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BIOMASS YIELD, NUTRITIVE VALUE AND SELECTIVITY OF HEDGEROW SPECIES GROWN IN WEATHERED ACID SOILS OF SRI LANKA

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ABSTRACT

Major portion of the mid country soils are heavily eroded and weathered with a very thin topsoil. Shrub species are grown as hedgerows to control further soil erosion. These hedgerows provide high quality fodder to feed livestock, whereby the small holder land owners gain an additional income from livestock products. In hedgerows *Gliricidia sepium, Calliandra calothyrsus, Erythrina verigata, Desmodium ransonii, Flemingia macrophylla, Sesbania grandiflora, Tithonia diversifolia, Morus alba* were planted as double hedgerows at 7 meters apart. Lopping was done at 12 week intervals for one year. Yields were estimated on 100 meter linear length per year. Highest leaf dry matter yield (LDMY) was observed in *E. verigata* (302 " 18 kg) and the lowest in *D. ransonii* (92 " 14 kg). The crude protein (CP) content of leguminous fodder was highest in *C. calothyrsus* (26 " 3.4%), whereas in non legumes in *T. diversifolia* (24.9 " 3.4). All species showed a acid detergent fibre (ADF) content of >30% and an acid detergent lignin (ADL) content between 7.5 " 1.2 to 24.1 " 6.5%. *Invitro* dry matter digestibility (IVDMD) of all species were >50%, except F. macrophylla (44.7"3.7). The total degradable fraction (a+b) was highest in *T. diversifolia* (94.1%), except *F. macrophylla* and *C. calothyrsus*, all fodder species had a total degradable nitrogen of >70%. The highest acceptance by goats was *M. alba* (48g/day/kg BW) and the lowest was *F. macrophylla* (20g/day/kg BW). This suggest that both leguminous and non legume species can be successfully grown in sloppy acid soils and provide quality biomass which are highly nutritious and accepted by livestock.

Key words: Hedgerows, Fodder, Nutritive value, Acceptance, Digestibility

INTRODUCTION

Mid country of Sri Lanka, which situated within the elevations of 300 - 1500 meters and receives an annual rainfall of 800 - 1500 mm. Some lands of this region are under traditional home garden systems, which is also known as Kandyan forest gardens, one of the oldest agro forestry systems in Asia. Much of the land was under tea plantations and these slop tea lands were subjected to gradual degradation in soil fertility and due to excessive surface soil erosion. After many decades, the productivity of these lands started to diminish and became marginal. Later under different settlement programs these lands were allocated to landless peasants as small blocks with an average extent of 0.5 - 1.0 ha. The major crops grow by the farmers are tobacco and vegetables demands intense land preparation and weeding. Both these conditions induce severe erosion. To control the soil erosion and to improve the soil fertility, >Slop Agricultural Land Technology = (SALT) was introduced to these lands with leguminous and non-leguminous species as live hedges. The leaf biomass produced were used between the inter row space as a live mulch and a source of green manure. The biomass produced by these hedge species was in excess and often wasted. In addition the income obtained from the cash crops was seasonal and inadequate to meet the basic family needs. Therefore, it became important to find an alternate source of income to alleviate the poverty. Therefore, to improve the income source and to maximize the utilization of leaf biomass produced, a livestock component was introduced to this

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farming system (Simple Agro Livestock Technology or SALT). Inclusion of livestock component into this production system not only generate additional income but also make benefits to the soil by recycling plant nutrients through addition of animal wastes as urine and dung. This has become a very successful method among the farmers, but no work has been conducted in Sri Lanka to evaluate the biomass production by different hedge row species under these conditions, their feeding value and preference for these fodder species by ruminant livestock.

MATERIALS AND METHODS

An experiment was conducted in a typical small-scale farm in the mid country intermediate zone of Sri Lanka, where the annual rainfall is between 800 - 1500 mm. The soil type of the experimental location was Reddish Brown Latersolic and Immature Brown Loam, with a soil pH of 5.0 - 5.5. The hedgerows of *Desmodium ransonii, Calliandra calothyrsus, Leucaena leucocephala, Flemingia macrophylla* and *Sesbenia grandiflora* were established on the contour by direct seeding and after 6 weeks of germination the excess plants were thinned to maintain a within a row spacing of 25 cm. *Gliricidia sepium, Erythrina verigata, Tithonia diversifolia* and *Morus alba* were planted using stem cuttings with a spacing within a row of 25 cm. All species were planted as double rows with an inter row spacing of 45 cm. The length of each hedgerow was about 60 - 75 m and each species had at least three rows. The hedgerows were allowed to grow through two monsoonal rainy seasons with light lopping prior to the initiation of the data collection. During the experimental period the hedgerows were lopped on a 12 week lopping cycle over a period of one year. At each lopping the total edible biomass yield was estimated which included leaves petioles and tender twigs. At each recording of biomass a sub sample was taken for dry matter determination and chemical analysis. The dried samples of all lopping were composited by species and were ground to pass a 2 mm sieve.

The ground samples were then analyzed for proximate composition (A.O.A.C., 1990), cell wall constituents (Goering and Van Soest, 1970) and acid insoluble ash (AIA) (Keulan and Young, 1977). *Invitro* dry matter digestibility (IVDMD) was determined using the *invitro* two stage technique (Tilley and Terry, 1963) using rumen fluid from goats feeding on *ab libitum* fresh *Brachiria brizantha* grass and coconut oil meal at the rate of 15 g per kg $BW^{0.75}$.

Six male, castrated and ruminally cannulated goats feeding on the same diet were used for the nylon bag study. Five grams of each composited ground fodder sample placed in the nylon bags (7 X 13 cm) with a pore size of 61 mm) and incubated for the time periods of 8, 16, 24, 48 and 72 h. Once the bags were withdrawn at the respective time interval, they were thoroughly washed and dried at $60c^{o}$ in an forced draft oven until a constant weight was attained. Both dry matter (DM) and organic matter (OM) were estimated in the residue.

The disappearance of dry matter and nitrogen was calculated and the results were analyzed by non-linear regression (SAS, 1985), using $p = a + b\ (1\text{-}e^{-ct})$ exponential equation. (Mehrez and Ørskov 1977); where

p = Degradability at time t (%)
a = Soluble fraction (%)
b = Insoluble but potentially degradable fraction (%)
c = Fractional rate of degradation (% / hr)
a + b = Potential Degradability (%)
t = Incubation period (hrs)

Another experiment was carried out to investigate preference for fodder species when offered free of choice. This study was done by using the *"Cafeteria method"* where individual fodder species were provided separately at the same time so that the animals have the free access to any fodder type free of choice. Eight goats (average BW 15 " 1.3 kg) were stalled in a large pen and different fodders were provided in separate feed boxes. The feed boxes were made into a size that there will not be any competition for the same fodder. Pre weighed fresh fodder

was supplied every four hours. Every time when the fresh fodder was introduced the leftovers of the previous feed was removed and weighed to estimate the intake. The group intakes were calculated by the difference of total offered and total refused. The preference was ranked according to the 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 the subsequent harvests. Highest initial regeneration was *in G. sepium, T. diversifolia* and *F. macrophylla*. However, the other species picked up the growth during the latter part of the growth period. The LDMY of the fodder species (Table 1), ranged from 90 "14 kg (*D. ransonii*) to 302 "18 kg (*E. verigata*). The low LDMY of *D. ransoni* was due to the low leaf density, small plant structure associated with low dry matter (24.0 "2.6 kg) content. Both *C. calothyrsus* and *G. sepium* produced substantial LDMY (288 "12 kg and 230 "14 kg, respectively) which is also comparable to *E. verigata*. Among the non-leguminous species *T. diversifolia* (146 "14 kg) and *M. alba* (155 "16 kg) was much superior to some leguminous species especially to *L. leucocephala* (95 "12 kg). This low LDMY of *L. leucocephala* was due to its low tolerance to the acid soils. However the low LDMY of *F. macrophylla* (118 "10 kg) and *S. grandiflora* (112 "14 kg) was due to its low leaf density.

The highest leaf DM was found in *L. leucocephala* (43.2 "4.3 %) and lowest in *T. diversifolia* (23.2 "3.6%) and *D. ransonii* (24.0 "2.6%). High DM of *E. varigata* and *L. leucocephala* attributed to thick leaf structure associated with well developed and highly lignified vascular system (Perera, 1994b). Al the fodder species had a total ash content ranging from 8.4 " 1.2 (*D. ransonii*) to 4.8 " 1.3 (*S. grandiflora*), with an average value of 6.9 " 1.6. The CP content of both non leguminous and leguminous tree fodders was > 20% (22.3 " 2.2 to 26.4 " 2.4%) except *M. alba* (18.4 " 3.5). These CP values were similar to the commercial protein supplements used (coconut poonac; CP = 20%) to feed ruminants in Sri Lanka. Therefore, the nitrogen contributed by these tree fodders was sufficient to maintain an optimum rumen ammonia nitrogen level (200 mg/l) for an efficient microbial activity. In addition to nitrogen, these tree fodders also provide enough FOM for better utilization of the soluble rumen nitrogen. Jayawardane and Perera (1991) reported of the high potential of *T. diversifolia, E. verigata* and *L. leucocephala* as a green feed and its high utilization when used as a supplement or as a sole diet for goats. The other proximate components such as EE, CF and NFE were at a satisfactory level and comparable with the values reported by Perera (1990), Rajaguru (1990) and Jayawardane and Perera (1991). Tree fodders are generally high in cell wall constituents compared to pasture grasses and legumes. This is due to the presence of highly lignified vascular system and inclusion of large proportion of other edible parts such as petioles, twigs and even barks. The ADF of the tree fodders ranged from 30.6 " 4.5% (*D. ransonii*) to 47.9 " 2.1% (*F. macrophylla*) with an average value of 35.7% (Table 2). The cellulose content of all the species were close (about 25%) except in *C. calothyrsus* (32.4 " 3.2%) and *F. macrophylla* (36.1 " 4.5%). The ADL fraction was highest in *F. macrophylla* (24.1 " 6.5%) and lowest in *E. verigata* (7.5 " 1.2%). The ADL of *D. ransonii* is similar to *E. verigata* (8.3 " 1.4%). The values observed were comparable to the values reported by Perera (1990, 1994a) and Rajaguru (1990). The IVDMD of *F. macrophylla* was very low (44.7 " 3.7%), whereas the other species were above 50% (range 52.3 " 5.6 to 78.8 " 10.3%). Therefore, these tree fodder species provide quality green forage compared to many roughage feeds used for ruminants. These feed resources become very important during dry season when the only life saving feed becomes rice straw. Under these circumstances tree fodder play a significant role as a supplement to bridge the nutritional gap.

The bioavailability of nutrients is more important than the physical quantity present. The behavior and the rumen kinetics associated with the breakdown and utilization

of nutrients in the gastro intestinal tract provide a better estimate of nutrient utilization. For this reason, many in vitro techniques were suggested such as solubility in buffer solutions (Crooker *et al.*, 1978) and gas production technique (Blummel and Ørskov, 1993). Nylon bag technique (Mehrez, 1977) is another reliable method of evaluating the degradation characteristics of feed incubated in the rumen. The degradation characters of rumen suggested that *T. diversifolia* and *G. sepium* had a high soluble fraction ('a') compared to other tree fodder species (45.4% and 42.4%, respectively). Except *F. macrophylla* (23.6%) and *D. ransonii* (25.4%), the other species had an 'a' fraction .30%. When these tree fodders with a high 'a' is fed to ruminants, in the rumen the available FOM is improved leading to efficient microbial activity. The values for 'a' fraction reported in this study has been confirmed by Perera *et al.*, (1992) and Yaparatne *et al.*, (1993) in their previous studies. The insoluble but potentially degradable fraction ('b') of dry matter is high in all tree fodder species (>30%) except *F. macrophylla* (23.7%). Considering the total degradable fraction (a+b), 94.1% DM of *T. diversifolia* disappeared within 72 hrs. This can be further confirmed by its high IVDMD (98.8%). In addition to *T. diversifolia*, *E. verigata*, *G. sepium* and *M. alba* also had a total degradable dry matter of >70% (79.4%, 73.8% and 81.7%, respectively). These indicate the high rate of degradation of dry matter in the rumen allowing a high FOM in the rumen. These results were comparable with the results of Perera *et al.*, (1992) and Yaparatne *et al.*, (1993).

Availability of fodder nitrogen in the rumen play a vital role in nutrient utilization and microbial activity in the rumen. Since these fodders are used as protein supplements in ruminant diets, their contribution of nitrogen to the rumen becomes very important. *G. sepium* (59.1%) and *E. verigata* (52.6) had the highest soluble nitrogen fraction ('a') in the rumen. This implies that their ability to provide soluble nitrogen to the microbes were rapid compared to other tree fodder species tested. The lowest 'a' for nitrogen was observed in *C. calothyrsus* (6.7%). This may be due to the presence high tannin in this species and however, further evidence is necessary to confirm this statement. The 'a' for nitrogen of *F. macrophylla* was low (14.6%), but higher than *C. calothyrsus*. The other species exhibited a moderate level of 'a' fraction and the values were comparable to the earlier results of Perera *et al.*, (1994b). In contrast, the potentially degradable fraction for nitrogen of *C. calothyrsus* was higher (31.8%), but lower in *F. macrophylla* (9.2%). Although the 'a' fraction for nitrogen of *G. sepium* was much higher than that for *C. calothyrsus*, the 'b' fraction for nitrogen of *G. sepium* was lower than *C. calothyrsus* (29.6%). This may be because most of the nitrogen in the *G. sepium* was in the soluble form and readily solubilized in the rumen soon after ingestion. The total degradable nitrogen fraction (a+b) of *T. diversifolia* was superior to any other tree fodder species tested. 94.1% of the total DM and 99.3% of the total nitrogen of *T. diversifolia* completely disappeared in the rumen within 72 h of incubation. Similar results for *T. diversifolia* has been reported by Yaparatne *et al.*, (1993). However, much of the nitrogen degraded and absorbed through the gastro intestinal tract is removed as urea in urine resulting a low net retention (Jayawardane and Perera, 1991). All fodder species except *C. calothyrsus* (38.5%) and *F. macrophylla* (23.8%), contribute more than 70% of the total nitrogen into the rumen within 72 hrs. This was a clear indication that the tree fodders could be successfully used as protein supplements for ruminants. However, in tree fodder the availability of FOM and nitrogen depend on the extent of degradability. This can be highly influenced by the presence of deleterious substances or plant secondary metabolites. These deleterious substances are commonly found in many tree fodders and some examples are tannin, coumarin, saponin etc. Presence of these deleterious substances not only influences the nutrient utilization but also restrict the feed intake. No matter nutritionally how superior the fodder is if the acceptance by the animal is low. Therefore, evaluating of these trees fodder for their preference by ruminants also important.

The information on the preference and the dry matter intake of different fodders

by goats is given in table 5. The most palatable tree fodder for goat was *M. alba* (48g/kgBW) and the least was *F. macrophylla* (20g/kgBW). High preference for *M. alba* may be due to the succulency and the taste due to the presence of oxalic acid. For goats, the recommended DM intake was 3 - 4 of their body weight (Devendra and Burns, 1983). Except *C. calothyrsus, S. grandiflora* and *F. macrophylla* (2.5, 2.2 and 2.0 kg/100kg BW), rest of the fodder species had a DM intake of >3.0 kg/100kg BW. The order of preference was highest for *M. alba* and lowest for *F. macrophylla*. Certain tree fodder species were highly palatable when they are fresh. The animals relish. But once they are wilted or dry the preference was tended to decrease. This may be due to some chemical changes taking place during the drying. One good example is *G. sepium*; the local land race, when it is offered fresh, ruminants relish without hesitation. But the wilted form or dried form is completely rejected (Perera, 1992). However other than *G. sepium*, other tree fodders were equally accepted either dried or wilted.

Finally, inclusion of both leguminous and non leguminous tree fodder species in marginal lands with acid soils will improve the soil fertility and crop productivity by addition of plant nutrients and reducing the soil erosion. The excess biomass provides an excellent fodder for ruminant livestock making avenues for sustainable integration. These provide additional income to the resource poor farmer to uplift his economic and living standards.

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