been reported to significantly decline in dry season due to the decline in crude protein content of pastures which falls below 7% and becomes limiting for milking cows (Reid *et al*, 1973).

2.3.2 Mineral content

The balance, concentration and nature of minerals in herbage varies with plant species, stage of growth and mineral content, however, species differences are still evident when optimal fertilization is done. Factors affecting the mineral composition of herbage have been reported (Long *et al*, 1972; Crowder and Chheda, 1982 and Little, 1982).

Changes in mineral contents that occur with advancing plant age are largely related to alterations in proportions of leaf and stems; flowering and setting of seed (Little 1982). He also reported that variations have been observed but in general terms calcium levels remain relatively constant, while those of phosphorus, nitrogen, sulphur and most trace elements decline with increasing age.

Intake and digestibility are adversely affected when plant mineral content drops below the level required for animal growth (Little, 1982).

2.3.3 Fibre content

It has been reported that as pasture plants mature there is usually an increase in the proportion of fibre and a reduction in the protein and non-structural carbohydrates of the cell contents (Stobbs, 1971). Associated with these changes, digestibility and intake by animals are reduced (Reid *et al*, 1973; Van Soest, 1965). This general trend has been confirmed for 14 grasses and legumes (Demarquilly and Jarrige, 1973). Different species reach peak carbohydrate contents at different stages of growth, and total levels of carbohydrates in tissues vary with species (Norton, 1982). Few changes occur in the carbohydrate content of forage legumes during growth (Minson, 1982). Cell-wall content (also known as the neutral detergent fibre) of leaves is usually lower than that of stems, with differences between leaf and stem being greatest in the legumes (Milford and Minson, 1968; Laredo and Minson, 1973). Cellwall content of both legumes and grasses increases continuously during growth to maturity, although grasses have higher contents at maturity than the legumes (Minson, 1982).

2.3.4 Digestibility and feed intake of forages.

Animal production is a function of the daily intake of digestible DM and, therefore, depends on both the quantity and digestibility of the feed consumed (Minson, 1982; Norton, 1982). Several researchers have shown that digestibility of tropical pasture plants generally falls as they mature due to rapid increase in lignin fraction (Reid *et al.*, 1973; Ochodomuge, 1978; Sabiiti, 1979; Karachi, 1988). High *in vitro* organic matter digestibility values ranging from 75 to 85% after one week's regrowth have been reported in several improved tropical pastures varieties (Milford and Minson, 1968).

Most of the tropical legumes, with the exception of the *Desmodium* species have high initial digestibility (70 to 90%) with relatively low rates of decline in digestibility with advancing maturity (Reid *et al.*, 1973). This may be due to the relatively lower contents of hemicellulose in legumes (Minson, 1982). Boonman (1993) reported low *in vitro* organic matter digestibility of *Desmodium spp.* even of young leaves, because of high content of tannins which protect the protein against enzymatic attack. The decline in digestibility with age has been reported to be more rapid in tropical grasses than in tropical legumes (Milford and Minson, 1968). This is different from the digestibility changes noted in two annual forage legumes, *Lablab* and *Vigna sinensis*, which maintain high digestibility values with age increases (Milford and Minson, 1968; Kiflewahid and Mosimanyana, 1987).

The relationships among intake, digestibility and chemical composition are highly specific (Van Soest, 1965). Vertical differences in digestibility are also encountered in tropical pastures. Crowder and Chheda (1982)

observed that within the mass of herbage, digestibility decreases from top downwards. Rapid maturation of stems and senescence of leaves in the basal layers can reduce overall forage digestibility.

Leafiness in pastures tends to influence forage quality, due to a positive correlation between leaf percentage in a given plant species and protein, mineral composition and DM digestibility (Norton 1982, Reid *et al.*, 1973; Laredo and Minson, 1973). Milford and Minson (1968) reported that towards pasture plants maturity, digestibility decreases due to the decrease in proportion of the young more digestible leaves, which contain low levels of cell-wall (NDF). In addition, they are readily fermentable, and form a rich source of both protein and energy for the microbes. Karachi (1988) reported higher decline in leaf digestibility of *Lablab* than in the stem fraction. Protein content was higher in leaves than in stems and declined by 3 to 5% in both fractions over time. Leaf to stem ratio at forage harvest is, therefore, an important factor associated with digestibility. The differences in intake between leaf and stem are closely related to physical properties of the fraction (bulk density, surface area per gramme) than to differences in chemical composition (Demarquilly and Jarrige, 1973). In tropical legumes, there are larger differences in digestibility between leaf and stem than in grasses (Minson, 1982). The consumption of legume stems, therefore, results in reduction in animal productivity. Increase in intake as forage canopy height increases to an optimum has been reported by Stobbs (1973). Daily intake is, therefore, a product of grazing time per day, bite size and biting rate.

The effect of plant age is further worsened by differences in physiological characteristics of the leaves produced later in the life of the plant (Hogson, 1982). Forage species which maintain high digestibility for long periods during growth are of higher value for animal production than those which have high digestibility at a young stage of growth but decreases rapidly towards maturity.

The procedures used for selecting forage species of high quality must, therefore, take into account not only digestibility but also the rate at which digestibility changes towards maturity.

2.4 Nutritive value of conserved forages

The energy, nutritive value and voluntary intake of hays has been reported to depend first on that of the standing herbage. Again, whether herbage was dried during good weather in the swath or on tripods, the loss of crude protein was only 16%, however, after drying herbage in the swath in bad weather, the loss reached 40%. Demarquilly and Jarrige (1973) who studied swath, rack and artificial methods of drying herbage, came to similar conclusions. Although the digestibility of organic matter fell as the herbage dried, no distinction was found between hays conserved by the various methods, except when the conditions for drying were unfavorable. In U.S.A. Slack *et al.* (1960a) cited by Davidson and Woodman (1966) made hay, both field and barn dried, from first and second year growths of herbage, harvested at the same time and without damage from adverse weather. Tests with cattle showed that the nutritive value of the barn-dried, chopped hay was not appreciably better than that of field-dried baled material. Digestion and intake of conserved forages are also affected

by changes in moisture content and composition. Leaf losses during hay making can reduce the protein content of a forage crop by 40%. In addition, it reaches voluntary intake and digestibility due to insufficient nitrogen for sustained activity of microorganisms (Demarquilly and Jarrige, 1973).

Ensiling has been reported to have a slight depressing effect on digestibility and energy utilization efficiency of forages (Demarquilly and Jarrige, 1973). However, it causes greater reduction in the utilization efficiency of crude protein. On the other hand, the major factor limiting the production potential of animals fed on silage is the level of voluntary intake which can be as low as 70% of dried forages (Davidson and Woodman, 1966; Bareeba, 1977). The intake of silage is generally lower than that of the fresh herbage (Jarrige *et al.*, 1982). The fall in intake has been observed even in well conserved silage having the same digestibility as the fresh crop. Low silage intake is due to the modifications done to the herbage during the processes of harvesting and conservation. Modifications include the production of free organic acids from the fermentation of soluble carbohydrates, amino acids and sometimes pectic substances; breakdown of proteins into non-protein products; increase in the proportion of cell-wall constituents; effects due to chopping, compaction and fermentation (Jarrige *et al.*, 1982).

The effects of feeding conserved forages to lactating dairy cows on milk yield has been reported by Phillips (1988) to reflect the increased total DM intake when hay is fed. He further reported that milk yields are increased by offering hay although, individual experiments have reported different effects on fat and protein contents. Where hay and silage have

been made from the same swath, hay has been reported to be equivalent or slightly higher (Davidson and Woodman, 1966) feeding value to silage when used as a pasture supplement. Where silage is of lower or similar quality to herbage, inclusion of silage in the diet generally results in a depression in milk yield relative to *ad-libitum* herbage (Phillips, 1988). Where silage is of higher quality than pasture, Bareeba, (1977), reported that milk yield was increased when silage was included in the diet. The effect of inclusion of silage on liveweight change is poorly documented and difficult to interpret because of possible gut fill changes (Phillips, 1988).

2.5 Effect of feeding concentrates on animal performance

Tropical grasses are usually of relatively low digestibility and this accounts for the limited levels of milk produced when they are fed such grasses (Reid *et al.*, 1973). This is because a larger proportion of the ingested nutrients is used to meet maintenance requirements and very little is available for milk production (Ogwanga and Mugerwa, 1976; Muinga *et al.*, 1993). Energy has been identified as the most limiting nutrient for milk production in tropical and subtropical environments (Phipps, 1970; Alhaussan and Owusu, 1980; Stakelum, 1980; Ruiz, 1983; Archibald, 1984; Tayeb and Takla, 1992; Jennings and Holmes, 1985, Vadiveloo, 1986). Royal and Jeffrey (1980), cited by Jennings and Holmes, 1985) compared the effects of a protein-rich or energy rich supplement, or a combination of both, given to cows grazing Kikuyu dominant pastures. They reported a linear correlation between DM intake of the energy supplement and milk production. This indicated that milk production was limited more by energy than protein deficiency.

Concentrates are rich sources of energy and/or nitrogen, contain little fibre and varying amounts of minerals and vitamins (Crowder and Chedda, 1982). Small amounts of concentrates containing nitrogen lead to an increase in the intake of low quality forages containing less than 1–1.2% N (Rees and Minson, 1976; Ruiz, 1983; Meijs and Hoekstra, 1984; Archibald, 1984; Jennings and Holmes, 1985; Kellaway and Porta, 1993). Jarrige *et al.* (1973) reported that with the exception of poor forages, the intake of forages often drops with increasing levels of concentrate feeding. The extent of the decline per unit of concentrate appears to be more marked with forages of high intake and digestibility than those lower intake and digestibility (Demarquilly and Jarrige, 1973), and with hays than with silage (Campling and Murdoch, cited by Siebert and Hunter, 1982). Devendra (1975) in a review of the feeding and management of dairy cows, emphasized the need for supplementation if high milk yields (up to 15 kg cow⁻¹ day⁻¹) are to be obtained from tropical grass pastures. He further suggested 60:40 concentrate to roughage ratio on "as fed basis" as optimum ration. Alhassan and Owusu (1980) and Hibbs and Conrad (1975) reported that under abundant forage conditions, of fairly good quality (approximately 9% CP), minimal concentrate supplementation ensures economic returns. Ruiz (1983) hypothesized that the key to significant increases in milk production is to ensure proper nutrition during the first two months of lactation when the cow has the greatest need for nutrients. He recommended that supplementation should start before parturition. He further suggested that concentrate feed levels should then be increased as the cow reaches lactation peak, and be reduced it afterwards until it is eliminated from the feeding programme.

Kellaway and Porta (1993) observed that increasing the proportion of concentrates in roughage and concentrate mixtures tends to reduce the time lag between peak milk yield and peak voluntary feed consumption. Peak milk yield in dairy cows, and accordingly maximum energy demand, generally occurs 5 to 8 weeks after parturition (Bines 1979).

Tergas (1983) concluded that daily milk production potential from improved tropical pastures can reach 10–12 litres cow⁻¹ and over 10 000 litres ha⁻¹ if the correct species, fertilizer regimes and management practices are used. He further suggested that supplementary feeding is not usually necessary except when the fodder is mature or in the dry season, but mineral supplements are required. Forage legumes are therefore critical in animal production and it is therefore important to diversify the feed resources base in Uganda.

2.6 *Lablab purpureus* [L. Sweet] forage legume

2.6.1 Botany

Lablab bean is commonly referred to as: *Dolichos lablab*, Haricot bean, Hyacinth bean, Indian butter bean, Lablab niger, *Lablab purpureus*, Lubia or Njhai beans. It belongs to the family *Leguminosea* and sub-family *Papilionacea* (Thomas and Dabas, 1982). *Lablab* is a herbaceous perennial herb, often grown as an annual crop which vigorously trails and twines. Only two cultivars, Rongai and Highworth are available commercially but a very wide range of types exist, varying both in morphological and maturity features. The lablab bean plant looks like cowpea plant, but its stems are

stronger and more fibrous, and it is more resistant to root diseases which is common in cowpea (van Schaaffhausen, 1963 cited by Skerman *et al.*, 1988).

Lablab bean occurs in two botanical types. The garden type twines and has to be grown on supports; is late maturing and is mainly used as a green vegetable. The field type is perennial, erect, bushy, matures earlier can be used as a green vegetable. The pods are fibrous and have an unpleasant smell. Over 200 genotypes are recognized (Cameron, 1988). Their variable characteristics include: pod size and shape, colour and seed size, shape, colour and seed attachment within the pod; foliage size, shape, hairiness, or colour, flower abundance, fragrance, corolla size, peduncle length and colour. Also, physiological differences such as seedling vigour, drought tolerance, day-length sensitivity, flowering time, maturation time, disease and pest resistance, and seed viability may be distinguishing factors (Thomas and Dabas, 1982)

2.6.2 Origin and distribution

Lablab plant probably originated in South-East Asia, but has been grown in Africa for over 100 years (Thomas and Dabas, 1982). East Africa as a whole has been recognized as the center of greatest diversity ("gene center") of some legumes such as *Lablab* and *Vigna* species NAS (1979). More recently, it has been adopted as a forage crop in Australia, South America and throughout the tropics and sub-tropics (Boonman, 1993; Rowland, 1993). Cultivar Rongai originated from Rongai in Northern Kenya. Lablab forage legume was introduced to the smallholder dairy farmers in Uganda in 1989 through the Dairy Development Committee with a major

objective of seed multiplication for sale to dairy farmers and feed for livestock (Ndyanabo, 1992). Only two cultivars, Rongai and Highworth are available commercially in Uganda.

2.6.3 Adaptability

Lablab plant is already widespread throughout the tropics with many varieties, many uses and wide adaptability in most countries. Its productivity potential however, has not been reached (Skerman *et al.*, 1988; Boonman, 1993). Although Lablab plant is more suited to the warm climate, the crop is cultivated under different agro-climatic conditions due to its wider adaptability (Sabiiti and Lusembo, 1990; Sabiiti *et al.*, 1994). It prefers rainfall in excess of 750 mm but below 2,500 mm (Skerman *et al.*, 1988). It grows well in soils ranging from acid to alkaline, pH (4.4–7.8) as well as in aluminous soils (Thomas and Daban, 1982).

It requires warm temperature for good growth. Minimum temperature for growth is about 3⁰C (Cameron, 1988; Skerman *et al.*, 1988). It is more tolerant to cold than velvet bean (*Mucuna pruriens*). It does not tolerate flooding and will not grow in wet soils; it, therefore, requires good drainage (Skerman *et al.*, 1988). Furthermore, its growth is generally unaffected by low soil nitrogen content (Skerman *et.al.*, 1988).

2.6.4 Agronomy and dry matter yield

The plant performs best when drilled into a well prepared seedbed, but it can establish by broadcasting in roughly ploughed or cultivated land if the seed is covered to some extent. It can be drilled with maize at planting time or when the maize is about 15 cm high. Sometimes it competes

too vigorously with the cereal, in which case it should be relay-planted when the maize or sorghum crop is 3–5 weeks old (van Schaaffhausen, 1963; cited by Skerman *et al.*, 1988). It does not establish in natural pastures unless they are cultivated. It can, however, be sod-seeded into pastures (Skerman *et al.*, 1988). *D. lablab* has been planted with elephant grass with some success (Strange, 1955 cited by Boonman (1993). Strange suggested to sow the legume first and to plant root splits of the fodder grasses later in the same row. The seed germinates from a sowing depth as deep as 10 cm but is usually sown at 2.5 cm and harrowed. A seed rate of 5 to 10 kg ha⁻¹ is recommended (Thomas and Dabas, 1982). It does not require any pre-planting treatment. It nodulates easily either with Lablab or cowpea type *Rhizobium*, common in soils worldwide (Skerman *et al.*, 1988). Good soil moisture is needed to get the crop established. Generally, in fertile soils, no fertilization is necessary. In poor soils, 250–500 kg ha⁻¹ molybdenized superphosphate and potash should be applied (Skerman, *et al.*, 1988).

Its dense growth smothers most weeds, in most cases it propagates by self-seeding, especially if the soil is re-cultivated to bury the seeds. A well established plant has a deep root system, often penetrating to water sources more than 2 m below the soil surface, permitting luxurious growth to persist long dry seasons. Thus, the lablab has a long production season and can provide food, fodder and soil protection when many other herbaceous plants have become desiccated.

Lablab herbage yields vary widely even within a given locality. In sub-tropical New South Wales, Murtagh and Dougherty (1968) cited by Skerman *et al.*, (1988) reported leaf yields ranging from 0.40 to 2.21 t DM

ha⁻¹ and total herbage yields from 0.64 to 4.62 t DM ha⁻¹ which compares favorably with the yields of velvet bean grown in the same trial. Rowland (1993) reported yields over 12 tons fresh material ha⁻¹ were obtained in Sudan and 15–20 ton fresh material ha⁻¹ can be expected under irrigation. Hendericksen and Minson, (1985) reported that *L. purpureus* cv. Rongai DM accumulated at rates ranging from 10 to 83 Kg ha⁻¹ day⁻¹. Maximum DM yield was 6.3 t ha⁻¹ at 121 days of age, and green leaf comprised of 30–40% DM yield at 100 days after sowing. Fifty percent of this green leaf was in layer 30–60 cm above the soil surface and had a bulk density of 23–31 kg DM ha⁻¹.

In Uganda, Sabiiti *et al.* (1993) reported that the Lablab accessions (ILICA Nos. 6534, 7278 and 7403) were the highest yielders compared to *D. uncinatum*, *D. intortum*, *Stylos*, *N. wightii* and *M. atropurpureum* (Appendix Table 1). It combined both productivity and persistence and established well under natural swards when planted into hoe-cultivated strips. Sabiiti and Mwebaze (1989) reported that the legume has a very high potential for herbage production and is compatible with *Panicum maximum* and elephant grass.

2.6.5 Nutritive value

Crude protein content of the leaf has been reported to range between 20 to 29%, that of the stem 8–16% and the whole plant 14–19% (Hendericksen *et al.*, 1981; Thomas and Dabas, 1982; Hendericksen and Minson, 1985; Karachi, 1988; Jakhmola and Pathak, 1981). Thurbon *et al.*, (1970) found Lablab hay to have a protein content of 11–14%. It is excellent for bridging the gap between dry and wet seasons. Morris and Levitt

(1968) reported 24.9% DM, 2.3% N, 1.5% Ca and 0.3% P before ensiling. *In vitro* organic matter digestibility of the DM of the young plants (77 days) was 61.3%, for old plants (140 days), 48.6%, and CP, 66.4 and 61.7% respectively (Thurbon *et al.*, 1970). Favoretto and Costa (1978) reported that when Lablab was cut 77, 84, 91, 98 and 105 days after sowing, when 10, 20 or 30 cm high, production of DM per ha was greatest with cutting at from 84 to 105 days and at 10 cm or even 20 cm. DM and crude protein, ranged from about 19 to 21%, were not affected significantly by treatment. Crude fibre increased progressively, but was fairly stable from 91 days. Regrowth was greatest with cutting at 91 days and at 20 or 30 cm.

Hendricksen *et al.* (1981) made hay from *L. purpureus* was chopped and separated into leaf and stem fractions. Diets were given to 4 cattle and 6 sheep fitted with rumen fistulae. Mean voluntary intake of the DM in the leaf fraction was 79% higher by cattle and 61% higher by sheep than for the stem fraction, and this seemed to be associated with the shorter time it was retained in the rumen. Both leaf and stem DM were digested to a similar extent by cattle. Sheep digested the leaf fraction to the same extent as did cattle but the DM digestibility of the stem eaten by sheep was lower than that of the leaf fraction. Cattle retained the DM, organic matter and neutral detergent fibre in all diets for longer in the rumen than did sheep. This difference led to a 48% higher voluntary intake (g kg^{-1} bodyweight) 0.9 daily by sheep. The proportion of large particles that disappeared within the rumen was lower for cattle than for sheep. The large particles of the leaf and stem fraction were retained by sheep for 5.7 and 5.6 h and by cattle for 13.8 and 21.6 h. The rate of disappearance of large particles in the rumen seemed to be only a minor factor causing the longer retention

time of stem fractions in the rumen. Henderkicksen and Minson (1985) reported that the OMD of leaf and stem in the canopy layers (30–75 cm) were higher than in the bottom layer (0–30 cm) and declined with maturity in all but the top (60–75 cm) layer. The average rate of decline per day was 0.06% units and 0.11% units for leaf and stem respectively. Nitrogen, K and P contents of the leaves increased with canopy height whereas Ca, Mo; Mn and Zn content decreased. They concluded that the DM yield, nutrient concentration and digestibility of leafy herbage in the top half of Rongai canopy are sufficient to sustain medium levels of animal production provided the animals are able to graze selectively. Milford and Minson (1968) noted that *Lablab* and *Vigna sinensis* are some of the annual legumes which maintain high digestibility values with age. Hendricksen and Minson (1980) in a study in Queensland, observed that at the beginning of grazing by cattle on a crop of the legume *L. purpureus*, the crop contained green leaf 2230 kg ha⁻¹ but after 12 days of grazing the crop contained only 300 kg. ha⁻¹. In the first 6 days cattle selected a diet which contained 85% green leaf but after 12 days of grazing the selected diet contained only 17% green leaf. As available leaf decreased, grazing time increased from 465 min on day 1 to 685 on day 6 before decreasing to 490 min on day 12. Maximum grazing time occurred with a green leaf yield of 1185 kg ha⁻¹. The number of eating bites increased from 26 000 to 44 500 between days 1 and 6 and then decreased to 30 000 after 12 days of grazing. Grazing time and the number of eating bites were significantly correlated ($r = 0.99$). Bite size decreased from 410 mg organic matter/bite on day 1 to 90 mg bite⁻¹ on day 12. This decrease in bite size caused a linear decrease to 927 g day⁻¹ in estimated intake of organic-matter. The rapid decrease in bite

size and intake was caused by the reduction in the quantity of leaf unit⁻¹ area and the reluctance of cattle to eat stem. They concluded that the desire of cattle to select leaf is so strong that stem yield should be largely disregarded when considering Rongai as a grazing crop.

2.6.6 Utilization

(i) Forage for livestock

Husks and broken bits of the seeds during splitting are valuable feed for milking cows (Thomas and Dabar, 1982). In Uganda, the plant is grazed by cattle, sheep, goats, pigs and pecked by poultry.

Lablab hay is palatable, and if cut at a young leafy stage, is chemically comparable to alfalfa, though less digestible (Morris and Levitt, 1968). It also makes good silage (Hendericksen *et al.*, 1981). Integrating this crop into grass pasture improves the quality, palatability, and digestibility of the pasture and therefore animal performance (Skerman *et al.*, (1988). Stobbs (1973) reported that high intake of Lablab kept dairy milk production of Jersey cows at about 10 kg cow⁻¹, compared to less than 7.0 kg cow⁻¹ on *Setaria* and Rhodes grass. Hamilton *et al.* (1970), demonstrated that in contrast with tropical grasses, Lablab was able to maintain a relatively higher level of milk production. In a study carried in Queensland, Australia, relatively high milk production (>10 kg cow⁻¹day⁻¹) was obtained from dairy cows rotationally grazing on pure legume pastures of *L. purpureus* (Skerman *et al.*, 1988). Hamilton (1969) obtained 9 to 13 litres of milk per head per day from cows grazing pure Lablab forage. Henderiksen and Minson (1985), working with *Lablab* fed to lactating dairy cattle reported that bite size declined from 0.41 g on day 1 to 0.09 g on

day 12. The decrease was caused by a reduction in leaf quantity and lack of desire of cattle to consume the stem fraction. Hendricksen *et al.* (1981) made hay from *Lablab*, chopped and separated into leaf and stem fractions prior to feeding to cattle and sheep. Both consumed 79 and 61%, respectively. Sheep ate 40% more leaf and 56% more stem fraction than cattle ($P \leq 0.01$). The higher intake of leaf was attributed to the shorter time it spends in the rumen and not due to the differences in digestibility. The cattle retained the DM of the stem in the rumen 83% longer ($P \leq 0.05$) than that of the leaf fraction. With sheep, the leaf stem fraction was retained 51% longer ($P \leq 0.01$).

2.6.7 Other uses

The varieties which are quick growing and have spreading habit, are useful as green manure and soil surface cover crops in plantations particularly coffee, fruits and coconuts (NRS, 1979; Cameron, 1988; Skerman *et al.*, 1988). Besides it remains green during drought periods and hence it suitable for drought-hit areas and is useful as a nitrogen-fixing crop in pure stands, inter-planted with field crops, or grown in rotation with these crops (Kiflewhid and Mosimanyana, 1987; Rowland, 1993). In Sudan it has been used with some success, to suppress the pernicious sedge (*Cyperus rotundas*) weed. Populations of this weed were reduced by 92%, and many others were completely suppressed (Rowland, 1993). It is also an important forage crop on the Gezira irrigation scheme and is grown in rotation with cotton and sorghum (Rowland, 1993). *Lablab* therefore, has multiple application potentials, namely as a forage legume, in pest control and in soil fertility improvement. Boonman (1993) In his conclusion on the

importance of this fodder reported that with so much focus on fodder legumes, so little attention had been spent on finding more room for this well adapted, nutritious and high yielding local pulse crop. Sabiiti *et al.*, (1993) suggested that Lablab like any other new forage legumes should be evaluated further to determine its production potentials in terms of animal production (milk and beef). This kind of research would lead to a comprehensive package of integrating forages into crop/livestock production systems in the country.

2.7 Elephant grass (*Pennisetum purpureum* Schumach.) and its hybrids

Elephant grass hybrids were introduced to Uganda as a suitable fodder crop in 1960 and has been increasingly associated with stall-feeding to meet the increasing demand for fresh milk (Boonman, 1993).

2.7.1 Nutritive value

The % DM of elephant grass has been reported to be the lowest of all cultivated grasses in East Africa (Boonman, 1993). Under normal harvest regimes, every 2-3 months, the % DM does not exceed 16.5% in contrast with Rhodes grass and Guinea grass which reach over 20%. A rapid decline in CP content in elephant grass with maturation has been reported (Ogwang, 1974; Ogwang and Mugerwa, 1976; Woulters, 1985; Boonman, 1993). Ware-Austin (1963) monitored the % CP of a Kitale elephant grass at Kitale, Kenya. He recorded 16.7% as a year-round monthly average. An elephant grass survey in Kenya, by Woulters (1987) cited by Boonman (1993) indicated that 80% of the farms investigated did not reach the target of

10% CP, while more than 40% had less than 7.5% however, a high level of CP (3-4% N) has been maintained with frequent top dressings of N (Crowder and Chheda, 1982). Ogwanga (1974) in his study on the qualitative and quantitative evaluation of elephant grass hybrids (Kw₄, P 99, P 87 and P 91) at Makerere University farm, Kabanyolo reported that all components of the fibrous fractions of the forages increased progressively with maturity, Kw₄ having a higher OMD coefficients than most hybrids although it did not significantly differ from P 99. Crowder and Chheda (1982) reported that elephant grass is characterized by high initial digestibility (70-85%) followed by a high rate of decline in digestibility with advancing maturity. When cut at the same interval, elephant grass has been reported to have a lower digestibility value than Rhodes grass (*C. gayana*) in the early and late parts of the rainy season (Boonman, 1993). When leaves and stems are chopped in stall-feeding operations, intake has been reported to be lowered because of high moisture content (Boonman, 1993).

2.7.2 Potential of elephant grass and its hybrids for animal production

Ogwang (1974) reported that P 99 has a high potential of for feeding dairy cows in Uganda. He noted that although yield results and energy concentration were found to be high, elephant grass and especially its hybrids harvested at 10 weeks would be too mature to meet the maintenance requirements of a mature cow. This contention was supported by the weight changes of sheep during the experimental period. The sheep fed on Kw₄ gained on average 67 g day⁻¹, those on P 99 lost 57 g day⁻¹.

Mpairwe (1994) also reported a significant increase in live weights of sheep fed on elephant grass hay supplemented with *Gliricidia* hay.

An average of 773 grazing days and up to 3,125 kg ha⁻¹ of milk annually with guinea, elephant grass and para grasses in the Philippines has been reported by Payne (1963). He suggested that improved pastures in the tropics should be capable of supporting five lactating cows per hectare each producing 2,270 kg of milk annually or a total of 13,600 kg ha⁻¹.

Supplementation of elephant grass with forage legumes has been reported to improve dry matter intake, live weights and milk production. *L. leucocephala* has been reported to increase elephant grass intake average daily milk yields and reduced liveweight losses (Muinga *et al.*, 1992; 1993). Lack of available energy has been reported to restrict milk yield from elephant grass fodder only diets although the amount of digestible crude protein that it contains is adequate to maintain 12 or more litres of milk from the Jersey type of animal (Mugerwa, 1975). In a study conducted by Combellas and Martinez (1982), 12 cows were given chopped elephant grass to appetite with 3, 6 or 9 kg of concentrate (CP, 19.4%) daily. Milk yield was increased linearly by increasing concentrate supplementation (from 9.7 to 12.5 kg in the 1st and from 7.6 to 9.9 kg in the 2nd trial. Milk fat content was decreased by increased supplementation but there was no effect on protein and SNF. Maria-da-Cruz and Vilela (1986) in their study with 22 Holstein x Zebu dairy cattle fed *P. purpureum* ensiled with 1.42 or 1.60% ground maize and a bacterial additive with cottonseed meal or cottonseed meal plus ground maize reported that CP from both diets was maintained at 1.15 kg day⁻¹ and TDN intake was 2.16

and 3.57 kg day⁻¹ for the supplements, respectively. Average milk production from *P. purpureum* silage plus concentrates was 10.2 kg day⁻¹ and 9.3 kg of FCM. The additive did not increase milk production or DM intake. Increasing TDN intake and maintaining CP intake did not affect milk yield but increased milk protein. DM intake was 63 g kg⁻¹ metabolic weight. There were no peaks in the lactation curves. In studies carried out in the Highlands of Kenya, Anindo and Potter cited by Muinga *et.al* (1993) reported that Friesian cows fed on elephant grass fodder *ad libitum* gave more milk when they were given concentrates. The cows fed only the forage gave 10.5 kg milk daily, while those given 8 kg concentrate along with the forage gave 10.5 kg. The total feed intake per cow was 3.16 and 4.29 kg DM per 100 kg body weight for the unsupplemented and supplemented cows respectively. In a study where elephant grass fodder was offered to lactating dairy cows with and without protein concentrates, Muinga *et al.*, (1993) reported that additional protein did not affect elephant grass fodder dry matter intake but total intakes of dry matter were higher for the cows receiving the protein supplements. However, the provision of additional protein from different sources gave the animal extra energy. In a study carried out at the Nova Odessa Experimental Station, Brazil, dairy cows were either grazed *P. purpureum* (i) without or (ii) with legumes, or grazed *Brachiaria mutica* (iii) without or (iv) with legumes and concentrates. Average individual daily 4%-FCM yields were 9.68, 9.54, 6.84 and 7.88 kg for cows on (i)–(iv) respectively (Velloso and Freitas, 1973). Fahmy *et al.* (1985) in their study at the Malloway Station of the Animal Production Research Institute, Egypt, reported that Ca, K, Mn and Si content increased with the successive cuts, however, Mn and Si contents

dropped in the 4th and K in the 5th cut. K content was extremely high (approx. 6% of the dry matter). P, Na and Mg contents decreased in the successive cuts. The energy content decreased with advanced maturity. It was found that the 2nd cut contained the highest and the 5th cut the lowest nutritive value. Palatability tests with Ossimi rams showed that dry matter intake increased with successive cuts (average $2.068 \text{ kg } 100 \text{ kg}^{0.75}$). The total yield of the 5 cuts was $209.5 \text{ tons ha}^{-1}$ and 29 tons ha^{-1} , for fresh and dry matter respectively. They concluded that elephant grass is a suitable fodder crop to be grown in crop rotation during the summer period.

Ware-Austine (1963) reported that milk yields in the wet season were lower from elephant grass than on sown pastures. He observed that milk production fell at a much faster rate on elephant grass than on ley pasture. Arias and Combellas (1979) reported an average daily milk yield of 6.7, 7.7 and 8.7 kg for 6 Holstein-Friesian cows, when cut *P. purpureum* forage was given *ad lib.*, supplemented with 0, 3 and 6 kg concentrates day^{-1} . Average changes in the cows' weight were -0.54, -0.34 and +0.16 kg day^{-1} , and daily forage intake was 3.89, 3.74 and 3.51 kg of DM. Average daily milk yield of all 6 cows was 9.5 and 7 kg in the 1st and 2nd periods of the trial (end of dry season) and 6.7 kg in the 3rd period (start of rainy season).

CHAPTER 111: EXPERIMENTS

3.1 EXPERIMENT I: Herbage biomass DM yield, chemical composition and *in vitro* OMD of *L. purpureus* cv Rongai with advancing maturity

3.1.1 Materials and methods

Study area

The study was conducted at Namulonge Agricultural and Animal Production Research Institute (NAARI) ($0^{\circ}32'N$ $32^{\circ}35'E$; 1150 m.a.s.l). The soils are ferralitic sandy clay loams, low in phosphorus (4 ppm P) with pH of 5.4–6.0 (NAARI Annual report. 1993). The site lies in a subhumid zone of Uganda with a mean annual rainfall of about 1100 mm which is bimodally distributed with peaks in March–May and September–November. Mean annual temperature is $20^{\circ}C$ with mean maximum and minimum temperatures of $29^{\circ}C$ and $10^{\circ}C$, respectively (Anon, 1993).

The study site was previously under *Chloris gayana* pasture for three years (1991–1993). The site was slashed and the trash removed prior to seed-bed preparation. This was disc-ploughed and harrowed three times. The seed bed was finally rotovated. The Experiment started in March, 1994 and lasted up to August, 1994.

3.1.1 (a) Experimental design

The Experiment was laid out in a randomized complete block design (RCBD) with four replications. Plot size was 5 m by 8 m. Lablab seeds were planted at a spacing of 1.0 m by 1.0 m, a sowing depth of 2.5 cm and a seed rate of 7.5 kg ha^{-1} . Two seeds per hill were planted. All plots received

a blanket fertilizer applications of 50 kg of P_2O_5 ha^{-1} before sowing to improve the phosphorus (P) content of the soils. Soils at NAARI are low in P content. The plots were kept free of weeds.

3.1.1 (b) Sampling and measurement

Harvesting of Lablab forage was done at three developmental stages of growth of the plants: namely at vegetative (VS); flowering (FS) (when at least 50% of the plants in each plot had flowered and 50 % had put on pods), and pod-ripening (PS) stages.

Harvesting forage was done on quadrant (1 m by 1 m). Whole plants (stems + leaves) within the quadrant were cut using hand-shears at a cutting height of 30 cm above ground. This is the recommended cutting height of lablab plants (Favoretto and Costa, 1978). The harvested samples were used to estimate herbage biomass yield and the chemical composition of Lablab. Before harvesting, plant spread was measured using a tape measure. Measurements of plant spread involved recording the distance between two furthest ends of the branches of a plant on four plants per plot. Fresh weights were measured using a spring balance. Subsequently, a sub-sample of about 1 kg was randomly removed, partitioned into leaf and stem. The partitioned samples were weighed and oven dried at $60^{\circ}C$ to constant weight for 48 hours. The dried samples were weighed, ground, sieved through a 1 mm sieve and stored in air tight bottles for chemical analysis. After harvesting, all the remaining plants in the plots were cut back to 30 cm above the ground level to allow regrowth.

The plants were sampled at 75, 110 and 140 DAP and these sampling dates corresponded to VS, FS and PS respectively. The plots were weeded once up to the VS, twice from planting to flowering and three times from planting to Flowering stage.

3.1.1 (c) Chemical analysis

Forage crude protein content (CP), calcium (Ca) and phosphorus (P) contents were determined using the A.O.A.C. methods (1975). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined as outlined by Goering and Van Soest (1975). *In vitro* organic matter digestibility (IVOMD) was determined using Tilley and Terry (1963) method.

3.1.1 (d) Statistical analysis

All the data collected were subjected to statistical evaluation by analysis of variance (ANOVA) using a computer, software package, Mstatc, for a 2-way ANOVA for a RCBD. Regression analysis was also done to determine the relationships between age of the plants and herbage biomass DMY, CP, NDF and IVOMD contents of the plants. Separation of means for the different parameters was done using the least square differences (LSD) approach at ($P=\pm 0.05$).

RESULTS AND DISCUSSION

3.1.2

3.1.2 (a) Field observations

Lablab seedling emergence started five days after planting (DAP). The initial establishment of the crop was rather slow but eventually became vigorous as the rooting system of the plants developed fully. However, this was towards the flowering stage of the plants. It was also at this time when the leaves and flowers were attacked by aphids. This coupled with natural senescence, caused a reduction in the amount of harvestable foliage.

3.1.2 (b) Relationship between stage of growth and the measured Lablab attributes

Data on changes in Lablab herbage dry matter percentage, and biomass DMY, plant spread and leaf to stem ratio at different stages of growth, are presented in Table 1. All parameters increased consistently over the period of the Experiment, except the leaf fraction which decreased significantly ($P \leq 0.05$) with age of the plants. According to Minson (1982), biomass yields of a plant increases tremendously up to flowering but with the on-set of the reproductive stage, a lot of energy is expended on reproductive bio-processes. Besides, there is de-mobilization and redirection of resources such as photosynthates, proteins, mineral nutrients, etc., from older plant parts like leaves and stems towards flowers and seeds. Consequently, plant growth virtually stops and senescence of older leaves ensues. This probably explains why leaf biomass yield reduced at the different times of sampling. A positive relationship between herbage biomass yield and maturity of the plants up

Table 1. Herbage biomass Dry matter yield, spread and leaf to stem ratio of *L. purpureus* cv. Rongai with advancing maturity

Parameter	Stage of growth			Mean	SEM
	Vegetative stage	Flowering stage	Pod ripening		
Dry matter content (%)	16.7 ^a	23.7 ^b	29.0 ^c	23.1	± 0.78
Plant spread (cm)	172.2 ^a	269.7 ^b	309.0 ^c	250.3	± 34.1
Biomass DM yield (kg ha ⁻¹)	6.6 ^a	10.9 ^b	12.2 ^c	9.9	± 0.66
% Leaf	61.4 ^c	54.8 ^b	35.9 ^a	50.7	± 10.70
% Stem	38.6 ^a	45.2 ^b	64.1 ^c	49.3	± 1.40

^{abc} Means within the same rows followed by different superscripts differ (P $\leq$ 0.05).

SEM: Standard error of the mean

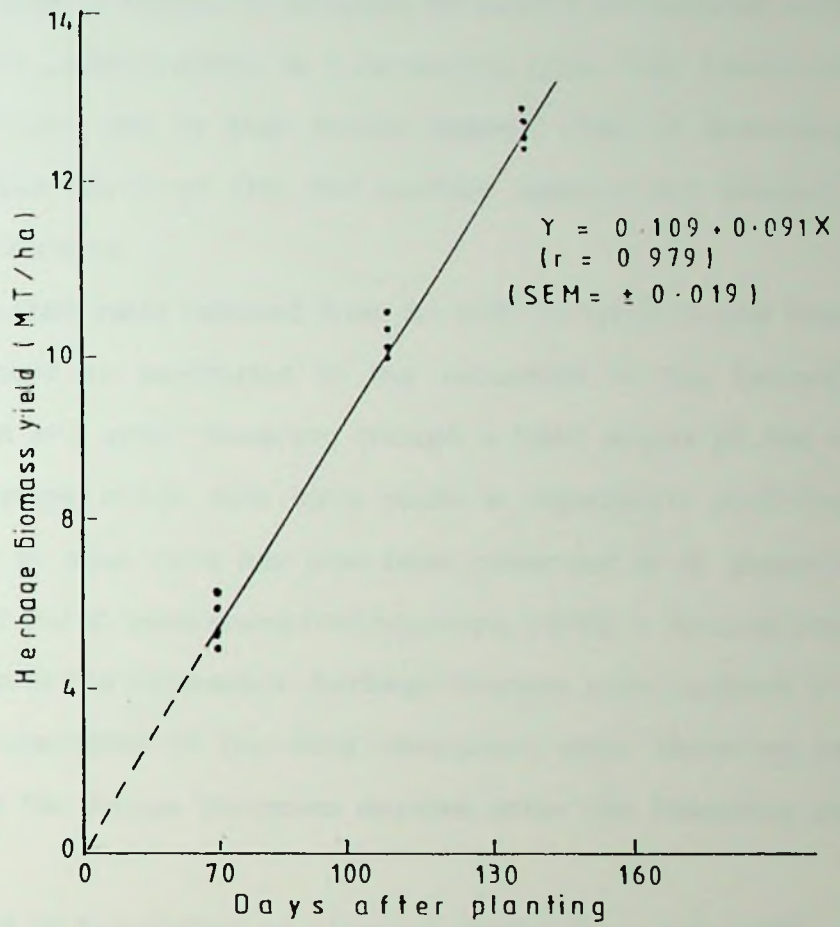


Fig. 1 : Effect of age on biomass yield of *L. purpureus* cv. Rongai with advancing maturity.

to flowering stage was established.

The plant spread significantly ($P \leq 0.05$) increased with maturity of the plants. The ability of cv Rongai to continue spreading throughout maturity suggests that this Lablab variety is a spreading type. This characteristic confers an important role to this forage legume; that of providing an effective vegetative cover on the soil surface against soil erosion and conserving soil moisture.

The leaf to stem ratio reduced from 2:1 (VS) to 1:1 (FS) and then 1:2 (PS) and this could be attributed to the reduction in the harvestable foliage fraction at and after flowering though a light attack of the aphid at this growth stage might also have made a significant contribution. Reduction in leaf to stem ratio has also been observed in *S. guyanensis*, *M. atropurpureum* and *C. pubescens* (Ochodomuge, 1978); *I. hirsuta* (Sabiiti, 1979). Hence, despite the increase in herbage biomass yield realized in this Experiment, the dominance of the stem component after flowering makes Lablab unsuitable for forage purposes anytime after the flowering stage.

3.1.2 (c) Effect of maturation on chemical composition and IVOMD of *L. purpureus* cv. Rongai

Data on changes in chemical composition and IVOMD of Rongai at different stages of growth are presented in Table 2. It is evident from the results of this Experiment that advance in plant age from VS to FS (about 75 to 110 DAP respectively) resulted in considerable decrease in CP content of the leaves and stems. The drop in CP during these growth stages could be attributed to the concurrent decline in the leaf fraction observed above. Hence, the simultaneous decrease in the leaf fraction and rise in the stem

Table 2. Changes in chemical composition and IVOMD of *L. purpureus* cv. Rongai at various stages of growth

Parameter	Stage of growth				
	Vegetative	Flowering	Pod ripening	Mean	SEM
Crude protein (%)					
Leaves	30.0 ^b	28.3 ^a	28.0 ^a	28.7	+0.95
Stems	16.6 ^b	13.1 ^a	11.2 ^a	13.6	+1.69
W/plant	24.9 ^c	20.3 ^b	14.9 ^a	20.0	+0.55
Neutral detergent fibre (%)					
Leaves	32.7 ^a	35.6 ^a	47.7 ^b	38.4	+2.99
Stems	46.8 ^a	56.7 ^b	65.6 ^c	56.3	+3.92
W/plant	38.5 ^a	51.5 ^b	67.9 ^c	52.6	+1.86
Acid detergent fibre (%)					
Leaves	26.2 ^a	38.2 ^b	56.6 ^c	40.3	+3.04
Stems	52.2 ^a	55.5 ^a	60.5 ^b	56.1	+2.21
W/plant	38.4 ^a	45.6 ^b	60.5 ^c	48.1	+0.47
Acid detergent lignin (%)					
Leaves	3.5 ^a	8.8 ^b	11.0 ^c	7.8	+0.90
Stems	8.7 ^c	10.5 ^b	13.4 ^c	10.9	+0.89
W/plant	10.5 ^a	10.9 ^a	13.2 ^a	11.5	+1.59
<i>In vitro</i> OMD (%)					
Leaves	61.4 ^b	62.7 ^a	61.3 ^a	59.5	+4.25
Stems	59.6 ^c	51.6 ^b	49.7 ^a	56.3	+3.19
W/plant	54.4 ^a	51.2 ^a	47.6 ^b	53.3	+0.46

^{abc} Means within the same rows followed by different superscripts

differ ($P \leq 0.05$). W/plant: whole plant

component of cv Rongai as the plants matured, dramatically reduced total CP content and consequently forage quality in terms of CP content. In contrast, Sabiiti, (1979) working with *I. hirsuta* in Uganda reported that flowering of that forage legume was not completely associated with large changes in nutritive value despite leaf loss through senescence. Despite the reduction of CP with maturity, the CP content of lablab plants in this Experiment remained higher than the minimum level (7%), required for maintenance of lactating dairy cows (ARC, 1980). This suggests cv Rongai to be a potential forage legume as a dairy cattle feed and that it compares well with other forage species which maintain similar levels of CP throughout their life time, e.g. *Stylosanthes guyanensis* (Milford, 1967), *I. hirsuta* (Sabiiti, 1979), *Macroptilium atropurpureum* and *Desmodium intortum* (Ochodomuge, 1978). Plant age was negatively correlated with CP ($r=-0.996$) (Figure 2a). For optimum CP content, therefore, lablab plants should be harvested when 50 % of the plants have flowered and 50 % have put on pods.

NDF which represents cellwall constituents namely hemicellulose, cellulose and lignin of the plants increased significantly ($P \leq 0.05$) with maturity (Table 2). The increase in NDF fraction was also associated with an increase in the proportion of mature stems. Mature stems of Lablab are coarse and fibrous. Moreover, Van Soest (1965) reported that mature stems consist largely of hemicellulose and lignin, which are the major components of NDF and that by comparison, stems contain more NDF than the entire plant. He further hypothesized that when DM contains less than 50-60 % NDF, intake of the herbage is not closely related to digestibility. Beyond a level of 60 % NDF, intake of the herbage is reduced.

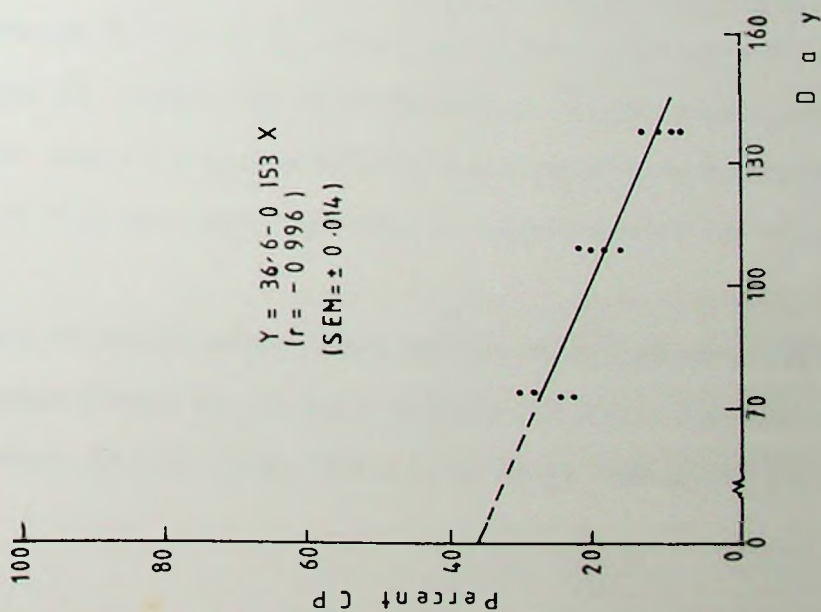


Fig 2a: Effect of age on crude protein content of *L. purpureus* cv. Rongai

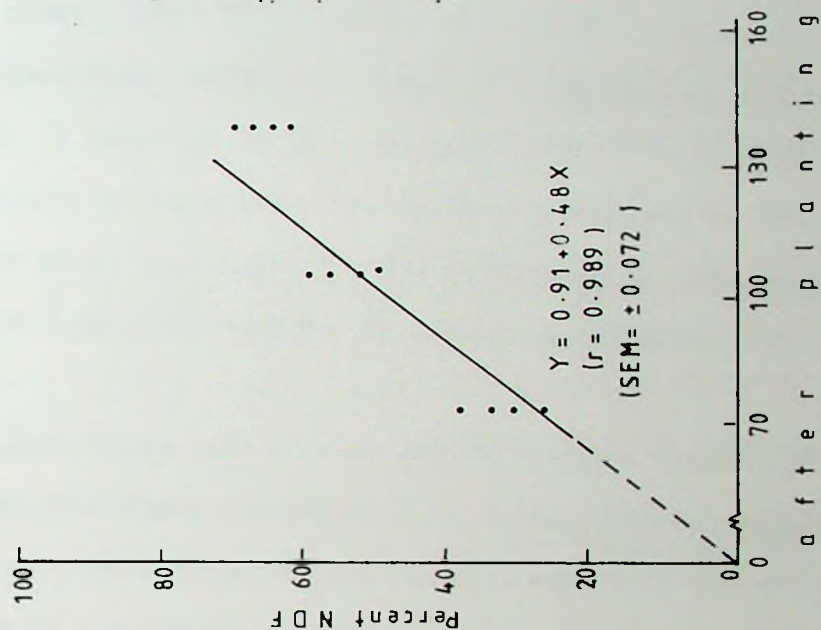


Fig.2b Effect of age on NDF content of *L. purpureus* cv. Rongai

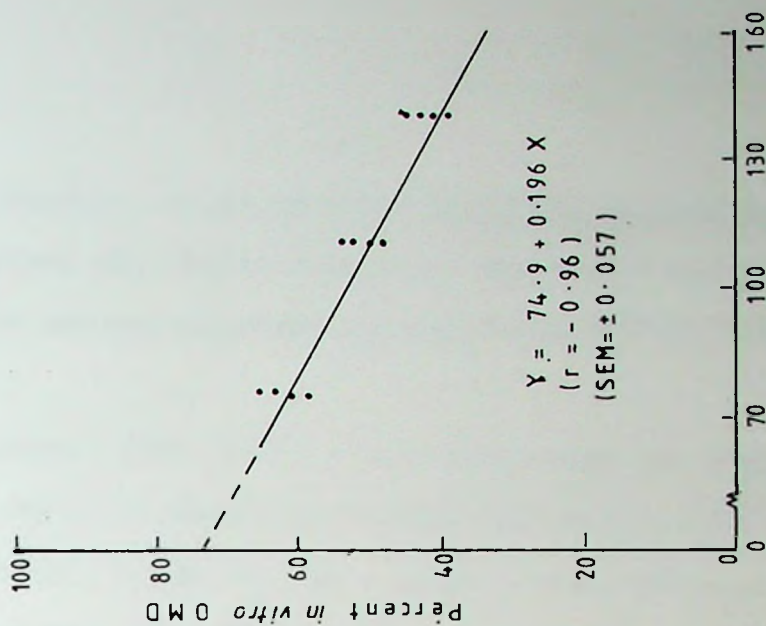


Fig-2c: Effect of age on *in vitro* OMD content of *L. purpureus* cv. Rongai

Lablab should therefore not be harvested for fodder beyond the FS stage as this will affect dry matter intake by cattle and therefore animal production. Plant age was positively correlated with NDF ($r = 0.986$) (Figure 2b).

Acid detergent fibre (ADF) which represents the ligno-cellulose fraction in the plants increased significantly ($P \leq 0.05$) with plant age (Table 2). This was probably due to the rise in lignin content which is associated with maturing plants (Van Soest, 1965). For example, Mugerwa (1975) observed low digestibility values for tropical forage plants ranging from 32 to 69 % with a mean of 54 %. He attributed this to high lignin deposition, especially in the stems, with advancing maturity of the plants. Mean ADF in this study was higher in the stems than in the leaves. This general trend has been confirmed for 14 grasses and legumes (Jarrige *et al.*, 1973).

Acid detergent lignin (ADL) which refers to lignin content of a cell wall in the leaves and stems significantly increased ($P \leq 0.05$) with age of the plants, however, the increase in the lablab plants was not significant at ($P \leq 0.05$) (Table 2). The reason for lack of significant increase might have been due to continued formation of young leaves which contained low ADL as was seen at the VS. Lignin has been described by Van Soest (1965) as a phenolic polymer that lowers digestibility of cell wall carbohydrates and the digestibility of NDF has been reported to depend partly on the lignin content.

In vitro OMD of lablab whole plant decreased significantly ($P \leq 0.05$) after flowering stage (Table 2). No such differences were observed prior to that growth stage. At this stage, the young stems had about the same

IVOMD as the leaves, so that the leaf to stem ratio was less critical in immature plants than in older plants. *In vitro* organic matter digestibility was maximum in the leaves (64.2 %) at flowering stage. This high IVOMD value coincided with the growth stage at which the leaf to stem ratio was almost equal. The occurrence of higher IVOMD in the leaves than in the stems (62.7 %) at FS conforms to the inference made above that lignin deposition is greater in stems than in leaves particularly towards plant maturity. This physiological development warrants consideration from the standpoint of forage use optimization. Forage attributes such as IVOMD may be impaired considerably by the low leaf content. The decline in IVOMD in the leaves with maturity is consistent with reports on other forage legumes used in Uganda, *M. atropurpureum*, *C. pubescens* and *D. intortum* (Ochodomuge, 1978); *I. hirsuta* (Sabiiti, 1979). Wood (1983) while working with *L. purpureus* cv. Rongai in Ord Irrigation Area, Australia, arrived at a similar conclusion. In the present study, lablab IVOMD was lower (56 %) than *Medicago sativa* (63 %), almost equal to that of Siratro (57.3 %) and that *D. intortum* (55.4 %) (Laredo and Minson, 1973). Plant age was negatively correlated ($r=-0.950$) to IVOMD (Figure 3a). In contrast, IVOMD appeared to be independent of plant leafiness but was negatively correlated ($r=-0.88$) to NDF content of the plants (Figure 3b).

Plant content of P remained constant even after flowering stage (Table 3). Lack of significant changes in the P content might mean that P has a relative immobility in plant systems. However, this requires further investigations before conclusions can be made since increasing P content in both leaf and stem fractions, with plant maturity has been observed by Hendericksen and Minson (1985).

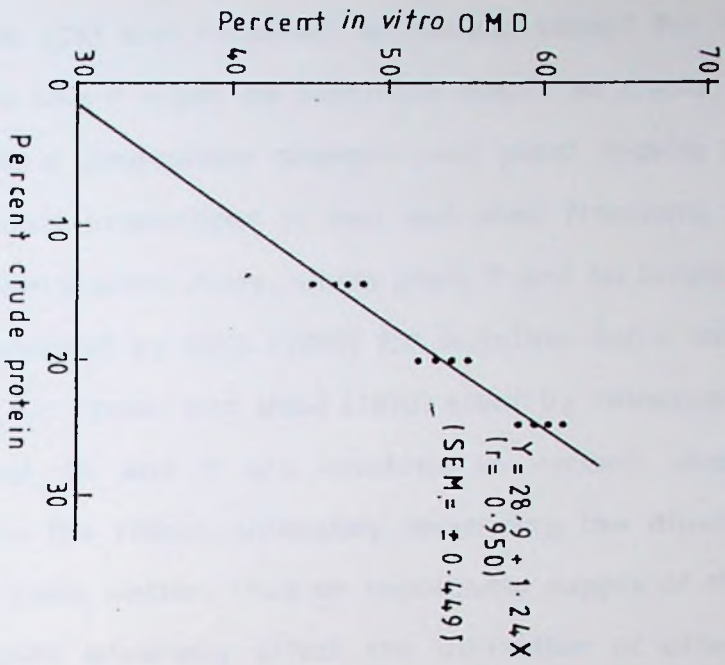


Fig. 3a: Relationship between (P content and *in vitro* OMD of *L. purpureus* cv. Rongai.

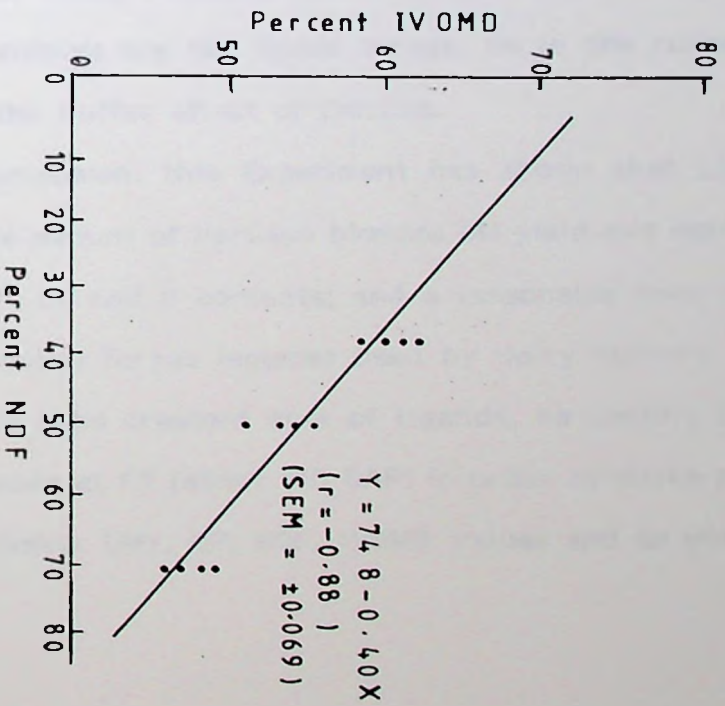


Fig. 3b: Relationship between NDF and *in vitro* OMD contents of *L. purpureus* cv. Rongai.

Plant Calcium (Ca) also remained unchanged except for the leaf fraction (Table 3). Ca like P might be sparingly mobile in plants. The occurrence of plant mineral composition changes over plant growth might be related to the changing proportions of leaf and stem fractions, flower and seed setting. In the present study, whole plant P and Ca levels were well above those recommended by ARC. (1980) for lactating dairy cows, that is 0.17% P and 0.22% Ca. Varner and Wood (1972) cited by Iwuanyanwu *et al.*, (1990) reported that Ca and P are involved in various phases of bacterial metabolism in the rumen, ultimately enhancing the digestibility of crude fibre and organic matter. Thus an inadequate supply of these nutrients in the diet would adversely affect the utilization of other nutrients and consequently animal production. Besides, low dietary P results in poor utilization of these elements. Mpairwe (personal communication) reported that when animals are fed lablab forage, pH in the rumen is always high indicating the buffer effect of Calcium.

In conclusion, this Experiment has shown that Lablab produces a considerable amount of herbage biomass DM yield and maintains fairly high levels of CP, Ca and P contents; and a reasonable level of NDF, compared to other tropical forage legumes used by dairy farmers in Uganda.

In the Lake crescent area of Uganda, harvesting Lablab for fodder should be done at FS (about 110 DAP) in order to strike a balance between herbage biomass DMY, CP, NDF, IVOMD values and to ensure high quality fodder.

Table 3 Changes in Calcium and Phosphorus values at various stages of growth of *L.purpureus* cv. Rongai at various stages of maturity

Parameter	Stage of Growth			
	Vegetative	Flowering	Pod ripening	SEM
Ca content (%)				
Leaves	1.6 ^c	1.5 ^b	1.3 ^a	± 0.14
Stems	1.2 ^a	1.1 ^a	1.0 ^a	± 0.15
Whole plant	1.7 ^a	1.6 ^a	1.4 ^a	± 0.13
P content (%)				
Leaves	0.2 ^a	0.3 ^a	0.3 ^a	± 0.04
Stems	0.1 ^a	0.1 ^a	0.2 ^a	± 0.03
Whole plant	0.3 ^a	0.3 ^a	0.3 ^a	± 0.05

^{abc} Means within the same rows followed by different superscripts differ ($P \leq 0.05$).

3.2 EXPERIMENT II: Effect of supplementing elephant grass, *P. purpureum* with Lablab (*L. purpureus*) hay on milk yield and composition of lactating dairy cows.

3.2.1 Materials and methods

3.2.1(a) Fodder establishment, harvesting and hay production

Six months prior to the start of the Experiment, two hectares of land were planted to *L. purpureus* cv Rongai and two months later, one hectare was planted to *P. purpureum* var. *P 99* at NAARI. The elephant grass variety used in this Experiment is a hybrid between *P. purpureum* and *P. typhoides*. It is known to produce more dry matter and higher CP values per unit area than the commonly used elephant grass hybrid, Kw₄ (local variety x *P. typhoides*) (Ogwang, 1974). It is one of the currently recommended varieties for feeding dairy cattle in Uganda. Planting materials were obtained from MUARIK. Planting and crop management was done according to Ogwang and Mugerwa (1976). Land preparation, establishment and management of Lablab crop was done following the procedures described in Experiment I. Establishment was done in August, 1994.

Lablab was harvested for fodder and hay production at flowering stage (using results obtained in Experiment I). Harvesting was done manually using hand-shears. This was done in five days to ensure a final product of good quality. Half of the harvested material was transferred directly to a drying shade where the stems were chopped into pieces of 15–30 mm long using a panga and later dried in the same place. The material was consistently turned using a rake to enhance drying. In this

method leaf shattering was minimized because the material was chopped, dried and baled in the same place. The hay retained its green colour because it was subjected to slow drying under a shade. It took three days for the leaves and six days for the chopped stems to dry. Because of lack of sufficient drying area, the remaining half of the harvested material was dried under direct sunshine. Some of the leaves were shattered during drying. However, all the shattered leaves were later collected and baled together with the remaining parts of the plants. After drying, the hay was put in baling boxes which had dimensions of 60cm x 75cm x 60 cm. The bales were tied using sisal strings. The baled hay was stored in a well ventilated store on wooden racks.

3.2.1 (b) Experimental design and animal management

Four cross-bred Friesian (Friesian x Zebu), were used in a 4 x 4 Switch-over Latin square design (Appendix Table 2). The animals which were in their third month of lactation had previously lactated 1-2 times, with a mean milk yield of 9.5 kg day⁻¹ and average live weight of 405.5 (S.D=±15 kg). Animals were selected from the NAARI dairy herd. Their weights were recorded prior to the start of the Experiment and, subsequently, after 14 days. Average daily weight changes was computed by dividing the change in live weights (final weight-initial weight) by 14.

The cows were housed individually in well-ventilated stall-feeding units. They were drenched with Levamisole hydrochloride or oxychlozanide (Nilzan) and dipped in Delnav acaricide twice a week, to control ticks. Routine vaccinations and the necessary veterinary services were applied.

3.2.1 (c) Diets and feeding management

The animals were fed on freshly harvested and chopped elephant grass fodder, *ad libitum*. The grass was harvested at an average height of 1.0 m (Ogwang, 1974; Muinga *et al*, 1992) and chopped into 2 cm pieces using a forage chopper. The feeder-troughs which were 90cm x 60cm x 60cm, were fodder-filled twice a day at 7.30 a.m. and at 5.00 p.m. to ensure *ad libitum* feed supply to the animals. Four levels (treatments) of Lablab hay, viz 0, 2, 3 and 4 kg day⁻¹ were additionally assigned randomly to each animal as summarized in Appendix Table 2 (on "as fed basis"). The zero lablab diet shall be termed the "control diet". The experimental diets were maintained for a period of 28 days; this included 14 days of adjustment to the diets and 14 days for data collection. The animals were allowed a 7-day adaptation period prior to the start of each treatment. Fresh, clean tap water and mineral lick were availed to the animals *ad libitum*.

3.2.1(d) Sampling procedures

Dry matter intake (DMI) was recorded based on daily weight differences between the feed supplied and the portion refused by each animal (on DM basis). This was done every morning before providing fresh feed to the animals. Concurrently, feed intake and feed refusal samples were taken, weighed and oven-dried at 60°C to constant weight and ground through a 1-mm sieve. Samples were subsequently analyzed for CP, NDF, ADF, ADL, IVOMD as described in Experiment I.

3.2.1(e) Milk yield and composition

The animals were hand-milked twice a day, in the morning at 7 a.m. and in the evening at 4.00 p.m. throughout the experimental period. Milk samples were collected simultaneously at the end of each feeding period. The corresponding morning and evening samples were bulked

into one sample and preserved under freezer conditions at -1°C for butterfat content analysis. Butterfat content was determined using Gerber method. Milk yield values were converted to 4 % FCM yield.

3.2.1(f) Statistical analysis

The data collected was subjected to statistical analysis using analysis of variance appropriate for a latin square design using a computer soft-ware package, Mstatc. Regression analyses were carried out to test the relationship between lablab hay supplementation and DMI, milk yield and composition. In each case, mean separation was done using the least significant difference (LSD), in most cases at 5% confidence interval.

3.2.2

RESULTS AND DISCUSSION

3.2.2(a) Forage quality evaluation

Data for percentage (%) chemical composition of the diets used in Experiment II is presented in Table 4. Generally, CP content of elephant grass was greater than 78 g kg^{-1} , the limiting CP level for ruminant production (ARC, 1980).

Table 4 Percentage (%) chemical composition (DM basis) of diets used in Experiment II

Parameter	DIETS	
	Lablab hay	<i>Pennisetum purpureum</i>
DM	85.4	21.0
CP	15.1	8.4
NDF	58.3	62.7
ADF	41.5	36.1
ADL	11.3	13.8
OMD	58.2	53.1
‡ME (Mcal. kg^{-1} DM)	2.1	1.9

‡It was assumed according to Close and Menke, (1986) that

$$\text{ME} = 0.15 \text{ IVOMD}$$

All DM and CP values obtained in this Experiment compared closely with those reported by Ogwang (1976) in a study involving EG at MUARIK in Uganda. CP content of Lablab hay was 15.1 %, and almost doubled that of EG. Metabolizable energy (ME) derived from IVOMD values according to Close and Menke (1986) for Lablab hay and EG was yielded 2.1 Mcal. kg^{-1} of DM respectively.

3.2.2(b) Utilization of EG supplemented with Lablab hay

Feed intake by lactating dairy cows is given in Table 5. Supplementing elephant grass diets with Lablab hay generally increased elephant grass DMI although increasing lablab hay levels in the diets resulted in no significant differences in the control diets. However, feeding lablab hay at levels higher than 3 kg day⁻¹ tended to reduce elephant grass DMI although the decline in DMI was not statistically significant. The decline in DMI though not significant ($P \leq 0.05$) could be attributed to the palatability and chemical composition of lablab as compared to elephant grass. Total dry matter intake (TDMI) and TDMI expressed as metabolic body weight (TDMI kg^{0.75} day⁻¹) significantly ($P \leq 0.05$) increased with supplementation. TDMI expressed as percent body weight (% BW) responded similarly to elephant grass when supplemented with Lablab and was above 2.5 % for all animals fed on supplemented diets. The highest % BW was obtained at a supplementation level of 3 kg day⁻¹ of lablab hay. The high DMI of EG in supplemented diets may be due to several reasons. Lablab hay provided essential nutrients, particularly CP (Table 4), which might have been lacking in the elephant grass for the animals to maintain optimal rumen activity. Lablab might also have been degraded more rapidly in the rumen. This is because of the positive effects of N in increasing microbial population and efficiency thus enabling them to increase the rate of breakdown of the digesta. As the rate of breakdown and passage of the digesta increases, feed intake is accordingly increased. Increased DMI attributed to the addition of legume hay to roughage diets has been reported from elsewhere (Mosi and Butterworth, 1985; Kimambo *et al.*, 1992); Muinga *et al.*, 1992; Mpairwe, 1994; Little and Agyemang, 1994; Nshalai, 1995).

Table 5: Utilization of elephant grass supplemented with Lablab hay

Parameter	Lablab hay (kg day ⁻¹)				SEM
	0	2	3	4	
Elephant grass DMI (kg day ⁻¹)	8.8 ^a	9.4 ^b	9.7 ^b	9.4 ^b	±0.10
Lablab hay DMI (kg day ⁻¹)	0.0 ^a	1.4 ^b	2.3 ^c	2.9 ^d	±0.05
TDMI (kg day ⁻¹)	8.8 ^a	10.8 ^b	12.0 ^c	12.3 ^c	±0.37
TDMI (% BW)	2.2 ^a	2.7 ^b	2.9 ^c	2.9 ^c	±0.09
TDMI (g/kg ^{0.75} day ⁻¹)	98.5 ^a	118.7 ^b	129.5 ^c	131.1 ^c	±4.10
Average daily gain (kg day ⁻¹)	-0.2 ^a	0.3 ^b	0.3 ^b	0.4 ^b	±0.01

^{abc} Means within the same row with different superscripts differ (P≤0.05).

However, the results from this Experiment depart from those of Boitumelo and Mahabile (1992) who observed no differences in DMI of elephant grass fed lactating cows, supplemented with Lablab hay in Botswana. In another study, Kifelewahid and Mosimanyana (1992), reported a depressing effect in DMI of maize stover when lactating dairy cows were supplemented with *Dolichos Lablab* (*L. purpureus*) in Botswana.

Supplementation with Lablab hay significantly ($P \leq 0.05$) improved animal live weights, however increasing lablab hay levels in the diets made no significant ($P \leq 0.05$) changes in the live weights of the supplemented animals. Animals fed on control diets lost weights (Table 5). The loss in weight of the animals is partly explained by the amount of CP (8.4 %) in the grass feed which was near the limiting levels (6–8 %). The unsupplemented control diet unlike Lablab supplemented ones could therefore not meet the maintenance and lactational CP and energy nutrient requirements for the animals used in this Experiment.

The reason for lack of significant differences in the liveweight gains of the supplemented animals might have been that, the animals' energy requirements for maintenance were met when they were supplemented with 2 kg day⁻¹ of Lablab hay and that any further increases in the level of the supplement resulted in the extra energy intake being partitioned in favour of milk yields as indicated from the results (Table 6). As opposed to pure stands of grass, Stobbs, (1969) reported an increase of 11–49 % in liveweight of fattening steers in Uganda from grass-legume mixtures of *Hyperrhania rufa* and *Stylosanthes guyanensis*. McDowell (1972) hypothesized that, in the tropics, animals need a diet

of 7 % CP and 45 % OMD to maintain their liveweight. He further reported that animals fed a diet with the 10-11 % CP and 55 % OMD are expected to gain weight.

3.2.2(c) Milk yields and composition for animals fed on elephant grass with and without lablab hay supplements

Data on milk yield and milk composition are presented in Table 6. Supplementation of elephant grass with Lablab hay increased milk yield and FCM yield significantly ($P \leq 0.05$) but had no effect on the butterfat content of the milk. Butterfat yield increased significantly ($P \leq 0.05$) but only beyond a level of 3 kg day⁻¹ of lablab hay. Increasing the level of Lablab beyond 3 kg day⁻¹, did not result in a further significant rise in milk yield. The low milk yield from control diets could be attributed to the fairly low intakes of ME and CP values observed in this diet (Table 7). According to ARC. (1980), the cow breed used in this Experiment, based on body weight and milk production required 11.2 Mcal. day⁻¹ for their maintenance. The amount provided by the control diets was approximately 17.8 Mcal. day⁻¹, (Table 7) which implies a difference of only 6.6 Mcal. day⁻¹ over its maintenance requirements.

Thus this ME in excess of maintenance was insufficient and generated only 5.8 kg FCM day⁻¹. The cows, therefore, received sub-optimal amounts of ME and were unable to lactate to their genetic capacities. The FCM yield values of the control diets used in this Experiment, though very low, were well within the expected range for elephant grass diets as reported by Mugerwa, 1975; Stobbs, 1976; Sabiiti and Mwebaze, 1989) in Uganda. Because the animals fed on control diets lost weight (Table 5), it is reasonable to conclude that milk yield was, in part, at the expense of the animals' body weights. In contrast, diets

Table 6: Milk yield and efficiency of digestible energy utilization for milk synthesis for lactating dairy cows fed on a basal diet of elephant grass fodder and supplemented with lablab hay

Parameter	Lablab hay (kg day ⁻¹)				SEM
	0	2	3	4	
Mean milk yield (kg day ⁻¹)	9.1 ^a	9.8 ^b	10.8 ^c	10.7 ^c	±0.15
Butterfat (%)	3.3 ^a	3.4 ^a	3.5 ^a	3.6 ^a	±0.09
FCM ₁ yield (kg day ⁻¹)	9.0 ^a	8.9 ^a	10.0 ^b	10.0 ^b	±0.11
Butterfat yield (g day ⁻¹)	300.3 ^a	333.2 ^a	378.0 ^b	385.2 ^b	±38.9
(1) Digestible energy intake (Mcal day ⁻¹)	20.4 ^a	25.3 ^b	27.7 ^c	29.2 ^c	±0.85
(2) Gross energetic efficiency of DE utilization for milk (%)	33.5 ^a	29.1 ^a	29.2 ^a	31.2 ^a	±0.86

^{abc} Means within the same row with different superscripts differ ($P \leq 0.05$).

(1) 0.82 is the multiplication factor for converting DE to ME (ARC., 1980).

(2) It is assumed that a standard milk containing 4% FCM would have an energy content of 0.75 Mcal kg⁻¹. (Close and Menke, 1986). Therefore the calculated gross energy efficiency of DE utilization for milk.

$$= \frac{\text{Energy content in the milk (Mcal kg}^{-1}\text{)} \times 100}{\text{Digestible energy intake}}$$

Table 7: Calculated milk production potentials derived from elephant grass and lablab hay rations in relation to daily ME and total CP requirements for lactating dairy cows (based on ARC, 1980)

Parameter	Lablab Hay levels (kg day ⁻¹)				SEM
	0	2	3	4	
Total ME intake (Mcal day ⁻¹)	17.8 ^a	21.6 ^b	23.6 ^c	24.0 ^c	±0.75
Total ME intake % of maintenance requirement	160.0 ^a	193.0 ^b	211.0 ^c	214.4 ^c	±6.65
ME in excess of maintenance requirement	6.6 ^b	10.4 ^b	12.4 ^c	12.8 ^c	±0.75
(¹)Estimated milk yield (kg FCM day ⁻¹)	5.8 ^a	9.2 ^b	10.9 ^c	11.3 ^c	±0.66
Total CP intake (g day ⁻¹)	747.8 ^c	997.3 ^b	1129.5 ^a	1186.1 ^a	±33.34
CP intake % maintenance requirement	143.5 ^a	191.4 ^b	216.8 ^c	227.7 ^c	±6.40
CP in excess maintenance requirement (g)	226.8 ^a	476.3 ^b	608.5 ^c	665.1 ^c	±33.34
(²)Estimated milk yield (kg FCM day ⁻¹)	2.9 ^a	6.1 ^b	7.8 ^c	8.5 ^c	±0.43

^{abc} Means within the rows with different superscripts differ (P≤0.05);

Lactating dairy cows similar to those used in this study require: 1.13 Mcal day⁻¹(¹) and 78 g protein(²), to produce 1 kg FCM yield (ARC, 1980).

supplemented with Lablab hay resulted in higher milk yields than their unsupplemented control diets. Better milk yields in the animals fed on higher ME and CP rations confirms the suggestion made earlier that lower productivity of the control diets was due to the correspondingly low magnitudes of these nutritional attributes. It can therefore be concluded that Lablab hay supplement can only suffice to maintain minimal milk production levels. However, for the high yielding animals to reach their genetic production ceiling, these unenriched forages would be certainly inadequate. In spite of this, the most significant contribution of lablab hay supplement was that the supplemented animals did not lose weights.

3.3: EXPERIMENT III: Effect of feeding *P.purpureum* and Lablab hay with or without concentrate on milk yield and composition of lactating dairy cows.

3.3.1 Materials and methods

Another lot of elephant grass crop was planted again for Experiment III, two months to its start (March, 1995). The remaining Lablab hay lot from Experiment II was used in Experiment III.

3.3.1 (a) Experimental design and animal management

A switch-over Latin square design was employed (Appendix Table 3 using lactating dairy cows selected from the station dairy herd. The animals which were in their second month of lactation had previously lactated once, with mean milk yield of 8.5 kg day⁻¹ with an average liveweight of 384.5 kg (SD=±15kg). One experimental cow developed mastitis during the Experiment, and was allowed to recover, thus

extending the Experiment for another seven days. The rest were in good condition and health throughout the Experiment. The Experiment was carried during the months of May to September, 1995. Management, feeding regime and sampling procedures were similar to those described in Experiment II. For Experiment III, however, Lablab was supplied at a fixed rate of 3 kg day⁻¹ per animal using results derived from Experiment II. In addition, a concentrate (Ugachick dairy meal) was provided to the animals randomly, at rates of 0, 1, 2 and 3 kg animal⁻¹ day⁻¹ (on "as fed basis". The zero concentrate shall be termed the control diet. The choice of the concentrate levels was based on the levels used by the small-holder dairy farmers in Uganda. The choice of a brand was based on the ease of accessibility of the feed from the factory. Half of the concentrate ration was provided to the animals at 7.00 a.m. and the other half at 4.00 p.m. at milking times.

3.3.1 (b) Statistical analysis

Statistical analyses were as for Experiment II. Regressions carried out tested the effects of concentrate supplementation on milk yield and composition.

3.3.2

RESULTS AND DISCUSSION

3.3.2(a) Forage quality evaluation

The percentage (%) chemical composition of dietary ingredients are presented in Table 8.

Table 8 Percent (%) chemical composition (DM basis) of diets used in Experiment III

Parameter	DIETS		
	[†] Lablab hay	Elephant grass	Dairy meal
DM	85.4	17.0	89.5
CP	15.1	9.5	17.5
NDF	51.3	58.1	23.1
ADF	41.5	34.9	17.4
ADL	11.3	13.1	9.0
OMD	58.2	56.2	71.3
[‡] ME (Mcal.kg ⁻¹ DM)	2.2	2.1	2.6

[†]Part of the remaining Lablab hay used in Experiment II was used in Experiment III.

[‡]It was assumed according to Close and Menke, (1986) that ME = 0.15 IVOMD.

3.3.2 (b) Utilization of elephant grass fodder and lablab hay under concentrate supplement

The DMI and live weight changes of animals fed control with or without a concentrate is given in Table 9. Inclusion of a concentrate in the diets significantly reduced elephant grass DMI. However, there was no significant difference between grass DMI for the various concentrate levels. In contrast, the intake of Lablab hay increased with increasing concentrate rates but dropped when the rate exceeded 2 kg day⁻¹. The rate of substitution at the 3 kg day⁻¹ of a concentrate was higher with the grass (2.9 %) than with lablab hay (%). The concentrate substitution effect on grass and Lablab hay might have been partly caused by the digestion of the starch in the concentrate which has been reported to depress rumen pH to as low as 6.0 (Kellaway and Porta, 1993) thus causing a decrease in the population of the cellulolytic bacteria. This might have reduced fibre digestion and extended the retention time of the particulate matter in the rumen causing a decrease in feed intake.

Regression analysis showed a negative correlation between concentrate DMI and the following parameters: grass DMI ($r=-0.650$), lablab hay DMI ($r=-0.441$) and TDMI ($r=0.867$).

TDMI and TDMI kg^{0.75} g/day⁻¹ increased only when the level of the concentrate in the diet was above 1 kg day⁻¹. Beyond this supplement level the increase was not significant. TDMI as % BW increased with supplementation in a similar manner. Animals fed on control and concentrate control diets gained weight but the differences in weight gains were not statistically ($P \leq 0.05$) significant. The lack of significant differences in live weight gains between animals fed on supplemented and control diets might have been partly due to the substitution effect caused as a result of concentrate feeding. Total energy intake for maintenance might therefore not have been increased.

Table 9 Utilization of elephant grass and lablab hay diets under concentrate supplementation

Parameter	Concentrate levels (kg day ⁻¹)				
	0	1	2	3	SEM
Elephant grass DMI (kg day ⁻¹)	7.8 ^a	7.2 ^b	6.9 ^b	6.7 ^b	±0.31
Lablab hay DMI (kg day ⁻¹)	2.8 ^a	2.6 ^{ab}	2.7 ^b	2.4 ^b	±0.06
Concentrate* DMI (kg day ⁻¹)	0.0	0.9	1.8	2.7	—
TDMI (kg day ⁻¹)	10.6 ^a	10.7 ^a	11.4 ^b	11.8 ^b	±0.35
TDMI g/kg ^{0.75} /day	122.4 ^a	122.4 ^a	130.9 ^b	136.1 ^b	±4.00
TDMI (as % BW)	2.8 ^a	2.8 ^a	3.0 ^b	3.2 ^b	±0.08
Average daily gain (g day ⁻¹)	0.5 ^a	0.5 ^a	0.6 ^a	0.5 ^a	±0.20

^{abc} Means within rows with different superscripts differ ($P \leq 0.05$).

* All the concentrate offered was consumed by the animals

3.3.2 (b) Milk yields and composition for lactating dairy cows fed elephant grass and lablab hay diets with a concentrate

Table 10 shows data for milk yield response by cows fed on rations of control diets with and without a concentrate supplement. In all cases, inclusion of a concentrate in the diet increased milk and FCM yields significantly ($P \leq 0.05$). Supplementation with 1.0 kg of concentrate per day resulted in FCM yield rise of 5.2 %. On the other hand, addition of an extra kg of the material raised FCM yield to 9 %, which is just less than twice the original increase.

Overall, application of 2 kg day⁻¹ of concentrate proved to be superior to other dietary combinations. The superior milk yield recorded with concentrate supplemented diets was probably due to extra ME and CP intake (Table 11). ME intake for the concentrate enriched diets was consistently greater than for the control diets. Despite the rise in ME intake, milk yield peaked at a supplement level of 2 kg day⁻¹ per day. Beyond this level, there was a slight drop in milk yield although the decrease was not significant ($P \leq 0.05$). This Experiment demonstrated similar milk responses to concentrate supplementation (Stockdale and Trigg, 1989; El-Tayeb and Takla, 1992; Muinga *et al.*, 1993), though not to the same magnitudes. Milk composition was not affected by supplementation with concentrate (Table 10).

Overall, it was recommended that application of 2 kg day⁻¹ of concentrate proved to be sufficient. Because this Experiment did not span the entire lactation period of the animals, further studies are recommended to probe the same parameters in the advanced stage lactation.

Table 10

Mean daily milk yields and efficiency of digestible energy (DE) for milk synthesis of lactating dairy cows fed elephant grass-lablab as a basal diet and supplemented with graded levels of a dairy concentrate

Parameter	Concentrate levels (kg day ⁻¹)				SEM
	0	1	2	3	
Mean milk yield (kg day ⁻¹)	9.8 ^a	10.4 ^b	11.3 ^c	11.0 ^c	±0.15
Butterfat (%)	3.9 ^a	3.8 ^a	3.9 ^a	3.8 ^a	±0.09
FCM yield (kg day ⁻¹)	9.5 ^a	10.0 ^b	10.9 ^c	11.1 ^c	±0.11
Butterfat yield (g day ⁻¹)	382.2 ^a	395.2 ^a	440.1 ^b	418.0 ^b	±44.3
DE intake (Mcal day ⁻¹)	25.2 ^a	23.3 ^a	22.9 ^b	21.7 ^c	±0.85
Gross energetic efficiency of DE utilization for milk (%)	29.2 ^a	33.5 ^a	37.1 ^a	38.0 ^a	±0.86

^{abc} Means within rows with different superscripts differ ($P \leq 0.05$)

Table 11 Calculated milk production potential derived from elephant grass, Lablab hay and a concentrate based diets in relation to daily total ME and CP requirements for lactating dairy cows (based on ARC, 1980)

Parameter	Concentrate levels (kg day ⁻¹)				SEM
	0	1	2	3	
Total ME intake (Mcal day ⁻¹)	21.5 ^a	22.0 ^a	23.9 ^b	25.2 ^c	±0.70
ME intake (% of maintenance requirement)	192.3 ^a	195.9 ^a	213.3 ^b	224.7 ^a	±6.22
ME in excess of maintenance requirement (Mcal day ⁻¹)	10.3 ^a	10.8 ^a	12.7 ^b	14.0 ^c	±0.71
Estimated milk yield from the excess ME (kg FCM yield day ⁻¹)	9.1 ^c	9.5 ^c	11.2 ^b	12.4 ^a	±0.62
Total CP intake (g day ⁻¹)	1163.0 ^a	1225.3 ^a	1371.4 ^b	1471.1 ^c	±35.13
Total CP intake (% of maintenance requirement)	223.3 ^c	235.1 ^a	263.2 ^b	282.4 ^a	±6.74
Excess CP intake over maintenance requirement (g)	642.4 ^a	703.7 ^a	850.4 ^b	950.3 ^c	±35.14
Estimated FCM yield (kg day ⁻¹)	8.2 ^a	9.0 ^b	10.9 ^c	12.3 ^d	±0.45

^{abc} Means within the same row with different superscripts significantly different ($P \leq 0.05$).

3.4 A cost benefit analysis of lablab and lablab with a concentrate as supplements to elephant grass

A simple economic analysis was carried out on the two diets: lablab and lablab with a concentrate as supplements to elephant grass using 1996 prices (Table 12). This involved the examination of overall profitability and the determinants of profitability. The gross margin, defined as the difference between the revenue received from the sale of milk and the costs of the supplements involved in the production of the milk. It was assumed that the cost of producing elephant grass and hired labour for all the diets were similar.

Further supplementation with a concentrate resulted increased the gross margin by 5%.

Table 12 **Costs and returns (shs/day) for milk produced under lablab hay and lablab hay plus a concentrate as supplements**

Item	DIETS	
	lablab hay	lablab hay plus a concentrate
Lablab hay	567	567
Concentrate	-	600
Total costs	567	1,167
Revenue from sale of milk	5,880	6,780
Gross margin	5,313	5,613

1 kg of milk costs shs 600

1 kg concentrate costs shs 300

1 kg of lablab hay costs shs 189 (Appendix Table 4)

CHAPTER IV

4 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

In Uganda, a major constraint to dairy production is the availability of all-year-round forage supply. The use of elephant grass fodder (*P. purpureum*) as a basal diet and Lablab (*L. purpureus* cv Rongai) green chop as a protein supplement for lactating dairy cows is a well-established practice on most smallholder dairy farms. The major problem associated with the two forages is that they mature early and become coarse and stemmy. These forages therefore have low feeding value for a greater part of the year which tends to result in low milk yield and loss of weight, long calving intervals and in some cases death of the animals. Lablab produces a lot of herbage during the growing seasons. This excess herbage, harvested at optimal feeding value (CP), could be conserved and stored as hay to supplement the low quality elephant grass and improve animal production during periods of feed shortages.

A study was therefore conducted at Namulonge Agricultural and Animal Production Research Institute, with the major objectives of evaluating the productivity and chemical composition of Lablab as a forage and to assess its potential, as a dry season protein supplement to elephant grass fed diets with and without a concentrate supplement for lactating dairy cows.

The effect of maturity on herbage biomass DMY, chemical composition and IVOMD of Lablab was assessed in Experiment I. The results showed that herbage biomass DMY increased tremendously with maturity and that it is high compared to that of other forage legumes currently used by the smallholder dairy farmers in Uganda. The biomass

DMY was 6.6, 10.9 and 12.2 Mt ha⁻¹ at Vegetative, flowering and pod-ripening stages of growth respectively. The results further showed a decline in the leaf to stem ratio (2:1; 1:1 and 1:2 respectively) with maturity of the plants. It was also observed that Lablab forage maintain fairly high levels of CP (15.0–25.0 %), Ca (1.4–1.7 %), P (0.3 %) and a reasonable level of NDF (52.6 %). Other attributes of lablab forage observed in this Experiment were: its spreading habit, which makes it an important forage for conserving soil moisture in areas with long dry periods; its ability to produce more than two ratoon crops in a year when harvested at 30 cm above the ground and above the branches of the plants, this makes it a dependable source of protein and minerals for dairy cows throughout the year; its initial establishment is rather slow but eventually became vigorous as the plants mature, it can therefore be used to suppress weeds in plantations; lablab is not susceptible to most of the diseases which attack forage legumes.

Based on the results of the herbage biomass DMY, chemical composition and IVOMD, it was recommended that in the Lake crescent region of Uganda, Lablab should be harvested for fodder at flowering stage, when 50 % of the plants have flowered and 50 % have formed pods, about 110 days after planting. Harvesting afterwards results in low forage of low CP and high NDF values.

The effect of supplementing lactating dairy cows fed on elephant grass based diets with Lablab hay was assessed in Experiment II. It was also observed from this Experiment that elephant grass utilization and TDMI, milk and FCM yield of lactating dairy cows could be improved by lablab hay supplementation and that small quantities, up to 3 kg day⁻¹ of lablab hay are required to enhance DMI and milk yield for animals similar to those used in this Experiment. The increase in DMI with this

supplement level was 19.3 %. This was approximately 3 % of BW which enabled them to gain weight. Higher levels of lablab hay supplementation appeared to result in a substitution effect (by 3 %) and reduced milk yields (by 1 %). Although the CP and ME values in elephant grass were sufficient to maintain lactating cows during the experimental period, it was observed that these quantities were insufficient for optimum milk production. CP content of the elephant grass used in this Experiment was 9.5 % which was lower than the minimum amount required for moderate levels of ruminant production (11-12%, ARC, 1980). Nevertheless, this was higher than the limiting level (6-8%) below which appetite is depressed and pasture intake is less than would be expected (ARC, 1980). Because the animals fed on unsupplemented diets lost weight, it was concluded that milk yield was, in part, at the expense of the animals' body weights.

It was however observed that for the high yielding animals to reach their genetic potential, Lablab hay enriched forages were certainly inadequate. It was therefore important to provide these animals with extra energy through concentrate supplementation.

The most important contribution of Lablab hay supplementation in this Experiment was not only the improvement in milk yields but also the superior live weight gains of the supplemented animals. This type of feeding is therefore important for regions which experience long dry seasons during which feed for livestock is scarce. What remains to be addressed from this type of feeding, is to establish appropriate technologies for harvesting Lablab that could minimize harvest losses, reduce manpower requirement (Appendix Table 4), preserve nutritional qualities and ensure an acceptable final product for the animals. The effects of feeding higher levels of lablab hay to lactating dairy cows for

longer periods need to be fully investigated as well. However, it is important to note that carefully managed elephant grass can also play an important part in alleviating the situation of feed shortages in the dry seasons when most of the other grasses and legumes may not yet fully have emerged from their dormancy. It is important to emphasize that for elephant grass to succeed in this purpose it must be carefully managed in such a manner that it can always be fully utilized in its young stages of growth.

Experiment III evaluated the performance of lactating cows fed on elephant grass supplemented with 3 kg day⁻¹ of elephant grass-Lablab hay diets with or without a concentrate supplement. The results indicated that although supplementation with a concentrate progressively reduced elephant grass and Lablab hay DMI, TDMI increased.

The percent (%) increase in TDMI at the highest supplement level was 17 %. The substitution rate was higher for elephant grass fodder (7.7 %) than for lablab hay (7.1%). Inclusion of a concentrate in the diets improved milk yield. A concentrate supplement level of 2 kg day⁻¹ gave an average of 18.5 % more milk than the control over the period of the Experiment. Further increases in the concentrate level resulted in a slight decline in milk yield (0.9 %). The results further showed that although supplemented animals fed on control diets gained weight (33 %), the differences in weight gains was not statistically significant. Lack of significant differences in weight changes might have been due to the substitution effects of concentrate feeding in supplemented animals. Accordingly, ME intake was higher in the concentrate enriched diets than in those without concentrate. It was therefore apparent that despite the ME and CP values in the control diets being sufficient to improve DMI, animal live weight and milk production during periods of

feed shortage, these quantities were again insufficient for optimal milk production. Provision of extra energy through concentrate supplementation was essential for optimal milk production. Milk composition was not affected by concentrate supplementation.

In conclusion, the overall productivity of cross-bred lactating dairy cows similar to those reported here which depend on low quality elephant grass fodder during periods of feed shortages can be improved by providing at least up to 2 kg day⁻¹ of concentrate and 3 kg day⁻¹ of locally produced lablab hay. In this case, lablab hay supplementation will reduce live weight losses and improve milk yields but not to their optimal genetic potential. For animals with a higher genetic potential for milk production, further supplementation with 3 kg day⁻¹ of a concentrate is essential for optimal milk production. Further supplementation with a concentrate resulted in an increase of 5% in gross margin received from milk sales.

In Uganda, however, utilization of elephant grass accompanied by Lablab hay with a concentrate for lactating dairy cattle is a new intervention which has not now been documented especially. This practice certainly needs to be encouraged in light of the results of this study. The results from this study form a basis for testing this feeding technology on-farm for-zero grazing.

REFERENCES

- Alhaussan, W.S. and Owusu, Y.D. 1980. Lactation responses of dairy cattle to concentrate feeding in humid tropics. *Trop. Anim. Health Prod.* pp. 171-176.
- Anon 1993. *Livestock Services Project Annual Report*, Ministry of Agriculture Animal Industry and Fisheries report, Uganda. 1994: pp. 3.
- Anon, 1993. *Namulonge Agricultural and Animal Production Research Institute, (NAARI), 1993 Annual Report.* pp. 32.
- Anon, 1994. State of the Environment report for Uganda 1994. Ministry of Natural Resources. National Environment Information Centre. Livestock Centre for Africa), Addis Ababa, Ethiopia. pp. 351-364.
- A.O.A.C. 1975. Official methods of analysis (12th ed.) (*Association of Official Analytical Chemists*). Washington, D.C. pp. 957.
- ARC. (Agricultural Research Council). 1980. *The Nutrient Requirements of farm Livestock*. Commonwealth Agricultural Bureaux, Farnham Royal, Slough, UK.
- Arias, P.J.; Combellas, J. (1979). Evaluation of a cut forage for milk production. Informe Anual 1979, *Instituto de Produccion Animal*. 1980, pp. 67-68. Maracay, Venezuela; Universidad Central de Venezuela. (Microfiche).
- Archibald, K.A.E. 1984. Dairy cattle feeding in the humid or high rainfall tropics. *Proc. Dairy nutrition conference held in Edinburgh from the 2-6th April 1984.* pp. 110-119.
- Bareeba, F.B. 1977. The ensiling characteristics and nutritive value of maize, amaranthus-enriched maize and sorghum silages preserved with either molasses or formaldehyde. *M.Sc. Thesis, Makerere University, Kampala.*
- Bayer, 1986. Utilization of fodder banks. In: von Kaufmann, R, Chater, S. and Blench (eds), *Livestock Systems research in Nigeria's subhumid zone. Proc. 2nd ILCA/NAPRI Symposium held in Kaduna, Nigeria, 29th Oct.- 2nd. Nov. 1984 . ILCA (International Livestock Centre for Africa)* pp. 40-41.
- Bines, J.A. 1979: Voluntary feed intake in dairy cows in relation to milk production. *Livestock Prod. Sc.* 3: 115-128.
- Boonman, J.G. 1993. *East African Grasses and Fodders: Their Ecology and Husbandry*. Kluwer Academic Publishers. pp. 196.

- Boitumelo, W.S. and Mahabile, W. 1991. Improving milk production in small-scale dairy farms in Botswana: Incorporating legume fodder in the farming systems. *In*: Stares, J.C.S.; Said, A.N. and Kategile, J.A. (eds). 1992. The complementarity of feed resources for animal production in Africa. *Proc. Joint feed resources networks Workshop held in Gaborone, Botswana*. 4-8 March, 1991. pp. 353-362.
- Bredon, R.M. and Horrel, C.R. 1962. The chemical composition and nutritive value of some common grasses in Uganda. *E. Afr. For. J.* 39: 13-17.
- Butterworth, M.H., Mosi, A. and Preston, T.R. 1985. Molasses/urea and legume hay as supplements to poor quality roughage in Ethiopia. *Proc. XII Intern. Congress of Nutrition, Brighton, England*, (Microfich).
- Close, W. and Menke, K.H. 1986. Selected Topics in animal Nutrition. A manual prepared for the 3rd Hohnheim Course on Animal Nutrition in Tropics and Semi-tropics 2nd edition. pp. 74-85.
- Combellas, J.; Martinez, N. 1982. Intake and milk production in cows fed chopped elephant grass (*Pennisetum purpureum*) and concentrate. *Trop. Anim. Prod.* 1982. 7: (1). 57-60.
- Crampton, E.W.; Donefer, E.; and Liyod, L.E. 1960. The nutritive value index for forages. *J. Anim. Sci.* 19: 538-340.
- Crowder, L.V. and Chheda, H.R. 1982. Tropical Grassland Husbandry. Longman, London and New York. pp. 308-384.
- Davidson and Woodman (1966). The effects of processing on the nutritive value of foodstuffs. *In*: Abram, J.T. 1966. Recent Advances in animal nutrition. Little, Brown and Company, Boston. pp. 1-50.
- Davison, T.M.; Cowan, R.T.; Shepherd, R.K. and Martin, P. 1985. Milk production from cows grazing on tropical grass pastures. 1. Effects of stocking rate and level of nitrogen fertilizer on pasture and diet. *Austr. J. Exp. Agr.* 1985. 25. 505-514.
- Demarquilly, C. and Jarrige, R. 1973. The comparative nutritive value of grasses and legumes. *European Grassl. Federation. 5th General meeting. Uppsala*. 12-15 June, 1973.
- Denium, B. and Dirven, J.P.G. 1975. Climate, Nitrogen and grass comparison of yield and chemical composition of some temperate and tropical grass species grown at different temperatures. *Netherlands J. Agr.* 23: 69-82.
- Demaquilly, C. 1989. The feeding value of forages. *Proc. XVI Intern. Grassld. Congress. 4-11th Oct. 1989*. pp. 1817-1822.
- Devendra, C. 1975. Efficient feeding and management of dairy cows. *Proc. Sympos. on Dairy Nutrition. 3rd-4th February 1975, Shah alam, Malaysian*, pp. 194-162.

- El-Tayeb, A.E. and Takla, A. 1992. Effect of addition of concentrates to sudan grass (*Sorghum sudanense*) in the pre-calving period on performance of Holstein-Friesian heifers in Sudan. In: Stares, J.E.S.; Said, A.N. and Kategile, J.A. (eds). 1992. The complementarity of feed resources for animal production in Africa. *Proc. Joint feed resources networks Workshop held in Gaborone, Botswana*. 4-8 March, 1991. pp. 75-84.
- Favoretto, V.; Costa, J.L.A. 1978. Effect of height and season of cutting on production, chemical and nutritive composition and percentage regrowth of lablab (*Dolichos lablab*). *Cientifica*. 6: (2). 321-328.
- Fisher, M.J. 1969. The growth and development of Townsville lucerne (*Stylosanthes humilis*) in ungrazed swards at Katherine, North Territory. *Aust. J. Expt. Agr. Anim. Husb.* 9: 196-202.
- Goering, H.K. and Van Soest, P.J. 1970. Forage fibre analyses. (Apparatus, reagents, procedures and some applications). *USDA Agr. Handbook No. 379 U.S. Dept. of Agr., Washington, D.C, U.S.A.* Jacket No. pp. 387-598.
- Hamilton, R.I., Lambourne, L.J., Roe, R. and Minson, D.J. 1970. Quality of tropical grasses for milk production. *Proc. 10th Intern. Grassld. Congress. Surfer's Paradise*. pp. 860-864.
- Hendricksen, R.; Minson, D.J. 1980. The feed intake and grazing behaviour of cattle grazing a crop of *Lablab purpureus* cv. Rongai. *J. Agr. Sci.* 95: 547-554.
- Hendericksen, R.E.; Poppi, D.P.; Minson, D.J. 1981. The voluntary intake, digestibility and retention time by cattle and sheep of stem and leaf fractions of a tropical legume (*Lablab purpureus*). *Aust. J. Agr. Res.* 32: 387-398.
- Henderisken, R.E. and Minson, D.J. 1985. Growth , Canopy structure and chemical composition of *Lablab purpureus* cv. Rongai and pp Samford, S.E. Queensld. *Trop. Grassld.* 18: 81-87.
- Hibbs, J.W. and Conard, H.R. 1975. Minimum concentrate feeding for efficient milk production. *Ohio Res. and Dev. Centre, Dairy Sci. Dept. Series No. 25-75*: pp. 33-37.
- Hogson, J. 1982. Influence of sward characteristics on herbage intake by the grazing animal. In: J.B. Hacker (eds). 1982. Nutritional limits to animal production. *Proc. Intern. Sympo. held at St.Lucia, Queensland, Australia. Aug. 24-28th 1981*. pp. 153-160.
- Iwuanyanwu, E.J., Umnna, N.N. and Dim, N.I. 1990. Effects of urea supplement with or without Molasses on the intake, digestibility and liveweight changes of beef heifers fed native hay. *Anim. Feed Sci. and Tech.* 31. 277-284.
- Jakhmola, R.C. and Pathak, T. 1981. Evaluation of the nutritive value of field bean. *Kerala Journ. Vet. Sc.* 12: (2): 295-300.

- Jarrige, R. and Demaquilly, C., Dulphy, J.P. 1973. The voluntary intake of forages. *Europea Grassl. Federation. 5th General Meeting Uppsala*, 12-15th June 1973.
- Jarrige, R.; Demarquilly, C.; Dulphy, J.P. 1982. Forage Conservation. Techniques of Intensive Forage Production. ASPAL. *Food Fert. Tech. Cent. Extn. Bull.* 81: Taiwan.
- Jennings, P.G. and Holmes, W. 1985. Supplementary feeding to dairy cows grazing tropical pasture: a review. *Trop. Agr. (Trinidad)* 62: (4). 266-272.
- Kang, B.T.; Raymonds, L.; Atta-Krah, A.N. 1990. Alley Farming. *Advances in Agronomy.* 43: 315-359.
- Karachi, M. 1988. Yield and quality and *Lablab purpureus* ecotypes in high altitude Semi-arid lands in Kenya. *In: African Research Network for Agricultural By-products (ARNAB), 1989. Overcoming constraints to the efficient utilization of agricultural by-products as animal feed. Proc. Fourth Annual Workshop held at the Inst. of Anim. Res., Mankon St., Bamede, Cameroun, ILCA, ARNAB Addis Ababa, Ethiopia. 16-19th Oct. 1987.* pp. 123-137.
- Karuaichamy, K.S.T.K. and Oaliwal, K. 1993. Monthly changes in plant biomass, net primary productivity and transfer dynamics of a tropical grazing land ecosystem in Southern India. *Proc. XVII Intern. Cong. 8-21 Feb.* pp. 109-110.
- Kellaway, R. and Porta, S. 1993. Feeding concentrates: Supplements for Dairy Cows. Dairy Research and development Corporation. pp. 35-145.
- Kiflewahid, B. and Mosimanyana, B. 1992. *Dolichos lablab* (*L. purpureus*) in by-product-based diets for lactating cows in Botswana. *In: Overcoming constraints to the efficient utilization of Agricultural by-products as animal feed. Proc. 4th annual workshop held at the Inst. Anim. Res., Mankon Station, Bamede, Cameroon, 20-27th Dec. 1987.* pp. 155-171.
- Kimambo, A.E.; Makiwa, A.M.; Shem, M.N. 1992. The use of *Leucaena leucocephala* supplementation to improve the utilization of maize stover by sheep. *In: Stares, J.E.S.; Said, A.N. and Kategile, J.A. (eds). 1992. The complementarity of feed resources for animal production in Africa. Proc. Joint feed resource networks Workshop held in Gaborone, Botswana. 4-8 March, 1991.* pp. 163-172.
- Koume C; Hoefs S; Powell J.M.; Roxas D.; and Renard C. 1992: Intercrop *Stylosanthes* effects on millet yields and animal performance in the Sahel. *In: Stares, J.E.S.; Said, A.N. and Kategile, J.A. (eds). 1992. The Complementarity of Feed Resources for Animal Production in Africa. Proc. Joint feed resources networks workshop held in Gaborone, Botswana 4-8th March 1991.* pp. 137-146.

- Kusekwa, M.L., Kyamanywa, R.S. and Ngowi, M.D. 1992. Fitting forage legumes into the cropping systems of semi-Arid Tanzania. *In*: Stares, J.E.S.; Said, A.N. and Kategile, J.A. (eds). 1992. The complementarity of feed resources for animal production in Africa. *Proc. Joint Feed Resources Net-workshop held in Gaborone, Botswana, 4-8 March 1991*. pp. 215-23.
- Laredo, M.A. and Minson, D.J. 1973. The voluntary intake digestibility and retention time by sheep of leaf and stem fractions of five grasses. *Austr. J. Agr. Res.* 24: 875-888.
- Lascano, C.E. and Avilo, P. 1993. Milk yields of cows with different genetic potential on grass and grass-legume tropical pastures. *Proc. XVII Intern. Grassld. Congress. 1993*. pp. 2006-2007.
- Little, D.A. 1982. Utilization of minerals. *In*: J.B. Hacker (eds). 1982. *Nutritional limits to animal production from Pastures. Proc. Intern. Symp. held at st. Lucia, Queensland, Australia. Aug. 24-28th. 1981*. CAB, Farnham, Royal, U.K. pp. 110 -115.
- Little, D.A. and Agyemang, K. 1994. An assessment of Stylo as a source of supplementary feeding. *In*: de Leeuw, P.N., Mohamed-Saleem and Nyamu, A.M. (eds). 1996. *Stylosathes as a forage and fallow crop. Proc. Regional Workshop on the use of Stylosanthes in West Africa, held in Kaduna, Nigeria, 26-31 Oct. 1992: pp. 40-45, ILCA (International Livestock Centre for Africa). Addis Ababa, Ethiopia*.
- Long, M.I.E.; Marshall, B.; Ndyababo, W.K.; Thornton, D.D. 1972. Mineral status of dairy farms in eastern Uganda. 2. Nitrogen and mineral content of grasses and some mineral contents of bovine plasma. *Trop. Agr. J.* 49: (3). 227-234. (Microfiche).
- Maria-da-Cruz, G.; Vilela, D. 1986. Evaluation of elephant grass (*Pennisetum purpureum*) silage for milk production. *Revista-da-Sociedade-Brasileira-de-Zootecnia*. 1986, 15: 1, (Microfiche).
- McDowell, R.E. 1972. *Improvement of Livestock Production*. W.H. Freeman and Company, San Francisco. pp. 7-18.
- Meijs, J.A. and Hoekstra, J.A. 1984. Concentrate supplementation of grazing dairy cows. 1. Effect of concentrate intake and herbage allowance on herbage intake. *Grass and Forage Sci.* 39: 59-66.
- Mepham, T.B. 1992. The development of ideas on the role of Glucose in Regulating Milk Secretion. *Aust. J. Agric. Res.* 44: 509-520.
- MFEP (Ministry of Finance and Economic planning). Background to the Budget 1994-1995. Economic Performance (1993-1994) and Prospects (1994-1995).
- Milford, R. and Minson, D.J. 1966. The feeding value of tropical pastures. *In*: Davies, W. and Skidmore, C.L. (eds). *Tropical Pastures*. London, Faber and Faber. pp. 106-114.

- Milford, R. 1967. Nutritive values and chemical composition of seven tropical legumes and lucerne grown in subtropical Southern Queensland. *Austr. J. Agr. Anim. Husb.* 7: 540-545.
- Milford, R. and Minson, D.J. 1968. The effect of age and method of hay making on the digestibility and voluntary intake of forage legume "*Dolichos lablab* and *Vigna sinensis*" *Austr. J. Expt. Agric. Anim. Husb.* 8: 409.
- Minson, D.J. 1982. Effects of chemical and physical and composition of herbage eaten upon intake. In: J.B. Hacker (eds). 1982. *Nutritional limits to animal production from Pastures. Proc. Intern. Symp. held at St. Lucia, Queensland, Australia.* Aug. 24-28th. 1981. CAB, Farnham, Royal, U.K. pp. 89-110.
- Morris, J.G. and Levitt, M.S. 1968. The intake and digestibility of silage made from *Dolichos lablab* (*L. purpureus*) alone and with sorghum cv. sugar drip. *Proc. Aust. Soc. Anim. Prod., 7th Bienn. Conf.* 7: pp. 78-85.
- Mpairwe, D. 1994. Evaluation of *Gliricidia sepium* (Jacq.) Walp as a fodder Tree/Shrub for ruminant production. *M. Sc. Thesis, Makerere University.* 1994.
- Mugerwa, J.S. 1975. Milk producing capacity of tropical forages in East Africa (unpublished).
- Muinga, R.W.; Thorpe, W.; Topps, J.H.; Mureithi, J.G. 1992. Responses to *Pennisetum purpureum* basal diet harvested at two different heights and fed with three levels of *Luekeaena* forage to cross bred dairy cows in the subhumid tropics. In: Stares, J.E.S.; Said, A.N. and Kategile, J.A. (eds). 1992. The complementarity of feed resources for animal production in Africa. The Complementarity of Feed Resources for Animal Production in Africa. *Proc. Joint feed resources network workshop held in Gaborone, Botswana* 4-8 March, pp. 75-77.
- Muinga, R.W.; Thorpe, W. and Topps, J.H. 1993. Lactational performance of Jersey cows given Napier fodder (*Pennisetum purpureum*) with and without protein concentrates in the semi-humid tropics. *Trop. Anim. Hlth. Prod.* 25: 118-128.
- NAS (National Academy of Sciences). 1979. Tropical Legumes: Resources for the Future. Report of an Ad Hoc Panel of the Advisory Committee on Technology Innovation Board on Sciences and Technology for International Development Commission on International relations National Research Council. Washington, D.C. 1979. pp. 59-67.
- Ndyanabo, W.K. 1992. The role of Livestock Services Project. *Paper presented at the 2nd FAO Regional working group on grazing (RWG) at Makerere University, Kampala, Uganda.* 30th Mar -3rd Apr 1992.

- Ngwa, A.T. and Tawah, C.L. 1992. Effect of legume crop residues and concentrate supplementation on voluntary intake and performance of Kirdi sheep fed a basal diet of rice straw. *In: Stares, J.E.S.; Said, A.N. and Kategile, J.A. (eds). 1992. The complementarity of feed resources for animal production in Africa. the Complementary of Feed Resources for Animal Production in Africa. Proc. Joint resources Network Workshop held in Gaborone, Botswana, 4th-8th March 1991. pp. 239-247.*
- Norton, B.W. 1982. Differences between species in forage quality. *In: J.B. Hacker (eds). 1982. Nutritional limits to animal production from Pastures. Proc. Intern. Symp. held at st. Lucia, Queensland, Australia. Aug. 24-28th. 1981. CAB, Farnham, Royal, U.K. pp. 89-110.*
- Nsahlai, I.V. and P.O. Osuju. 1995. Sesbania and Lablab supplementation of oat hay basal diet with or without maize grain. *Anim. Feed Sci. Technol. In press*
- Nsubuga, H.S.K. 1993. Pastures in the feeding of dairy cattle in Uganda, with particular reference to zero grazing. *In: Sabiiti, E.N.; Bareeba, F.B. and Mwebaze, S. Proc. of the second Uganda Pasture Network workshop, Makerere University, 14-16 Dec. 1992. pp. 64-68.*
- Nsubuga, H.S.K. 1994. Prospects for the dairy industry in Uganda. Aucipices of the Uganda Society. Paper presented to " Uganda society " at the Uganda Museum, Kampala, Uganda. 17th. Nov.1994.
- Ochodumuge, P.K. 1978. Effect of advancing maturity on the production and feeding value of *D. intortum*, *M. atropurpureum* and *S. guyanensis* in Uganda. *M. Sc. Thesis Makerere University, Kampala.*
- Ogwang, B.H. 1974. Qualitative and quantitative evaluation of *Pennisetum purpureum* x *Pennisetum typhoides* hybride. *M. Sc. Thesis. Makerere University, Kampala.*
- Ogwang, B.H. and Mugerwa, J.S. 1976. Yield response to Nitrogen application and *in vitro* dry matter digestibility of Elephant grass x bulrush millet hybrids. *E. Afr. Agr. For. J. 41: 231-242.*
- Otim, J.J. 1973. The potential of improved pastures for fattening steers in Uganda. *M. Sc. Thesis, Makerere University Kampala.*
- Otim, J.J. 1975. Comparative beef production from ley and improved natural pastures. *E. Afr. Agr. and For. J. 41: 45-46.*
- Phillips, C.J.C. 1988. The use of conserved forage as supplement for grazing cows. *Grass and Forage Sci. 43: 215-230.*
- Phipps, R.H. 1970. Some aspects of supplementary feeding of dairy cows in the Lake Crescent areas of Uganda. *E. Afr. Agr. For. J. 36. 192-227.*

- Rees, M. and Minson, D.J. 1976. Influence of supplementation on the voluntary intake and digestibility of feed. An alternative in fertilizers? *In: G.T. Bland (ed). Review in Rural Sci. 3. The efficiency of Phosphorous Utilization, University New England: Armidale.* pp. 165-169.
- Reid R.L.; Post, A.J.; Olsen, F.J.; Mugerwa, J.S. 1973. Studies on the nutritional quality of grasses and legumes in Uganda. 1. Application of *in vitro* digestibility techniques to species and stage of growth effects. *Trop. Agr. (Trin).* 50: 1-15.
- Ruiz, M.E. 1983. Supplementing dairy cows in the tropics. *The dairy Science Handbook.* 33: pp. 337-342.
- Rowland, J.R.J. 1993. Dryland Farming in Africa. The Macmillan Press Limited. pp. 282-284.
- Sabiiti, E. 1979. The potential of *Indigofera hirsuta* as a pasture legume in Uganda. *M. Sc. Thesis. Makerere University, Kampala.*
- Sabiiti, E.N. 1993. Forage Integration into crop-livestock Production Systems. *In: Sabiiti, E.N.; Bareeba, F.B. and Mwebaze, S. Proc. of the second Uganda Pasture Network workshop, Makerere, University, 14-16 Dec. 1992. pp. 19-20.*
- Sabiiti, E.N. and Mwebaze, S. 1989. Dairy Industry Development Project. UNDP/FAO Project UGA/84/023. Working paper No. 99: pp. 91-99.
- Sabiiti, E.N.; Mugerwa, J.S. and Bareeba, F.B. 1994. Agronomic Evaluation of Forage Legumes for improving native pasture systems in Uganda. *African Crop Science Conference Proc., Kampala, 14-18 June, 1993. In: Ekwamu, A; Ogenga-Latigo, M.W. and Bekunda, M.A. (eds). Afric. Crop Sc. J. 1. 171-173.*
- Siebert, B.D. and Hunter, R.A. 1982: Supplementary feeding of grazing animals. *In: J.B. Hacker (eds). 1982. Nutritional limits to animal production from Pastures. Proc Intern. Symp. held at st. Lucia, Queensland, Australia. Aug. 24-28th. 1981. CAB, Farnham, Royal, U.K. pp. 112-118.*
- Skerman, N.H., Carmeron, D.F., Riveros, F. 1988. Tropical forage legumes. 2nd ed. *Food and Agriculture Organization of the United Nations.* pp. 311-319.
- Smith, O.B. 1993. Feed resources for intensive smallholder in the tropics. The role of crop residues. *Proc. XVII Intern Grassld. Congress. 1993. pp. 1969-1971.*
- Stakelum, G. 1980. Herbage intake of grazing dairy cows. Effect of autumn supplementation with concentrate and herbage allowance on herbage intake. *Ir. J. Agri. Res.* 25: 31-40.
- Stobbs, T.H. 1965. The influence of inorganic fertilizers upon the adaptation, persistence and production of grass/legume swards. *E. Afr. Agr. and For. J.* 35: 112-114.

- Stobbs, T.H. 1969. The value of *Centrosema pubescens* (Benth.) for increasing animal production and improving soil fertility in Northern Uganda. *E. Afr. Agr. For. J.* 35: 197-202.
- Stobbs, T.H. 1971. Quality of pasture and forage crops for dairy production in tropical regions of Australia. *Trop. Grassld.* 5: 159-170.
- Stobbs, T.H. 1973. The effect of plant structure on the intake of tropical pastures. 1. Variation in the bite size of grazing cattle. *Austr. J. Agr. Res.* 24: 809. 59-66.
- Stobbs, T.H. 1976. Milk production per cow and per hectare from tropical pastures. *In: Seminario Inter de Ganaderia, Trop., Memorias. FIRA, Acapulco Mexico.* (Microfiche).
- Stobbs, T.H. 1977. Short term effects of herbage allowances on milk production, milk composition and grazing time of cows grazing nitrogen fertilized tropical grass pasture. *Austr. J. Exp. Agr. Animal Husb.* 17: 892-894.
- Stockdale, C.R. and Trigg, T.E. 1989. Effect of pasture feeding levels on the responses of lactating dairy cows to high energy supplements. *Austr. J. of Expt. Agr.* 29: 739-44.
- Tayeb, A.E. and Takla, G. 1992. Effect of addition of concentrates to Sudan grass (*Sorghum sudanensis*) in the pre-calving period on performance of Holstein Friesian heifers in Sudan. *In: Stares, J.E.S.; Said, A.N. and Kategile, J.A. (eds). 1992. The complementarity of feed resources for animal production in Africa. the Complementary of Feed Resources for Animal Production in Africa. Proc. Joint Feed Resources Networks Workshop held in Gabrone, Botswana 4-6 March 1991. pp. 259-264.*
- Tilley, J.A.M. and Terry, R.A. 1963. A two stage technique for *in vitro* digestion of forage crop. *J. Brit. Grassl. Soc.* 19: 104-105.
- Thomas, T.A. and Dabas, B. 1982. Lablab bean- A multipurpose legume crop. *National Bureau of Plant Genetic Resources, IARI Campus, New Delhi.* pp. 23-25.
- Thurbon, P.; Byford, I. and Winks, L. Evaluation of *Dolichos lablab* cv. Rongai, Sorghum/Sudan grass hybrid cv. Zulu, and Townsville lucerne (*Stylosanthes humilis* H B K) on the basis of organic matter and crude protein digestibility. *Proc. 11th Intern. Grassld. Congress, Surfers Paradise, Australia,* pp. 743-747.
- Vadiveloo, J. 1986. Alleviating the low quality of Tropical forages. *Malays. Applied Biology* 15: (2) 161-168.
- Van Soest, P.J. 1965. Symposium on factors influencing the voluntary intake in relation to chemical composition and digestibility. *J. Anim. Sci.* 24: 834-843.

- Welloso, L.; Freitas, E.A.N.-de 1973. Milk production from cows on grass or mixed (grass + legume) pastures. *Zootecnia* 11 (3): 177-182.
- Wendt, W.B.; Stobbs, T.H.; Tilley, C.E.D. and Turker, G.C. 1970. *Pasture Handbook for Uganda*. Dept. of Agriculture, Entebbe, Uganda. 4-5.
- Ware-Austine, W.D. 1963. Napier grass for milk production in the Trans Nzonja. *E.A. Agric. and For. J.* 21: 223-226.
- Woulters, A.P. 1985. Fodder production for zero-grazing. Recent research findings. *Paper presented at the Animal Prod. Society of Kenya Symp. on Zero-grazing for Milk Prod., Kabete, 22nd Nov. 1985.*
- Wood, I.M. 1983. Lablab bean (*Lablab purpureus*) for grain and forage production in the Ord Irrigation Area. *Aust. J. Agric. Anim. Husb.* 23: 162-171.

APPENDIX TABLES

Appendix Table 1: Mean dry matter production (kg ha⁻¹ for 1988/89 and 1990/1991 growing seasons at Kabanyolo, Uganda

Forage species	ILCA No	1988/89	1990/91
<i>D. uncinatum</i>	6765	1444	1600
<i>D. intortum</i>	104	1200	1450
<i>D. discolor</i>	6988	2404	3800
<i>S. guinanensis</i>	73	1538	1655
<i>S. scabra</i>	140	1613	1712
<i>M. atropurpureum</i>	2769	2719	2984
<i>L. purpureus</i>	6534	4275	4970
<i>L. purpureus</i>	7278	5190	3977
<i>L. purpureus</i>	7403	4781	5012
<i>N. wightii</i>	6762	1286	2443
<i>N. wightii</i>	9979	1601	1845

Source: Sabiiti *et al.*, (1993)

Appendix Table 2 Experimental design for Experiment II

	Animals			
	1	2	3	4
Feeding Period				
1	EL ₀ ^a	EL ₂	EL ₃	EL ₄
2	EL ₂	EL ₄	EL ₀	EL ₃
3	EL ₃	EL ₀	EL ₄	EL ₂
4	EL ₄	EL ₃	EL ₂	EL ₀

^a Treatments - Each animal received each treatment once.

EL₀: Animals fed on sole elephant grass (*ad-libitum*) (control diets).

EL₂: Animals fed on elephant grass fodder *ad-libitum* supplemented with 2 kg day⁻¹ of Lablab hay.

EL₃: Animals fed on elephant grass fodder *ad-libitum* supplemented with 3 kg day⁻¹ of Lablab hay.

EL₄: Animals fed on elephant grass fodder *ad-libitum* supplemented with 4 kg day⁻¹ of Lablab hay

Each feeding period lasted for 28 days (14 days adjustment and 14 data collection)

Table 3 Experimental design for Experiment I11

Feeding Period	Animals			
	1	2	3	4
1	EL ₁ [*]	ELC ₃	ELC ₀	ELC ₂
2	ELC ₂	ELC ₀	ELC ₁	ELC ₃
3	ELC ₃	ELC ₂	ELC ₂	ELC ₀
4	ELC ₀	ELC ₁	ELC ₃	ELC ₁

Footnote: ^{*} Each animal received each treatment once

Each animal was fed on elephant grass fodder *ad libitum* plus 3 kg of Lablab hay day⁻¹ with 0, 1, 2, and 3 kg of concentrate represented as C₀, C₁, C₂, and C₃.

Appendix Table 4 Production costs for *Lablab purpureus*
(Shs kg⁻¹)

Item	Quantity (Per hectare)	Rate (Shs/ha ¹)	Total Cost (Shs)
Lablab seed	7.5	3,000 (300 kg)	22,500
Land preparation	50 lts fuel	1,000	50,000
Weeding (twice)	25 MD x 2	1,000	50,000
Harvesting fodder	50 MD	1,000	50,000
Chopping and Drying	30 MD	1,000	30,000
Baling	20 MD	1,000	20,000
Sisal strings	15	1,500	22,500
Baling box	2	4,000	8,000
Labour for baling		200 shs/bale	15,250
Total		SHS	258,250

Number of bales per ha 105 @ 13 kg = 1365 kg

MD: Mandays; 1 MD = (8 hours)

Cost per kg of Lablab hay: Shs 189.00