FODDER BIOMASS YIELD, FEEDING VALUE AND PALATABILITY OF SHRUB FODDER SPECIES GROWN IN MARGINAL LANDS IN THE MID COUNTRY OF SRI LANKA

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ABSTRACT

Marginal lands in the mid country region are steep, heavily eroded and highly acidic. In most of these lands the top soil is limited to a very thin layer or completely absent. Therefore, this study was conducted to evaluate the potential of different shrub species for fodder biomass production, feeding value and preference by ruminants. This will provide an opportunity to introduce a profitable livestock production system to generate a successful income source for the resource poor farmers in the mid country region. Legumes; *Gliricidia sepium, Calliandra calothyrsus, Erythrina verigeta, Desmodium ransonii, Flemingia macrophylla* and non legumes ; *Tithonia diversifolia, Morus alba* were established in double row hedges, 7 meters apart. Leaf dry matter yields (LDMY) were estimated for 100 m. linear lengths, with a lopping cycle of 16 weeks for a period of 1 year. Highest LDMY was observed in *E. Verigeta* (276±23 kg. DM/year) and the lowest was in *D. ransonii* (86±12 kg. DM/year).

G. sepium, L. leucocephala, C. calothyrsus and *F. macrophylla* produced a LDMY of 205±17, 188±18, 165±10 and 100±15 kg/year, respectively. *Tithonia diversifolia* and *M. alba* yielded 146±22 and 143±16 kg/year, respectively. The Crude Protein (CP) content of leguminous shrub species ranged from 210±21 g/kg (*F. macrophylla*) to 270±21 g/kg (*C. calothyrsus*). In non leguminous species, *T. diversifolia* had a higher CP content (180±26 g/kg) than *M. alba* (120±32 g/kg). Acid Detergent Fibre (ADF) in all fodder species were above 300±21 g/kg., and the highest was in *F. macrophylla* (480±63 g/kg.). Lignin content was highly variable between species, from as low as 81±14 g/kg. (*D. ransonii*) to as high as 284±26 g/kg. (*F. macrophylla*). The In Vitro dry matter digestibility (IVDMD) was above 500 g/kg. in all fodder species, except for *F. macrophylla* (466±124 g/kg.). The highest rapidly degradable fraction (a) was in *G. sepium* (42.0%) and lowest in *F. macrophylla* (24.4%). The potential degradability (a+b) was highest in *T. diversifolia* (79.4%). The highest soluble fraction of nitrogen were in *G. sepium* and *E. verigeta* (59.1% and 52.6%, respectively). All fodder species, except *F. macrophylla* and *C. calothyrsus* consist a potential degradable nitrogen (a+b), above 80%. The most preferred fodder species was *M. alba* and the least preferred was *F. macrophylla* (720 and 300 g. DM/d/head). This study suggest that the leguminous and non leguminous fodder species performed successfully in marginal lands and open an avenue for ruminant livestock production through providing quality fodder biomass for feeding.

Introduction

Mid country of Sri Lanka comprise of about 160,000 ha. of marginal lands which are under tea or completely neglected. These lands had been under tea for many decades and subjected to severe erosion due to poor soil conservation and other agronomic practices. These lands are at an altitude of 300 - 1500 m. and receive an annual rainfall of 800 - 1500 mm. These lands suffered prolonged and severe erosion leaving shallow or completely absent of top soil. Heavily weathered soils resulted high acidity causing low pH. These conditions collectively make the soil infertile and unsuitable for many plants. Therefore, only few species of plants which are acid tolerant and require low soil fertility will sustain making a narrow floristic bio diversity.

As an attempt to reduce the soil erosion and improve the soil fertility Pinus was introduced through the reforestation programmes. However, this crop has been subjected to many controversies by hydrologist and ecologist due to its affects on hydrological cycle and narrow floristic bio diversity. In addition, these marginal lands even under Pinus, are subjected to periodic fire during the dry season. The bush fire is fueled by the thick ground cover of the accumulated Pine needles and the well dried dense under growth of both Guinea grass (*Panicum maximum*) and Wild Citronella (*Cymbapogum spp*).

Some of these marginal lands are put into use through settlement programs (NADSA) and some are encroached by the villagers to cultivate short term cash crops such as vegetables and tobacco. This land use system aggravated the soil erosion due to the frequent disturbance of the soil for planting and other inter-cultivation operations.

A very successful system has been introduced to Sri Lanka from Philippines to minimize the soil erosion in slopy terrain, where these lands are used for agricultural purposes and this system is known as **'Slopy agricultural land technology'** or **'salt'**. This is done by introducing leguminous shrub species grown as hedge rows on contours. These leguminous shrub species reduce soil erosion and improve soil fertility by atmospheric dinitrogen fixation through symbiosis and providing organic matter to the soil through their periodic lopping. This system will enhance the soil physical and chemical characteristics and also influence the soil micro floral and faunal activity.

Many studies have revealed that the green leaf (fodder) biomass produce in SALT system for mulching or green manuring is in excess to the requirements. The potential of this fodder as a feedstuff for livestock is not been ignored. To make use of this excess green fodder to generate an additional income for the resource poor small holder, a livestock component was introduced to the existing **salt** system and defined as **'Simple agro-livestock technology'** or **'Salt II'**. Under **salt** II system, the most appropriate species of livestock found to be the goat. This system will recycle plant nutrients back to the system via urine and dung in much available and efficient form than through natural decomposition of green manure. This system is being successfully practiced in Philippines in small farm holdings and in Sri Lanka this is tested as pilot projects. The main objectives of this system is to minimize the soil erosion, improve the productivity of the land and improve family budget by utilizing limited resources in a sustainable manner.

The objectives of this study were to;

i. evaluate the dry fodder production potential of different leguminous and non leguminous shrub species
ii. evaluate the feeding value, digestibility and rumen kinetics
iii. order of preference of different fodder species by goats.

Materials and Methods

This experiment was conducted in the mid country intermediate zone of Sri Lanka, at an altitude of 900 m. receiving an annual rainfall of 800 - 1500 mm. The soil type of the experimental area was Reddish Brown Latersolic and Immature Brown Loam, with soil pH of 5.0 - 5.5. Hedge rows of *Desmodium Ransonii, Calliandra calothyrsus, Flemingia macrophylla* and *Leucaena leucocephala* were established by direct seeding along the contour rows and *Gliricidia sepium, Tithonia diversifolia, Erythrina Verigeta* and *Morus alba* were planted by stem cuttings. All species were established as double row system, with an inter row spacing of 45 cm. within the double row. The linear length of the hedge row of each species was 50 m. Prior to the data collection all species were lopped twice a year during the two monsoonal rainy seasons over a period of two years. During the experimental period, a 16 week lopping cycle was adopted for a period of one year. The total fresh biomass of all species were measured and a sub sample was taken for determination of dry biomass yield. Dried samples were ground to pass 2 mm. sieve using

a laboratory mill. The samples of each fodder at each sampling were composite to analyzed for feeding value.

Dry matter (DM), organic matter (OM), ash, crude protein (CP), ether extract (EE), crude fibre (CF) were determined by standard method (A.O.A.C., 1980) and nitrogen free extract (NFE) is estimated by the difference.

Cell wall constituents such as Acid Detergent Fibre (ADF), Acid Detergent Lignin (ADL), Cellulose by Goering and Van soest (1970) and Acid Insoluble Ash (AIA) by Keulan and Young (1977). In vitro Dry Matter Digestibility (IVDMD), according to Tilley and Terry (1963), using rumen fluid from goats fed on medium quality Guinea grass (*Panicum maximum*) and coconut oil meal as a concentrate.

Rumen disappearance studies were conducted with three ruminally cannulated goats fed on Medium quality Guinea grass fed *ad libitum* and Coconut oil meal 15 g. per kg. $w^{0.75}$. Nylon bags (7 cm. x 13 cm.) with a pore size of 61m were used for the incubation of fodder in the rumen. Ten g. of the ground sample of each fodder species were placed in separate bags and incubated for 4, 8, 24 and 48 hrs. Once the bags were withdrawn from the rumen in respective incubation periods, they were thoroughly washed and dried at 60 °C until a uniform weight was obtained. The residue was analyzed for dry matter and nitrogen and the disappearance was calculated as a percent of initial value.

The disappearance of both dry matter and nitrogen were analyzed by non lineal regression (SAS, 1980) using $p = a + b (1 - e^{-ct})$ exponential equation (Orskov and McDonald, 1979);
where p = Degradability at time t (%),
a = Rapidly degradable fraction (%),
b = Potentially degradable fraction (%),
c = Fractional rate of degradation (% / hr),
a+b = Potential degradability (%) and
t = Incubation time (4 - 48 hrs).

Individual fodder intake and the order of preference by the goats were determined by using 'Cafeteria Method'. This method will allow the goats free access to all fodder types free of choice. This facilitate to select the ones according to their preference. Eight goats were stalled in a large pen (average body weight 15±1.3 kg.) and each fodder was offered in separate feed boxes at the same time. The feed boxes were made to a size that there will be no competition to the same fodder. Pre weighed fresh fodder was supplied every four hours from 06.00 - 20.00 hr. Each time when fresh fodder was introduced, the refusals of the previous supply was removed and weighed. The group intake was calculated by the difference of fodder offered and refused. The preference were ranked according to dry matter intake on unit body weight basis.

Results and Discussion

All fodder species used in this study exhibited a successful coppice dry biomass yield in subsequent harvests. The rate of regeneration was rapid in *G. sepium, T. diversifolia* and *F. macrophylla*. However, the other species caught up during the latter part of the growth period. The leaf dry matter yield (LDMY) of the fodder ranged from 86±12 kg. (*D. ransonii*) to 276±23 kg. (*E. verigeta*) (Table I). The low LDMY in *D. ransonii* was due to the small plant structure and low leaf density associated with low DM (224±18 g/kg.). *Calliandra calothyrsus* also exhibited a high LDMY (264±10). Both non leguminous species, *T. diversifolia* and *M. alba,* were much superior in LDMY (146±22 and 143±16, compared to leguminous species, *L. leucocephala* and *F. macrophylla* (118±18 and 110±15 kg. respectively).

The DM content of fodder species ranged from 457±16 g/kg. (*L. leucocephala*) to 223±20 g/kg. (*T. diversifolia*). *Calliandra calothyrsus* and *F. macrophylla* were in the upper range of DM (Mean 315 g/kg) and *D. ransonii, G. sepium, E. verigeta, T. diversifolia and M. alba* in the lower range (mean 239 g/kg). This high DM in *C. calothyrsus* and *F. macrophylla* attributed to thick leaf structure associated with well developed and lignified vascular system (Perera, 1994b). The total ash content of the fodder ranged from 52±6 g/kg. (*F. macrophylla*) to 84±7 g/kg. (*D. ransonii*) with a mean value of 68 g/kg. These results were in agreement with results previously reported by Perera (1990) and Rajaguru (1990). High ash content of fodder play a vital role in satisfying the mineral requirement of ruminant livestock feeding on these fodder (Rajaguru, 1990).

Both the leguminous and non leguminous fodder species exhibited a high CP content, which is above 200 g/kg. This is similar to commonly used concentrate; Coconut oil meal (200 - 220 g/kg. CP). The CP content of fodder species ranged from 210±21 g/kg. (*F. macrophylla*) to 270±32 g/kg. (*C. calothyrsus*). The non leguminous species *T. diversifolia* and *M. alba* also exhibited a high CP content (241±18 and 212±20 g/kg, respectively) even higher than the leguminous species *F. macrophylla* (210±21 g/kg). In mid country *T. diversifolia* is a major contributor to the roughage feed supply in small holder dairy sector. These feed resources come from road sides and other waste lands (Perera, 1994b). This observation was made by many investigators. Jayawardane and Perera (1991) reported the high potential of *T. diversifolia* as a green feed and its high utilization when used as a supplement or as a sole diet in goats. Ether extract of all fodder were within the reported values by Perera (1990) and Rajaguru (1990). *Flemingia macrophylla* and *E. verigeta* showed a high CF content (387±23 and 303±17 g/kg.) and is clearly evident by the coarse nature of the leaves. In all fodder species the NFE was satisfactory and comparable to reported values by Rajaguru (1990) and Jayawardane and Perera (1991). This high NFE will provide substantial amount of fermentable organic matter for a satisfactory microbial activity (Perera et al., 1992).

Tree and shrub fodder is generally higher in ADF compared to pasture and fodder grasses. The high ADF in tree fodder is mainly due to the present of highly developed vascular system in the leaves and high proportion of fibrous petioles. The ADF of tree fodder ranged from 308±24 (D. ransonii) to 484±20 g/kg (*F. macrophylla*) (Table II). Similar value were reported by Perera (1994a) and Rajaguru (1990). In cell wall components, Cellulose and ADL exhibited a negative relationship. *Flemingia macrophylla* exhibited the lowest cellulose and highest ADL content. This is due to the presence of highly developed and well distributed vascular system in the leaves and, long and fibrous petiole, which is also a characteristic of E. verigeta. Despite the high ADL content in *F. macrophylla*, also had a very low AIA (7±1.1 g/kg). In other fodder tested the AIA was comparable to reported values. (Perera and Weerakoon, 1992).

Lowest IVDMD was observed in *F. macrophylla* (466±124 g/kg.). This was due to the presence of high ADL, low Cellulose, CP and NFE. Similar observations were reported in previous work (Perera, 1994a). All other fodder species had a IVDMD of above 500 g/kg. High IVDMD of certain tree fodder were reported by many others (Jayawardane and Perera, 1991., Perera, 1990). Due to high digestibility and high CP content, these fodder can be well used in greater proportions by the small holder livestock farmers to feed their livestock, which is mainly obtained from either naturally growing conditions in waste lands and road sides or grown as fence lines, support for pepper, shade for cocoa and tea.

Despite the feeding value of the fodder, it is also important to understand how these tree fodder are broken down in the rumen of the animals, which is a better estimate to evaluate the potential of nutrient utilization. For this reason, many in vitro methods have been suggested to predict the utilization such as solubility in buffers, mineral solutions and in autoclaved rumen fluid (Crooker et al., 1978) and by gas production technique (Blummel and Orskov, 1993). In addition,

estimates also done by using nylon bag technique by incubating fodder samples in the rumen for different incubation periods (Mehrez et al., 1977).

The degradation characteristics of DM in the rumen suggested that the *G.sepium* had the highest Rapidly Degradable Fraction (a) of 42.4% and with the lowest in *F. macrophylla* (24.4%), (Table III), which has been confirmed by Perera et al., (1992) and Yaparatne et al., (1993). The Potentially Degradable Fraction of the DM (b), ranged from 22.3% (*F. macrophylla*) to 64.7% (*T. diversifolia*). In *T. diversifolia*, 83.0% and in E. verigeta 72.6% of the DM was degraded within 24 hrs. In all tree fodder (except *F. macrophylla* 35.5% and *C. calothyrsus*, 45.1%) the DM disappearance within 24 hrs was >50% indicating high level of fermentable organic matter in these fodder species. This will result high rate of microbial protein synthesis if proper nitrogen concentrations are provided in the rumen (100 mg N/1000 ml, Rumen fluid) (Hoover, 1986). The low level of DM disappearance of *F. macrophylla* may be due to the presence of high tannin and ADL contents (Perera, 1994a). Due to the high degradation of the potential insoluble fraction, these tree fodder could be consider as high potential green feed to be use as supplements in ruminant rations with substantial proportions (Yaparatne et al., 1993).

Solubility of nitrogen is the key factor that determines the rate of microbial activity. The optimum level of ammonia nitrogen in the rumen for efficient microbial activity has been estimated as 100 mg N/1000 ml. rumen fluid (Hoover, 1986). *Gliricidia sepium* showed the highest soluble nitrogen (a) in the rumen (59.1%)(Table IV). Both the soluble and potentially soluble nitrogen of *F.*