ESTABLISHMENT OF DATABASE FOR COMMONLY USED FODDER VARIETIES IN BENGALURU

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CERTIFICATE

This is to certify that the thesis entitled ***"ESTABLISHMENT OF DATABASE** for commonly used fodder varieties in **BENGALURU"*** submitted by **Mr. UDAY KUMAR, I.D. No. MVHK 1508** for the award of degree of **MASTER OF VETERINARY SCIENCE** in **LIVESTOCK PRODUCTION AND MANAGEMENT** of the Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, is a record of research work carried out by him during the period of his study in this University, under my guidance and supervision and the thesis has not previously formed the basis of the award of any degree, diploma, associate ship, fellowship or other similar titles.

Place: Bengaluru
Date: August, 2017

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Affectionately Dedicated to

My Parents, Family &

Friends.

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Bengaluru ***(UDAY KUMAR)***

CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

Abbreviation		Description
ADF	-	Acid Detergent Fibre
ADFA	-	Acid Detergent Fibre Ash
ADL	-	Acid Detergent Lignin
ADS	-	Acid Detergent Solution
CFM	-	Compound Feed Mixture
CP	-	Crude Protein
DM	-	Dry Matter
DOMDM	-	Digestible Organic Matter on Dry Matter
EE	-	Ether Extract
FAO	-	Food and Agriculture Organization
FMS	-	Finger millet straw
ft	-	Feet
g	-	Gram
GOI	-	Government of India
ha	-	Hectare
Kg	-	Kilogram
L	-	Liter
ME	-	Metabolizable Energy
MJ	-	Mega Joule
MT	-	Metric Ton
NDF	-	Neutral Detergent Fibre
NDFA	-	Neutral Detergent Fibre Ash

NDS	-	Neutral Detergent Solution
OM	-	Organic Matter
RIVGP	-	*Rumen in-vitro gas production*
t	-	Ton
t/ha/yr	-	tonnes per hectare per year
TA	-	Total Ash

Introduction

I. INTRODUCTION

Livestock production has been considered a pro-poor enterprise owing to its income and employment generation potential and adoption among small holders, who constitute two thirds of the Indian rural household (Birthal and Jha, 2005). Although India ranks first in milk production and third in small ruminant production in the world, the production efficiency has been very low due to the low genetic potential of the livestock and the low feed resource availability (FAO, 2016). Considering the fodder resource, India has been facing a deficiency of green fodder by 61.1 per cent and dry crop residues by 21.9 per cent (GOI, 2016). The deficiency is aggravated due to the ever increasing demand of the arable land used for cultivation of food crops, which further shrinks the available land for fodder production. In this situation of dwindling land resource availability and fodder scarcity, efficient and judicial use of available arable land becomes vital from the point of producing good quality fodder with optimum levels of productivity. Therefore, knowledge on the agronomy of fodder production with updation of information on the genetically evolved high yielding varieties of fodder will be the prime need for efficient ruminant production.

Animal scientists have been continuously striving for upgrading the production potential of the livestock and improving the productive efficiency. This has resulted in the demand for better nutrition for livestock to achieve maximum potential. In this context, availability of quality green fodder plays a significant role for sustaining livestock farming and improving productivity of animals. Thus, Information on the fodder resource, agronomical practice, yield and chemical composition of different fodders in a given region will be of paramount importance.

Considering the feeding management systems of dairy cattle and small ruminants, the major fodder resource has been the crop residues of which, rice straw based diets are widely used. Generally, these crop residues have a very low nutritional value with low intake, energy and the protein content, and considered as non-maintenance type of roughages. Therefore, feeding of dairy cattle or fattening lambs necessitates supplementation of good quality green forage or leguminous fodder in the diet, especially at greater levels of production. Providing green fodder, both legume and non-legume, as a component of the ruminant diet not only sustain health and production, but can also evolve economic feeding management systems.

Fodder production forms a major component of dairy cattle and sheep production management. The quality and quantity of fodder are influenced by the type of soil and stage of growth (Yar and Waheed, 1991; Kim *et al.*, 2001). Fodders available for feeding livestock differ in their chemical composition depending on factors such as the variety of fodder, composition of soil, type of fertilizer, irrigation pattern, harvesting pattern and stage of maturity at the time of harvest. Legume plants utilize nitrogen available in soil due to presence of nitrogen fixing bacteria in their roots called rhizomes, at the same time will improve the soil quality. While the legume fodders provide a source of protein to the nutrition of livestock, non-legume forages supplement energy and bulk to the diet.

Karnataka is the second state next to Rajasthan in terms of total geographic area which is drought prone. Out of twenty nine districts of Karnataka, six districts belong to adequate feed dry matter available category with the mean availability of 87.51 per cent while five districts belonging to moderately adequate and the remaining eighteen districts belong to the deficient feed available categories. The mean feed dry matter availability in Karnataka state is 56.46 per cent (GOI, 2016). Bengaluru is located in the eastern dry zone region at an elevation of 900 m above mean sea level with an annual rainfall ranges from 679 to 889 mm. The type of soil is been red loamy in major areas with lateritic in remaining areas. The main crops cultivated being Ragi, Rice, Pulses, Maize and Oil seeds.

A major consideration in a dairy farming or small ruminants rearing will be the agronomy of fodder production. Health, growth and productivity of livestock primarily depend on the feed and fodder component of the diet and the plane of nutrition. Therefore, the farmers need to learn about the cultivation of high yielding and good quality type of fodders suitable for their geographic areas. Keeping this in view. Department of Livestock Production and Management, Veterinary College, Karnataka Veterinary Animal and Fisheries Sciences University, Bengaluru has established a fodder museum having many verities of fodder crops. The fodder museum provides training to livestock owners on the package of practices on the cultivation of various fodders and also supply seeds or root slips of fodders on a limited basis.

Establishment of a data base on the nutritional value of all the different types of fodders available in a geographical area should be mandatory, which could be handy to the farmers or Animal scientists to plan a feeding programme or compute ration for the livestock. Generation of such data on different fodder varieties and chemical composition will provide vital statistics to formulate and balance feeding management scientifically and efficient use of available feed resources. Nevertheless, it should be a continuous process to generate the database. Finally, establishing a database on fodders would be beneficial to livestock owners, planners and all the stake holders involved in livestock production activities. With an objective of establishing a database on the nutritional value of commonly used fodder varieties in Bengaluru, this study has been taken up. Specific objectives of this study are:

1. To determine the dry matter yield of five each leguminous and non-leguminous fodder varieties.
2. To evaluate the chemical composition of the fodder varieties (10 varieties).
3. Rumen in vitro gas production (RIVGP) to determine the metabolizable energy (ME) content of the fodder varieties.

Plate 1.1: Fodder Museum at Department of Livestock production and management

Review of Literature

II. REVIEW OF LITERATURE

Fodder is an agricultural term for animal feed and fodder crops are those plants that are raised to feed livestock. At present, the country faces a net deficit of 61.1% green fodder, 21.9% dry crop residues and 64% concentrate feeds. The livestock is the sub-sector of agriculture sector which adds almost 32% of Agriculture output in India (Vision 2030, 2015).

The projected livestock population estimation in India are based on 2012 livestock census. Government of India, which shows the increasing rate of livestock population. So it is important to maintain the sustainability in livestock feed and fodder but presently the nation is facing the shortfalls of livestock feed and fodder.

An assessment was made based on the availability and requirement of fodder as dry matter (DM) in each district. Secondary data of crop production, land utilization and livestock census data were used along with the primary data collected through pre-tested interview schedule. Out of twenty nine districts of Karnataka, six districts belonged to adequate DM available category with the mean availability of 87.51%. Five districts belonged to moderately adequate and 10 districts belonged to deficient DM available categories. However, one in every four districts belonged to severely DM deficient category. The mean DM availability for the state was 56.46%. Total contribution of crop residues to DM in the state was 72.59% with coarse straw contribution being one third of it (Nagaratna *et al.*, 2013).

2.1 Classification of fodders

Fodder can be defined as food stuff provided to farm animals for their better development and productivity (Rao, 2004).

1. Based on their life time
   a. Annuals: seasonal crops (pertaining to one season or year).
   b. Perinnials: remain more than one year on the field.

2. Based on their nutritive values
   a. Leguminous fodders
   b. Non-leguminous fodders

2.1.1. Leguminous fodders

Leguminous fodders are dwarf with dense foliage and less yield compared to non-leguminous fodders with an average crude protein of 12-16 % on dry matter basis, require less fertilizer as they are capable of fixing the atmospheric nitrogen because of symbiotic association with Rhizobium- an anaerobic bacterium (Rao, 2004).

2.1.2. Non-leguminous fodders

Non-leguminous fodders are usually tall growing crops with heavy foliage and higher biomass yield compared to leguminous fodder crops having an average of 5-8 % of crude protein requiring higher amount of fertilizers as compared to leguminous fodders as they do not have the capability to fix the atmospheric nitrogen (Rao, 2004).

Bengaluru belongs to eastern dry zone which consists of an area of 1.808 Mha. The annual rainfall ranges from 679.1-888.9 mm about 50% of rainfall receives during the kharif season. The elevation ranges between 800- 900 m and the soil are red loamy in major areas, lateritic in remaining areas. The main crops are Ragi, Rice, Pulses, Maize and Oil seeds. In winter temperatures rarely drop below 14 **°C** and summer temperatures seldom exceed 36 °C. Bangalore receives about 970 mm of rain annually.

Review of literature for the topic establishment of data base on commonly available fodders in Bengaluru is detailed under the following sub-headings:

2.2. Cultural practices of different fodder varieties

2.2.1. Leguminous fodders

2.2.1.1. Field preparations

Plough twice with an iron plough and three or four times with country plough to obtain good tilth	*Medicago sativa* (Lucerne)
Plough two to three times with an iron plough to obtain good tilth	*Sesbania grandiflora*
Plough the field two to three times to obtain good tilth	*Stylosanthes hamata*

(IGFRI, 2011)

2.2.I.2. Row spacing

The highest biomass of Moringa crop was obtained when it was planted in narrow spacing (5-15 cm) because the number of leaves produced per plant increased with time (Newton *etal.,* 2006).

Water soaked seeds of *Medicago sativa* (Lucerne) are sown in shallow furrows at row distance of 30 cm by seed -drill or *kaira* at sufficient soil moisture (IGFRI, 2011).

Seeds of *Medicago sativa* (Lucerne) can be directly sown at sowing depths of 1-2.5 cm, although deeper sowing may be necessary in sandy soils in dry areas to ensure sufficient water for germination (Froche, 2016).

Macroptilium atropurpureum (Siratro) seeds are sown in July after first heavy shower either in line at 50 cm space or broadcast. Sowing depth is 1.0 - 1.5 cm (IGFRI, 2011).

2.2.1.3. Irrigation requirement

Rao (2004) suggested an average irrigation requirement of 40-50 mm depending on the fodder variety and recommended the irrigation interval of 7-10 days in summer and 15 days in winter season.

To attain good germination, pre-sowing irrigation is essential. The leguminous crop needs very frequent irrigation during its early growth period at an interval of about one week but once the plants are established, subsequent irrigations are provided at an interval of 15-20 days during winter and 10-12 days during spring and summer seasons. Proper drainage should be ensured to avoid waterlogging in rainy season (IGFRI, 2011).

2.2.1.4. Seed Rate

In case of *Medicago sativa* (Lucerne) seed rate depends upon method of sowing and type of the crop, *i.e.*, pure or mixed stands. In broadcast method, a seed rate of 20-25 kg/ha should be used while line sowing needs only 12-15 kg/ ha but in case of intercropping, it requires only 6-12 kg/ha (IGFRI, 2011).

Duke (1983) suggested seed rate of 12-20 kg/ha in broadcasting method and 10-12 kg/ha when sown on ridges in case of *Medicago sativa* (Lucerne).

The optimum planting density (250,000 plants ha-1) for Moringa crop was reported by Sanchez *et al.* (2006), which gave 80,200 and 17,600 kg ha-1 fresh and dry biomass per year respectively.

2.2.1.5. Fertilizer Requirement

Subavasugi *et al.* (2008) reported that the application of farm yard manure at the rate of 6.25 t ha-1, poultry manure 2 t ha-1, vermicompost 2 t ha-1 and foliar spray of panchagavya, 2 per cent; vermi wash 20 per cent and humic acid 0.1 per cent resulted in the maximum leaf area index of 1.88, 1.88 and 1.93 at 60, 90 and 130 days, respectively.

A heavy dose 120 kg P2O5/ha should be added in the establishment year and in later years 40 kg/ha of N should be applied every year for increasing the yield in fodder *Stylosanthes hamata* (IGFRI., 2011).

2.2.1.6. Weeding

Medicago sativa (Lucerne) takes a long time to establish and therefore heavy weed infestation occurs up to first cutting. The sowing in lines makes weeding easier. Trifluralin, @ 4 kg/ha should be applied before sowing for good harvest. The *akasbel (C use ma reflexa)* should be removed from the field and burnt. The *akasbel* should not be allowed to set seed in any case. During monsoon, one interculturing or weeding improves the crop performance (IGFRI, 2011).

2.2.1.7. Harvesting

The first cut should be taken at 55-65 days after sowing and the subsequent cuts may be taken at 30-35 days interval (IGFRI, 2011)

Newton *et al.* (2006) also reported that Moringa plants gave higher yields when harvested at cutting intervals of 35-40 days.

In another experiment they found that higher biomass can be achieved when the Moringa crop was harvested at a 75-day cutting interval by Sanchez *et al.* (2006).

2.2.2 Non-leguminous fodders

2.2.2.1 Field preparations

Plough with an iron plough once and with a country plough twice.	Fodder sorghum
Plough with an iron plough two to three times to obtain good tilth.	Hybrid Napier
Plough 2 to 3 times to obtain a good' tilth and form ridges and furrows at 50 cm spacing	Guinea grass

(Sankaran, 2003)

2.2.2.2 Row spacing

One rooted slip or stem cutting of hybrid Napier is planted at a depth of 3-5 cm on one side of the ridge at 75 x 30 cm spacing at the rate of 40000 rooted slips or stem cuttings/ha (IGFRI, 2011).

Root slips or stem-cuttings of hybrid napier variety COS are planted at a distance of 60 X 90 cm, 90 x 90 cm or 90 x 120 cm depending on the soil status and other inputs (Sankaran, 2003).

Avtar Singh and Kang (2005) studied seed rates (10, 15 and 20 kg ha-1) and method of sowing (20, 30 cm row spacing vs broad casting) on the herbage yield of multi-cut hybrid Bajra *(Pennisetum glaucum)* FMH3 and reported the use of various seed rates of 10, 15 and 20 kg ha-1 did not influence the herbage yield. But the method of sowing had the significant influence on the herbage yield. Line sowing of multicut hybrid Bajra produced significantly more herbage yield than broad casting. However, closer spacing of 20 cm gave the highest herbage yield than wider spacing of 30 cm.

Manjunatha *et al.* (2014) found the row spacing of 45 cm and 60 cm recorded significantly higher total green fodder and total dry matter yield as compared to 30 cm in COFS 31 which was 12.63 and 12.62 per cent higher compared to 30 cm row spacing. The higher yield in 45 cm row spacing was mainly due to significantly green fodder yield per m row and dry matter yield per m row.

2.2.2.3 Irrigation requirement

Andrade *et al.* (2005) observed that plants in the irrigated area obtained higher number of green leaves (5) in a short growth interval (51.1 days) compared to those of non-irrigated area (4.3 leaves in 68 days). The average leaf appearance rate was 0.14 and 0.07 leaf day-1 for the basal and aerial tillers respectively.

2.2.2.4 Seed Rate

CO 3 root-slips and stem cuttings supposed to be in fresh status and with 3-4 active tillers and two nodes, respectively. Approximately, 10,000 - 11,000 root slips (1500 kg) or 20,000 - 22,000 stem-cuttings (1600 kg) are sufficient for establishment of a 1-hectare crop as stated by Premaratne and Premalal (2006).

One rooted slip or stem cutting of hybrid napier is planted at a depth of 3-5 cm on one side of the ridge at 75 x 30 cm spacing at the rate of 40000 rooted slips or stem cuttings/ha in the month of mid-February to July (IGFRI, 2011).

2.2.2.5 Fertilizer Requirement

Jayanthi (2003) reported that hybrid Napier grass fertilized with adequate organic manure especially poultry manure (2.62% nitrogen, 2.8% phosphorus and 2.82% potash) produced higher yield than those applied with inorganic fertilizer.

Sidhy (2003) reported that application of 20 t/ha (or 2 kg/plant) of farmyard manure before plating grass cuttings had increased overall production of Napier grass crop.

Fertilizer application of 100 kg N and 60 kg P2O5/ha for multi cut sorghum and 80 kg N and 40 kg P2O5/ha for single cut sorghum is recommended (IGFRI, 2011).

Farm yard manure (FYM) application @ 15 t/ha is necessary along with 80 kg N + 20 kg P2O5 per hectare to obtain optimum green fodder production of rye grass as reported by Dhillon and Balwinder (2007).

2.2.2.6 Weeding

Sankaran (2003) advised first hand weeding on 20 * day after sowing, thin the seedlings and gap fill with the thinned out seedlings thus maintaining a spacing of 15 cm between plants. Second hand weeding may be done between 35-40 days after sowing if necessary.

2.2.2.7 Harvesting

If fodder sorghum is a single cut, it should be harvested at 60-65 days (50% flowering) after sowing and if it is a multicut, the first cut is 60 days after sowing and a second, 40 days after the first as stated by Sankaran (2003).

2.3. Biomass yield

2.3.1. Leguminous fodders

Duke (1983) seen that *Medicago sativa* (Lucerne) yield ranges from 5-75 MT/ha per year (with 8-12 cuttings per year).

The average green forage yield of *Medicago sativa* (Lucerne) was significantly ($P<0.05$) higher during winter (144.70qs/ha) than summer (89.92qs/ha) and rainy (74.7qs/ha) season with mean yield 103.10qs/ha as reported by Fernandes *etal.* (2005).

In Nicaragua, Sanchez *et al.* (2006) reported that the maximum Moringa fresh and dry biomass (100,700 and 24,700 kg ha-1, respectively) can be obtained using a cutting frequency of 75 days during the first year of the experiment.

The highest biomass of Moringa crop was obtained when moringa plants were planted in narrow spacing (5-15 cm) because the number of leaves produced per plant increased with time as observed by Newton *et al.* (2006).

Newton *et al.* (2006) also reported that moringa plants gave higher yields when harvested at cutting intervals of 35-40 days, while Sanchez *et al.* (2006) reported that higher biomass can be achieved when the moringa crop was harvested at a 75-day cutting interval. The difference between the findings of these researchers might be due to different climatic conditions of the study sites.

Morus alba also showed that longer cutting intervals gave better leaf yield in comparison to shorter cutting intervals (Barnes, 1999; Latt *et al.*, 2000; Tuwei *et al.*, 2003). The reduced yield at shorter cutting intervals of plants might be due to the reduction in nutrient assimilation, which affects the growth rate of plants by affecting the leaf development (Latt *et al.*, 2000).

In an experiment conducted by Sanchez *et al.* (2005) they found highest fresh yield of 88.0 Mg/ha at plant density of 750000 plants / ha compared to 80.2 Mg/ha in plant density of 250000/ha and 79.1 Mg/ha in plant density of 50000 / ha.

Sanchez *et al.* (2005) reported that in moringa cutting frequency of 75 days produced highest biomass yield of 100.7 Mg/ha compared to 75.3 Mg/ha and 71.4 Mg/ha in cutting frequency of 60 and 45 days, respectively.

Macroptilium atropurpureum (Siratro) produces an average green fodder yield ranges from 15 to 20 tones/ha and dry fodder from 3 to 5 tones/ha, respectively (IGFRI, 2011).

Jayaprakash *et al.* (2016) recorded biomass yields of Desmanthus and *Stylosanthes hamata* were 40 and 20 t/ha/yr, respectively on fresh basis.

The dry biomass yield of *S. hamata* was 3.14 and 2.83 t/ha, respectively during the lush and lean season, respectively as reported by Murugan *etal.* (2003)

According to Alalade *et al.* (2014) *Stylosanthes hamata* hamata significantly enhances biomass yield, tillers and leaf width of *Panicum.*

Stylosanthes hamata scbra produces a green forage yield of 45 t/ha where as another variety *Stylosanthes hamata* Phule Kranthi produces green forage yield of 25-30 t/ha (IGFRI, 2011).

Chatterji *et al.* (1995) observed *Stylosanthes hamata* humilis produced green forage yield of 7.5-10 t/ha in Ranchi and Kalyani region with optimum rainfall of 1300-1500 mm.

2.3.2 Non-leguminous fodders

Narayanan and Dabadghao (1972) reported annual yield of 135 to 215 tones per year per hectare in Napier varieties.

Gawali and Rao (1996) studied performance of fodder maize (African tall), sorghum (SSG), hybrid Napier (Co-1) and Guinea grass (Hamil). The two grasses were harvested at 55-65 days intervals, maize at 60-70 days and sorghum at 45 to 50 days. The average green fodder yield per harvest was 27.1, 15.2, 35.4 and 31.4 t ha-1.

Among Guinea varieties, yield of 24-30 tons per year per hectare was reported by Rao (2004). Bundel guinea-2 variety exhibited potential to produce 70-90 t/ha/yr of green fodder with 7.8% crude protein content in rain fed condition. However it has potential to yield upto 150 t/ha/yr as reported by Wasnik *et al.* (2014).

A significant increase in biomass accumulation with increased height and maturity in Napier grass and this is inversely related to nutritional quality as reported by AgangaeZrz/. (2005)

Jayanthi (2003), in India, observed that a CO-3 crop planted on furrow and buried gave the highest green fodder yield of 375.3 t/ha/ year while the lowest was recorded when the two nodal stem cuttings were planted vertically in ridges.

COFS-31 in the station trials, had accomplished a mean green fodder yield of 201 t/ha/ year as compared to check CO (FS) 29 (172.8 t/ha/yr) while the results obtained from On Farm Trials revealed that COFS-31 executed a mean GFY of 183 t/ha /year as against 161.2 t/ha /year in CO (FS) 29. The per cent increase in GFY over CO (FS) 29 was 16.3 and 13.5 respectively as quoted by lyanar *et al.* (2015).

Manjunath *et al.* (2014) observed that the row spacing of 45 cm and 60 cm recorded significantly higher total green fodder of 153.99 t/ha/yr, 149.29 t/ha/ year over 134.54 t/ha/yr in 30 cm row spacing, respectively and total dry matter yield of 36.28

t/ha/yr, 35.18 t/ha/yr over 31.70 t/ha/yr in 30 cm row spacing. This was 12.63 and 12.62 per cent higher compared to 30 cm row spacing in fodder COFS-29.

2.4. Chemical composition of fodder varieties

2.4.1. Leguminous fodders

2.4.1.1 Proximate analysis

Neeler (2011) observed increase in C.P. content may be increased availability of nitrogen and thereby increase uptake corresponding in increase in protein content of herbage.

The mean CP, EE, CF, TA, NFE, Ca and P in *Medicago sativa* (Lucerne) varieties as 21.6, 2.7, 24.6, 10.2, 40.5, 2.27 and 0.27 respectively. He also added RL-88 is the best variety of *Medicago sativa* (Lucerne) in all seasons as reported by Fernandes *et al.* (2005).

Unextracted and extracted leaves of Moringa consists of 251, 115 g/kg and 435, 100 g/kg of CP and Ash respectively (Makkar and Beckkar, 1996).

Moringa fodder leaves and stem powder contains about 7.6, 15.31, 3 and 12 per cent of DM, CP, EE and Ash respectively as observed by Nouman *et al.* (2013).

Jayaprakash *et al.* (2016) observed 34.12, 96.28, 13.90, 25.28, 2.53 and 3.72 per cent of DM, OM, CP, CF, EE and TA in *Stylosanthes hamata.*

Macroptilium atropurpureum (Siratro) comprises of about 14.71 and 13.31 per cent of crude protein and total ash respectively as reported by Njarui eZ *al.* (2003).

Devendra (1991) observed 22.6, 18.4, 2.1 and 9.3 per cent of CP, CF, EE and Ash respectively in *Sesbania gt'andiflora.*

2.4.1.2 Cell wall fractions

Mupangwa *et al.* (1997) observed 279, 416, 326, 92, 174 g/kg of CP, NDF, ADF, ADL, Ash respectively in oven dried *Macroptilium atropurpureum* (Siratro).

Njarui *et al.* (2015) reported 14.71, 43.86, 46.18 and 13.31 per cent of CP, NDF, ADF and Ash respectively in fodder Macroptilium atropurpreum (Siratro).

In an experiment Makkar and Becker (1996) found that 219, 474; 114, 163; 18, 22 g / kg of NDF, ADF and ADL in unextracted and extracted leaves of Moringa, respectively.

In an experiment Fernandes et al. (2005) reported 47.5, 38.0 and 8.3 per cent of NDF, ADF and ADL in fodder *Medicago sativa* (Lucerne) he also concluded that *Medicago sativa* (Lucerne) fodder showed lesser NDF, ADF and ADL during rainy season.

Nouman *et al.* (2013) reported 14.5, 16 and 12 per cent of CF, NDF and ADF respectively in fodder Moringa.

2.4.2. Non-leguminous fodders

2.4.2.1 Proximate analysis

A study conducted by Rao (2004) reported the chemical composition of Guinea grass varieties for CP. EE, CF, NFE Ash contents on dry matter basis as 5.2, 1.6, 34.4, 44.8 and 12, per cent, respectively.

Wadhwa and Dogra (2006) reported the chemical composition of Guinea grass as 11.7, 11.61, 39.05, 1.77 and 36.6 per cent respectively for CP, TA, CF, EE and NFE. They further reported the values for NDF, ADF, ADL, Hemicellulose Cellulose and Silica as 4.66, 5.30, 33.6, 36.10 and 3.20, respectively.

CO-3 grass contains 18-20 % DM, 15-16 % C.P., 9.8-12.8 % Ash, 34-37 % ADF and 74-78 % of NDF on dry matter basis as observed by Premaratne and Premalal (2006).

lyanar *et al.* (2015) observed nutritive value of COFS-31 as 25.9, 9.86, 19.80, 2.5 per cent, 172 ppm of DM, CP, CF, Crude Fat and HCN content, respectively.

Senthilkumar *et al.* (2009) observed COFS-29 constitutes of 8.39, 24.01, 2.62, 10.86 per cent of C.P, C.F, E.E, and total ash compared to COFS-27 with 8.35, 33.03, 1.89, 8.38 per cent of C.P., CF, EE and TA, respectively.

Crude protein contents increased significantly with increased nitrogen level up to 300kg (8.20 %) as compared to lower nitrogen level in fodder COFS-29 as stated by Manjunath *et al.* (2014)

Fodder BHN-18 is found to contain about 23.69, 5.48, 0.77 and 13.81 per cent of DM, CP, EE and TA respectively as stated by Jagadamba (2008).

2.4.2.2 Cell wall fractions

Gupta *et al.* (1983) recorded NDF and ADF of COFS-27 was 66.78 and 48.40 per cent respectively.

In an experiment they observed decrease in crude fibre content of fodder COFS-29 as increase in nitrogen level this may be due to increased crude protein content due to increase in nitrogen level as reported by Gupta *et al.* (1983).

Senthilkumar *et al.* (2009) found 18.38, 34.29 and 13.76 per cent of hemicellulose, cellulose and lignin content respectively in COFS-27 which were similar in comparison with Gupta *et al.* (1983) ;Gabra *et al.* (1989).

Fodder BHN-18 contains about 73.75, 48.92 and 8.75 per cent of NDF, ADF and ADE, respectively as recorded by Jagadamba (2008).

2.5. In-vitro gas studies

2.5.1 Leguminous fodders

Sanchez *et al.* (2006) observed CP content and IVDMD of Moringa was within the range of 193-264 g CP kg^{-1} DM and 648-790 g kg^{-I} DM, respectively, as reported for Moringa by Makkar and Becker (1996); Aregheore (2002); Al-Masri (2003) and Manh *etal.* (2003).

The metabolizable energy and organic matter digestibility predicted from the extent of fermentation in *in vitro* incubation were 9.2 MJ / kg and 75.7% for the extracted leaves and 9.5 MJ / kg and 74.1% for the unextracted leaves of moringa as stated by Makkar and Becker (1996).

Mupangwa *et al.* (1970) observed that the potential dry matter degradability ***(a + b)*** is a measure of the proportion of the legume DM that can be fermented in the rumen if the feed does not pass to the lower digestive tract before maximal degradation occurs. The potential DM degradation was high for lablab (842 g/kg DM) followed by cassia (779 g/kg DM) and the least for *Macroptilium atropurpureum* (Siratro) (746 g/kg DM).

Njarui *et al.* (2015) observed that velvet bean had the highest lignin content (10.05%) and consequently lower IVDMD (51.30%) than lablab (65.83%), glycine (62.31%) and *Macroptilium atropurpureum* (Siratro) (55.31%).

In a study conducted by Fernandes *et al.* (2005) they found that *in vitro* dry matter digestibility (IVDMD) was higher in winter (71.88 %) compared to in summer (70.84 %) and rainy (69.08 %) in *Medicago sativa* (Lucerne). Also concluded that RL-88 variety of *Medicago sativa* (Lucerne) has higher IVDMD.

Jayaprakash *et al.* (2016) reported Gross energy values for the leaves of the Calliandra, Desmanthus and *Stylosanthes hamata wav* 4506, 4053 and 4737 GE/Kcal/Kg/DM, respectively. The differences between the energy values for the Calliandra leaves are high compared to Desmanthus and *Stylosanthes hamata.*

2.5.2 Non-leguminous fodders

Feed sample	ME (MJ/kg)	TDN (%)
Maize	14.10	85.82
Jawar	13.76	83.97
Bajra	12.61	77.79
Hybrid napier CO 3	7.13	48.36
Hybrid napier CO 1	7.46	50.13
Guinea grass	7.53	50.53
Hybrid sorghum	8.02	53.17

Garg *et al.* (2012)

Plate 2.1: ***Medicago sativa*** **(Lucerne)**

Plate 2.2: ***Moringa oleifera***

Plate 2.3: ***Sesbania grandiflora***

Plate 2.4: ***Macroptilium atropurpureum*** **(Siratro)**

Plate 2.5: ***Stylosanthes hamata***

Plate 2.6: BHN-18 (Bangalore hybrid napier)

Plate 2.7: CO-5 (Coimbatore-5)

Plate 2.8: Phule-1

Plate 2.9: Bundel guinea

Plate 2.10: COFS-31 (Coimbatore fodder sorghum)

Materials and Methods

III. MATERIALS AND METHODS

In the present study five leguminous fodder crops i.e. Lucerne *(Medicago sativa), Moringa oleifera, Sesbania grandiflora, Stylosanthes hamata* and Siratro *(Macroptilium atropurpreum')* and five non-leguminous fodder crops i.e. BHN-18 (Bangalore Hybrid Napier), CO-5 (Coimbatore-5), Phule-1, COFS-31 (Coimbatore fodder sorghum) and Bundel guinea (Guinea grass) were established in triplicates in plots measuring 15’xlO’ at the fodder museum maintained under Department of Livestock Production and Management, Veterinary College, Hebbal, Bengaluru.

Seeds/root/stem cuttings of the fodder crops used for the experiment are planted, irrigated and harvested as per the standard agricultural practices (IGFRI, 2011). The total yield of all the varieties was determined for a period of one year.

The detailed procedures of materials and methods employed for carrying out the research is presented in the following stages.

1. Study of cultural practices employed
2. Biomass yield
3. Evaluation of chemical composition of fodder varieties.
4. *In vitro* studies

3.1 STUDY OF CULTURAL PRACTICES

3.1.1 Field Preparation

The field was ploughed twice with a tractor drawn cultivator and levelled. This is followed by the formation of bunds around each individual plots, which were levelled with spade manually.

3.1.2 Sowing/Planting

Stem cuttings having two nodes were used as planting material for the hybrid Napier and tree fodder varieties. The stem cuttings were placed into the soil at an angle of 45° and the slips were planted. The spacing between the stem cuttings in each row was 60cm X 60 cm for fodders (BHN-18, CO-5, Phule-1, COFS-31, Bundel guinea, *Moringa oleifera* and *Sesbania grandiflora}* and seeds were sown in case of Medicago sativa (Lucerne), *Stylosanthes hamata*, *Macroptilium atropurpreum* (Siratro) with spacing between the seeds in a row was 45 cm x 45 cm. The stem cuttings and seeds were procured from fodder museum Department of LPM.

3.1.3 Weeding

Manual weeding was done at 20 and 40 days after sowing to keep the crop free from weeds. Then weeding used to be done at least once in 15 days to allow better fodder growth.

3.1.4 Irrigation

First irrigation was given soon after planting or sowing to the all fodder varieties. Then irrigation was done once in a week for the Hybrid Napier varieties (BHN-18, CO5, Phule-1, C0FS31, Bundel guinea) and fodder trees (Sesbenia and Moringa) and legume (Lucerne, Stylosanthes, Siratro) up to the first cutting, later which was reduced to once in 12-15 days.

3.1.5 Harvesting

The first cut was at 60-75 days after planting/sowing. Subsequent cuttings were done at an interval of 45 to 50 days based on the variety of the fodder to be harvested.

3.2 Biomass Yield

Biomass yield was recorded in kg of completely harvested fodder crops from three different plots of 15’ x 10’ size allotted to each fodder crop, then the sum of all three plots are projected for per hectare in terms of tonnes using simple calculations as given here under.

1 Hectare = 107639.104 sq.ft.

In our study plot size is 15’X10’ i.e. 150 sq.ft. Each fodder has been grown in triplicates. So, total area provided for each fodder crop is 3X150 sq.ft, i.e. 450 sq.ft.

Therefore, correction factor for calculating biomass yield per hectare is 239.19. To get total yield in per hectare for each fodder obtained in three plots is multiplied with correction factor of 239.19.

3.3 EVALUATION OF CHEMICAL COMPOSITION OF FODDER VARIETIES

3.3.1 Sample collection and processing

A representative sample of all ten varieties of fodder (about two kg on fresh basis) was cut manually and chopped in small pieces (1-2 cm) using chalf cutter. Later, the chopped fodder samples were dried in an oven at 70 °C for 48 hours and then dried sample was ground in laboratory grinding mill (Dietz-motoren GmbH & Co.) using a mesh screen of one mm size. The ground feed sample were stored in an air tight wide mouth plastic bottles for further laboratory evaluation in room temperature.

3.3.2 Chemical Analysis

3.3.2.1 Proximate principles

The Samples of different fodders grown in the Fodder Museum, Veterinary College, Hebbal was analyzed for proximate/chemical composition. The dry matter content of feed samples was analyzed by drying the samples to a constant weight in a forced hot air oven at 105°C. The ash content in the samples will be estimated as residue obtained after incineration of samples at 600°C for 3 hours. Crude protein (N x 6.25) was analyzed using Gerhardt digestion and distillation unit that agrees with Kjeldahl standards (A.O.A.C, 1995). The ether extract (EE) content in the feed samples was analyzed after extraction with petroleum ether using the procedure of A.O.A.C. (1995).

3.3.2.2 Fibre fractions

The neutral detergent fiber (NDF) and acid detergent fiber (ADF) was determined according to the methods described by Van Soest *et al.* (1991).

3.3.3 *In vitro* studies

Hohenheim gas test

3.3.3.1. *In vitro* evaluation

All the fodder varieties were subjected to rumen *in vitro* incubation for gas production (RIVIGP) and the ME (MJ/kg DM) was estimated by using procedures of Menke and Steingass (1988) as follows.

3.3.3.2. Donor cow and collection of rumen fluid

A lactating dairy cow producing three kg of milk per day, fitted with a flexible rumen cannula of large diameter (Bar Diamond, Inc. USA), receiving a basal diet consisting of FMS and CFM (Maize 60 per cent, Wheat bran 35 per cent, Mineral mixture 2 per cent, Urea 2 per cent and Salt 1 per cent) was used as the donor cow for collection of rumen fluid. The FMS and CFM were fed separately. Six kg FMS was offered in small portions four times in a day, starting at 09.00 hours. The CFM was offered 3.0 kg per day in two equal portions at 05.00 and 13.30 hours. Rumen fluid was collected in the morning between 04:45 hours and 05.00 hours before offering CFM and water.

All crops samples were subjected to RIVGP for 24 hrs to calculate the following.

3.3.3.3. Metabolizable energy (ME) determination

Air equilibrated fodder samples (200 ± 10 mg) were incubated in 100 ml calibrated glass syringes in triplicate according to procedure described by Menke and Steingass (1988) with 30 ml buffered rumen fluid with three blank incubations and the reference standards of roughage and concentrate. The incubation was done in a water bath maintained at 39 °C. The readings of displaced syringes were recorded at different time intervals over 24 h whenever the syringe readings exceed 80 ml, the readings were reset to 30 ml, then cumulative gas production for 24 h time period was calculated. For determination of ME content of test samples, 24 h net cumulative gas production was corrected for reference standard and blank. Using chemical composition and net gas production (corrected for blank and reference standard) at 24 h of incubation, ME was calculated using the following equation as per Menke and Steingass (1988).

$$ME = 2.2 + 0.1357\ GP + 0.0057\ CP + 0.0002859\ EE2$$

Where, GP = Gas production (ml/200 mg DM)

CP = Crude protein, g/kg DM

EE = Ether extract, g/kg DM

TA = Total ash, g/kg DM

ME = Metabolizable energy, MJ/kg DM

3.3.3.4. *In vitro* digestibility studies

Gas production recorded from an incubation and using corrected net gas production and the proximate composition, the determination of organic matter digestibility of the feedstuffs was predicted with the help of mathematical equations according to Menke and Steingass (1988).

$$\text{In vitro organic matter digestibility} = 14.88+0.8893GP+0.0448XP+0.0651XA$$

Where, GP = Gas production (ml/200mg)

XP = Crude protein (g/kg DM)

XA = Total ash (g/kg DM)

3.4 Nutrient yield per hectare

After analyzing various nutrients of different variety fodder samples the nutrient yield per hectare is calculated as follows

a. Dry matter yield of fodder ("X") is calculated as follows

1 atter
^Xi^Vha) = yield of fodder on fresh basis * DM per cent of fodder on fresh basis

b. Nutrient yield in t/ha calculated as follows

Nutrient yield (t/ha) = "X" * per cent of nutrient

3.4 statistical analysis

The data analysis was done by using software Graph Pad Prism version 5.0.1.

a) Field preparation

b) Irrigation of fodders

c. Fertilizer application

d. Chaffing of sample

e. Weighing of sample

f. Hohenheim gas test

Plate 3.1: Field preparation (a), Irrigation (b), Fertilizer application (c), Chaffing (d), Weighing of sample (e) and Honhenheim gas test (f) performed during the experiment.

Results

IV. RESULTS

The results obtained based on the study conducted on various parameters pertaining to five leguminous and five non-leguminous fodder crops grown at the fodder museum of the department of LPM, Veterinary College, Bengaluru are presented in this chapter.

4.1 Biomass yield

4.1.1 Leguminous fodders

The number of cuttings/year, average yield/450 sq. ft., average yield/cutting/ha and annul yield/ha of five leguminous fodder crops *Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* are presented in Table 4.1. Among leguminous fodders *Sesbania grandiflora* recorded highest yield per cutting of 99.87 t/ha followed by *Moringa oleifera, Macroptihum atropurpureum* (Siratro), *Stylosanthes hamata* and *Medicago sativa* (Lucerne) with values of 96.68, 26.45, 25.44 and 9.59 t/ha respectively. The average yields per annum for *Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* were 299.62, 290.04, 78.37, 76.34 and 115.15 t/ha, respectively.

4.1.2 Non-leguminous fodders

The number of cuttings/year, average yield/450 sq.ft., average yield/cutting/ha and annul yield/ha of five non-leguminous fodder crops BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 are presented in Table 4.2. Among non-leguminous fodders COFS-

31 recorded highest yield per cutting of 96.39 t/ha followed by CO-5, Bundel guinea, Phule-1 and BHN-18 with the values of, 88.27, 84.25, 74.85 and 63.24 t/ha, respectively. The average annual yield per hectare was highest in CO-5 with 353.08 tonnes followed by COFS-31, Bundel guinea, Phule-1 and BHN- 18 with values 289.19, 252.75, 224.57 and 189.74 t/ha, respectively.

4.2 Chemical composition

4.2.1 Leguminous fodders

4.2.1.1 Proximate analysis

4.2.1.1.1 Dry matter

The dry matter contents in five leguminous fodder varieties *viz. Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Sty'losanthes hamata* are presented in Table 4.3. The average dry matter content of five leguminous fodder varieties ranged from 91.21 to 93.90 per cent. *Sesbania grandiflora* showed highest dry matter content of 93.90 per cent. Dry matter values for *Sty'losanthes hamata*, *Macroptilium atropurpureum* (Siratro), *Moringa oleifera* and *Medicago sativa* (Lucerne) were 93.74, 93.46, 92.51 and 91.21 per cent, respectively.

4.2.1.1.2 Total Ash

The per cent of total ash in leguminous fodder varieties *viz. Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* are presented in Table 4.3. The per cent total ash of five leguminous fodders ranges from 7.28 to 11.11. *Medicago sativa* (Lucerne) showed highest total ash value of 11.11 per cent followed by *Macroptilium atropurpureum* (Siratro), *Moringa oleifera, Sesbania grandiflora* and *Stylosanthes hamata* with total ash values of 10.03, 8.96, 8.51 and 7.28 per cent, respectively.

4.2.1.1.3 Organic matter

The content of organic matter in five leguminous fodder varieties *viz. Medicago sativa* (Lucerne), *Sesbania grandiflora*, *Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* are presented in Table 4.3. The per cent of organic matter ranged from 88.89 to 92.72 in the five varieties of leguminous fodder crops. *Stylosanthes hamata* showed highest organic matter value of 92.72 per cent followed by *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Medicago sativa* (Lucerne) with organic matter values of 91.48, 91.03, 89.97 and 88.89 per cent, respectively.

4.2.1.1.4 Crude Protein

The per cent of crude protein in five selected varieties of leguminous fodder *viz. Medicago sativa* (Lucerne), *Sesbania grandiflora*, *Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* are presented in Table 4.3. The per cent of crude protein content in five leguminous fodder varieties ranged from 12.27 to 23.65. Among the five leguminous fodder varieties *Sesbania grandiflora* showed highest crude protein (%) value of 23.65 followed by *Medicago sativa* (Lucerne) (20.30 %), *Stylosanthes hamata* (15.07 %), *Macroptilium atropurpureum* (Siratro) (13.73 %) and *Moringa oleifera* (12.27 %).

4.2.1.1.5 Ether Extract

The ether extract (%) content in five selected varieties of leguminous fodder *viz.* *Medicago sativa* (Lucerne), *Sesbania grandiflora*, *Moringa oleifera*, *Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* are presented in Table 4.3. The per cent of ether extract contents in the selected leguminous fodder varieties ranged from 2.02 to 4.63. Among all the selected varieties *Moringa oleifera* showed highest ether extract value of 4.63 per cent followed by *Sesbania grandiflora*, *Medicago sativa* (Lucerne), *Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* with ether extract values of 3.68, 3.63, 2.45 and 2.02 per cent, respectively.

4.2.1.2 Cell wall fractions

4.2.1.2.1 Neutral Detergent Fibre

The per cent of neutral detergent fibre (NDF) content in five selected varieties of leguminous fodders *viz.* *Medicago sativa* (Lucerne), *Sesbania grandiflora*, *Moringa oleifera*, *Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* are presented in Table 4.4. The per cent of NDF content of selected leguminous fodder varieties ranged from 33.01 to 54.42. The NDF content in *Stylosanthes hamata* showed highest value of 54.42 per cent followed by *Medicago sativa* (Lucerne), *Macroptilium atropurpureum* (Siratro), *Moringa oleifera* and *Sesbania grandiflora* with NDF values of 50.17, 47.78, 45.72 and 33.01 per cent, respectively.

4.2.1.2.2 Acid Detergent Fibre

The per cent of acid detergent fibre (ADF) content in five selected varieties of leguminous fodders *viz. Medicago sativa* (Lucerne), *Seshania grandiflora., Moringa oleifera, Macroptilium atropiirpiireum* (Siratro) and *Stylosanthes hamata* are presented in Table 4.4. The ADF (%) content in legume varieties ranged from 28.44 to 41.57. Among the five varieties of leguminous fodders, *Stylosanthes hamata* showed highest ADF value of 41.57 per cent followed by *Macroptilium atropurpureum* (Siratro), *Moringa oleifera.*, *Medicago sativa* (Lucerne) and *Sesbania grandiflora* with ADF values of 37.85, 37.73, 30.20 and 28.44 per cent, respectively.

4.2.1.2.3 Acid Detergent Lignin

The per cent of acid detergent lignin content in five selected varieties of leguminous fodders *viz. Medicago sativa* (Lucerne), *Sesbania gi'andiflora*, *Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* are presented in Table 4.4. The ADL (%) content in legume fodders ranged from 4.83 to 8.68 per cent. Among these five varieties of leguminous fodder crops *Macroptilium atropurpureum* (Siratro) showed highest ADL value of 8.68 per cent, followed by *Stylosanthes hamata, Medicago sativa* (Lucerne), *Moringa oleifera* and *Sesbania grandiflora* with ADL values of 7.05, 6.85, 5.36 and 4.83 per cent, respectively.

4.2.1.2.4 Acid Detergent Fibre Ash

The per cent of acid detergent fibre ash (ADFA) content in five selected varieties of leguminous fodders *viz. Medicago sativa* (Lucerne), *Sesbania gi~andiflora*, *Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* are presented in

Table 4.4. The ADFA per cent values among the five leguminous fodder varieties ranges from 1.25 to 2.45. *Macroptiliiim atropnrpnreiim* (Siratro) showed highest ADFA value of 2.45 per cent followed by *Sesbania grandiflora*, *Moritiga oleifera*, *Medicago sativa* (Lucerne) and *Stylosanthes hamata* with the values of 2.16, 1.71, 1.38 and 1.25 per cent, respectively.

4.2.2 Non- leguminous fodders

4.2.2.1 Proximate analysis

4.2.2.1.1 Dry Matter

The dry matter content in five selected non-leguminous fodder varieties *viz.* BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 are presented in Table. 4.5. Dry matter content among non-leguminous fodder crops ranged from 92.60 to 95.21 per cent. Among these non-leguminous fodder varieties Bundel guinea showed highest dry matter value of 95.21 per cent followed by COFS-31, Phule-1, CO-5 and BHN-18 with dry matter per cent of 94.25, 93.71, 93.39 and 92.60, respectively.

4.2.2.1.2 Total Ash

Total ash content in five non-leguminous fodder varieties *viz.* BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 are presented in Table. 4.5. The total ash (%) of non-leguminous fodder crops ranged from 7.97 to 16.60. Among the non-leguminous fodder crops BHN-18 showed highest total ash value of 16.60 per cent followed by CO-5, Phule-1, Bundel guinea and COFS-31 with total ash values of 14.26, 12.01, 10.10 and 7.92 per cent, respectively.

4.2.2.1.3 Organic matter

The per cent of organic matter in five selected non-leguminous fodder varieties *viz.* BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 are presented in Table. 4.5. The organic matter contents of five varieties of non-leguminous fodders ranged from 83.40 to 92.03 per cent. COFS-31 showed highest organic matter value of 92.03 per cent followed by Bundel guinea, Phule-1, CO-5 and BHN-18 with organic matter values of 89.90, 87.99, 85.74 and 83.40 per cent, respectively.

4.2.2.1.4 Crude Protein

The per cent of crude protein content in five selected non-leguminous fodder varieties *viz.* BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 are presented in Table. 4.5. Per cent of CP in non-leguminous fodder varieties ranged from 5.03 to 8.83. Among the five non-leguminous fodders crops BHN-18 being showed highest crude protein value of 8.83 per cent followed by Phule-1, CO-5, COFS-31 and Bundel guinea with CP values of 6.26, 5.93, 5.30 and 5.03 per cent, respectively.

4.2.2.1.5 Ether Extract

The ether extract contents in five selected non-leguminous fodder varieties *viz.* BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 are presented in Table. 4.5. The ether extract (%) among the five selected non-leguminous fodder varieties ranged from 1.20 to 3.35. BFlN-18 showed highest ether extract value of 3.35 per cent fallowed by Phule-1, CO-5, Bundel guinea and COFS-31 with values of 2.33, 1.79, 1.33 and 1.20 per cent, respectively.

4.2.2.2 Cell wall fractions

4.2.2.2.1 Neutral Detergent Fibre

The neutral detergent fibre contents (%) in five non-leguminous fodder varieties *viz.* BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 are presented in Table. 4.6. Per cent of NDF in five selected non-leguminous fodders ranged from 71.53 to 76.15. Among these COFS-31 recorded highest NDF value of 76.15 per cent followed by Bundel guinea, Phule-1, CO-5 and BHN-18 with NDF values of 75.12, 74.52, 72.01 and 71.53 per cent, respectively.

4.2.2.2.2 Acid Detergent Fibre

The acid detergent fibre contents in five non-leguminous fodder varieties *viz.* BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 are presented in Table. 4.6. The per cent of ADF in non-leguminous fodder crops ranged from 41.55 to 53.20. COFS-31 showed highest ADF value of 53.20 per cent followed by Bundel guinea, Phule-1, CO-5 and BHN-18 with ADF values of 51.75, 47.07, 45.08 and 41.55 per cent, respectively.

4.2.2.2.3 Acid Detergent Lignin

The acid detergent lignin content in non-leguminous fodder varieties *viz.* BHN 18, CO-5, Phule-1, Bundel guinea and COFS-31 are presented in Table. 4.6. Per cent of ADL of five varieties of non-leguminous fodder crops ranges from 5.04 to 11.50. COFS-31 being showed highest ADL value of 11.50 per cent followed by Phule-1, Bundel guinea, BHN-18 and CO-5 with ADL values of 9.89, 9.50, 8.51 and 5.04 per cent, respectively.

4.2.2.2.4 Acid Detergent Fibre Ash

The per cent of acid detergent fibre ash content in five selected non-leguminous fodder varieties *viz.* BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 are presented in Table. 4.6. The ADFA among the non-leguminous fodder varieties ranged from 4.14 to 7.60 per cent. CO-5 showed highest ADFA value of 7.60 per cent followed by Phule-1, COFS-31, BHN-18 and Bundel guinea with ADFA values of 5.77, 5.29, 5.10 and 4.14 per cent, respectively.

4.3 Hohenheim gas test

4.3.1 Metabolizable energy (ME)

4.3.1.1 Legnminons fodders

The ME of five selected leguminous fodder varieties *Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* is presented in Table. 4.7. ME among five leguminous fodder crops varies in a range of 8.4 to 9.5 MJ/kg. Among these *Macroptilium atropurpureum* (Siratro) recorded highest ME of 9.5 MJ/kg followed by *Sesbania grandiflora, Medicago sativa* (Lucerne), *Moringa oleifera* and *Stylosanthes hamata* with ME values of 9.4, 9.2, 9.0 and 8.4 MJ/kg, respectively.

4.3.1.2 Non-leguminous fodders

The ME of five selected non-leguminous fodder varieties BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 is presented in Table. 4.8. ME among five varieties of non-leguminous fodder crops ranges from 6.50 to 7.8 MJ/kg. Among these CO-5 recorded highest ME of 7.8 MJ/kg followed by BHN-18, Phule-1, COFS-31 and Bundel guinea with ME values of 7.6, 7.7, 6.7 and 6.5 MJ/kg, respectively.

4.3.2 *In vitro* organic matter digestibility

4.3.2.1 Leguminous fodders

The *Iti vitro* organic matter digestibility of five selected leguminous fodder varieties *Medicago sativa* (Lucerne), *Sesbania grandiflora*, *Moringa oleifera*, *Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* is presented in Table 4.7. The *In vitro* organic matter digestibility among the five selected leguminous fodder crops ranges from 60.71 to 69.67 g/kg DM. *Sesbania gi~andiflora* recorded highest organic matter digestibility of 69.67 g/kg DM followed by *Medicago sativa* (Lucerne), *Macroptilium atropurpureum* (Siratro), *Stylosanthes hamata* and *Moringa oleifera* with organic matter digestibility values of 67.53, 67.40, 62.25 and 60.71 g/kg DM, respectively.

4.3.2.2 Non-leguminous fodders

The *In vitro* organic matter digestibility of five selected non-leguminous fodder varieties BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 is presented in Table 4.8. The *In vitro* organic matter digestibility among the five selected non-leguminous fodder varieties ranges from 49.56 to 79.58 g/kg DM. CO-5 recorded highest *In vitro* organic matter digestibility value of 79.58 g/kg DM followed by BHN-18, Phule-1, COFS-31 and Bundel guinea with organic matter digestibility values of 66.43, 58.24, 52.18 and 49.56 g/kg DM, respectively.

4.4 Nutrient yield per hectare

4.4.1 Crude protein yield

4.4.1.1 Leguminous fodders

The crude protein yield of leguminous fodder varieties *viz. Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptiliiim atropurpureum* (Siratro) and *Stylosanthes hamata* is presented in Table 4.9. Yield of crude protein in five leguminous fodders ranged from 2.24 to 15.57 t/ha/yr. *Sesbania grandiflora* showed highest crude protein yield of 15.57 t/ha/yr followed by *Moringa oleifera, Medicago sativa* (Lucerne), *Stylosanthes hamata* and *Macroptiliiim atropurpureum* (Siratro) with values of 7.36, 5.36, 3.37 and 2.27 t/ha/yr, respectively.

4.4.1.2 Non-leguminous fodders

Yield of crude protein in non-leguminous fodder varieties *viz.* BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 is presented in Table.4.10. Crude protein yield for non-leguminous fodder crops ranged from 2.37 to 5.19 t/ha/yr. COFS-31 showed the highest crude protein yield (t/ha/yr) of 5.19 followed by CO-5 (4.60), Bundel guinea (3.26), Phule-1 (3.15) and BHN-18 (2.37).

4.4.2 NDF yield

4.4.2.1 Leguminous fodders

Neutral detergent fibre yield of leguminous fodder varieties *viz. Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* is presented in Table 4.9. Yield of NDF (t/ha/yr) in five leguminous fodders ranged from 7.8 to 27.47. *Moringa oleifera* showed highest NDF yield of 27.74 t/ha/yr followed by *Sesbania grandiflora, Medicago sativa* (Lucerne), *Stylosanthes hamata* and *Macroptilium atropurpureum* (Siratro) with the values of 21.67, 13.25, 12.18 and 7.8 t/ha/yr, respectively.

4.4.2.2 Non-leguminous fodders

Yield of NDF in non-leguminous fodder varieties *viz.* BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 is presented in Table.4.10. NDF yield (t/ha/yr) for non-leguminous fodder crops ranged from 19.23 to 74.62. COFS-31 showed highest NDF yield with value of 74.62 t/ha/yr followed by CO-5, Bundel guinea, Phule-1 and BHN-18 with values of 55.80, 48.68, 37.46 and 19.23 t/ha/yr, respectively.

4.4.3 Metabolizable energy yield

4.4.3.1 Leguminous fodders

ME yield of leguminous fodder varieties *viz. Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* is presented in Table 4.9. Yield of ME in five leguminous fodders ranged from 156.32 to 622.85 MJ/ha/year. *Seshania grandiflora* showed highest ME yield of 622.85 MJ/ha/year followed by *Moringa oleifera, Medicago sativa* (Lucerne), *Stylosanthes hamata* and *Macroptilium atropurpureum* (Siratro) with values of 541.26, 244.99, 188.22 and 156.32 MJ/ha/yr, respectively.

4.4.3.2 Non-leguminous fodders

Yield of energy in non-leguminous fodder varieties *viz.* BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 is presented in Table 4.10. Energy yield for non-leguminous fodder crops ranged from 232.31 to 663.33 MJ/ha/year. COFS-31 showed highest ME yield of 663.33 MJ/ha/year followed by CO-5, Bundel guinea, Phule-1 and BHN-18 with values of 604.44, 421.18, 387.55 and 204.35 t/ha/yr, respectively.

4.5 Digestible Organic Matter in Dry Matter yield

4.5.1 Leguminous fodders

The digestible organic matter in dry matter for leguminous fodders *viz. Medicago sativa* (Lucerne), *Sesbania grandiflora*, *Moringa oleifera*, *Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* is presented in Table 4.9. The DOMDM in leguminous fodders ranged from 10020 to 40016 t/ha/yr. Sesbania grandiflora showed highest DOMDM of 40016 t/ha/yr followed by Moringa oleifera, Medicago sativa (Lucerne), Stylosanthus hamata and Macroptilium atropurpureum (Siratro) with values of 33893, 15565, 12353 and 10020 t/ha/yr, respectively.

4.5.2 Non-leguminous fodders

Digestible organic matter digestibility in dry matter for non-leguminous fodders *viz.* BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 is presented in Table 4.10. The DOMDM among non-leguminous fodder varieties ranges from 15853 to 50808 t/ha/yr. CO-5 showed highest DOMDM of 50808 t/ha/yr followed by COFS-31, Bundel guinea, Phule-1 and BHN-18 with values of 45071, 26527, 25363 and 15853 t/ha/yr, respectively.

Table 4.1: The number of cutting/year, average yield per 450 sq. ft., average yield/cutting/ha and annul yield/ha of five leguminous fodder crops

SI. No.	Fodder variety	Number of cutting/year	Average yield / 450 sq.ft, (tonnes)	Average Yield / cutting/ ha (tonnes)	Annual Yield/ ha (tonnes)
1	*Medicago sativa* (Lucerne)	12	0.48	9.59	115.15
2	*Sesbania grandiflora*	3	1.25	99.87	299.62
3	*Moringa oleifera*	3	1.21	96.68	290.04
4	*Macroptilium atropurpureum* (Siratro)	3	0.33	26.45	79.37
5	*Stylosanthes hamata*	3	0.32	25.44	76.34

Table 4.2: Number of cutting/year, average yield per 450 sq. ft., average yield/cutting/ha and annul yield/ha of five non-leguminous fodder crops

SI. No.	Fodder variety	Number of cutting/year	Average yield / 450 sq.ft, (tonnes	Average Yield / cutting/ ha (tonnes)	Annual Yield/ ha (tonnes)
1	**BHN-18**	3	0.79	63.24	189.74
2	**CO-5**	4	1.48	88.27	353.08
3	**Phule-1**	3	0.94	74.85	224.57
4	**Bundel guinea**	3	1.27	84.25	252.75
5	**COFS-31**	3	1.21	96.39	289.19

Table 4.3: The proximate composition (Per cent of DM, TA, OM, CP and EE) of five legnminons fodder crops

Proximate Principles	*Medicago sativa* (Lucerne)	*Sesbenia grandiflora*	*Moringa oleifera*	*Macroptilium atropurpureum* (Siratro)	*Stylosanthus hamata*
Dry matter	91.21±0.36	93.90±0.26	92.51±0.15	93.46±0.66	93.74±0.17
Total ash	ll.ll±0.84	8.518±0.28	8.969±0.15	10.03±0.19	7.284±0.03
Organic matter	88.89±0.86	91.48±0.28	91.03±0.23	89.97±0.29	92.72±0.03
C.P.	20.30±0.35	23.65±2.43	12.27±0.34	13.73±0.52	15.07±0.19
E.E.	3.63±0.01	3.68±0.02	4.63±0.04	2.45±0.02	2.02±0.05

Table 4.4: The cell wall fractions (Per cent of NDF, ADF, NDA, ADL and ADFA) of five legnminons fodder crops

Cell wall fractions	*Medicago sativa* (Lucerne)	*Sesbenia grandiflora*	*Moringa oleifera*	*Macroptilium atropurpureum* (Siratro)	*Stylosanthus hamata*
N.D.F.	50.17±0.55	33.01±0.24	45.72±0.42	47.78±0.20	54.42±0.39
A.D.F.	30.20±0.08	28.44±0.25	***3in3±QA'l***	37.85±0.23	41.57±0.09
N.D.F.A.	0.87±0.12	0.57±0.02	0.52±0.01	0.04±0.00	0.29±0.00
A.D.L.	6.85±0.17	4.83±0.11	5.36±0.40	8.68±0.25	7.05±0.07
A.D.F.A.	1.38±0.08	2.16±0.39	1.71±0.12	2.45±0.24	1.25±0.00

Table 4.5: The proximate composition (Per cent of DM, TA, OM, CP and EE) of five non-leguminous fodder crops

Proximate Principles	BHN-18	CO-5	Phule-1	BG	COFS-31
Dry matter	92.60±0.20	93.39±0.05	93.71±0.07	95.21±0.34	94.25±0.27
Total ash	16.60±1.42	14.26±0.05	12.01±0.04	10.10±0.13	*7.972±0.32*
Organic matter	83.40±2.23	85.74±0.00	87.99±0.04	89.90±0.20	92.03±0.50
C.P.	8.83±0.66	5.93±0.10	6.26±0.17	5.03±0.09	5.30±0.25
E.E.	3.35±0.24	1.79±0.04	2.33±0.27	1.33±0.05	1.20±0.00

Table 4.6: The cell wall fractions (Per cent of NDF, ADF, NDA, ADL and ADFA) of five non-leguminous fodder crops

Cell wall fractions	BHN-18	*CO-5*	Phule-1	BG	COFS-31
N.D.F.	71.53±0.18	72.01±0.02	74.52±0.40	75.12±0.25	76.15±0.22
A.D.F.	41.55±0.15	45.08±0.34	47.07±0.26	51.75±0.19	53.20±0.42
N.D.F.A.	1.67±0.07	2.03±0.00	2.30±0.03	1.23±0.01	1.20±0.05
A.D.L.	8.51±0.05	5.04±0.24	9.89±0.05	9.50±0.13	11.50±0.23
A.D.F.A.	5.10±0.02	7.60±0.20	5.77±0.08	4.14±0.05	5.29±0.09

Table 4.7: Metabolizable energy, *In vitro* organic matter digestibility and rnmen in vitro gas prodnction (RIVGP-24h ml/200mg DM) of five legnminons fodder crops

Parameters	*Medicago sativa* (Lncerne)	*Sesbenia grandiflora*	*Moringa oleifera*	*Macroptilium atropurpureum* (Siratro)	*Stylosanthus hamata*
ME MJ/kg	O.ZSiO.l?**	9.49±0.21“	9.01±0.11‘*	9.58±0.33“	8.413±0.0l'’
Organic matter digestibility	67.53±0.90“	69.67±2.3^"	60.71±0.01“'^’	67.40±1.47‘^‘^	62.25±0.57'’
RIVGP @ 24 hrs.	40.87±1.35“	40.91±0.56^	40.52±0.81‘'’	47.36±2.32'^’	38.61±0.ir

Note: means bearing different superscripts differ significantly.

RIVIGP: Rumen *in vitro* incubation and gas production (24 h, ml/200 mg DM)

ME: Metabolizable energy MJ/Kg DM)

Table 4.8: Metabolizable energy, *In vitro* organic matter digestibility and rnmen in vitro gas prodnction (RIVGP-24h ml/200mg DM) of five non-legnminons fodder crops

Parameters	BHN-18	CO-5	PHULE-1	BG	COFS-31
ME MJ/kg	7.6±0.06“	7.8±0.04‘’	7.71±0.07"	e.soio.so^*	6.77±0.15‘'
Organic matter digestibility	66.43±1.9“	79.58±0.29''	58.24±0.50"	49.56±1.93®	52.18±1.09^
RIVGP @ 24 hrs.	41.37±0.04“	59.33±0.26''	36.8^0.53^^*	29.17±2.22"	33.44il.37"*

Note: means bearing different superscripts differ significantly.

RIVIGP: Rumen *in vitro* incubation and gas production (24 h, ml/200 mg DM)

ME: Metabolizable energy MJ/Kg DM)

Table 4.9: The nutrient yield in tonnes (per hectare) of five leguminous fodder crops used during the experiment

Parameters	***Medicago sativa*** **(Lucerne)**	***Sesbania grandiflora***	***Moringa oleifera***	***Macroptilium atropurpureum*** **(Siratro)**	***Stylosanthes hamata***
Crude Protein	5.36	15.52	7.36	2.24	3.37
Ether Extract	0.96	2.42	2.78	0.40	0.45
Total Ash	4.38	9.36	7.21	1.65	1.79
Organic Matter	23.47	60.05	54.68	14.52	20.75
NDF	13.25	21.67	27.47	7.80	12.18
ADF	7.97	18.67	22.67	6.18	9.30
ME (MJ/ha/yr)	244.99	622.85	541.26	156.32	188.22
DOMDM*	15565	40016	33893	10020	12353

* DOMDM = Dry matter yield (t) X Organic matter (%) X digestibility of organic matter (%)

Table 4.10: The nutrient yield in tonnes (per hectare) of five non-leguminous fodder crops used during the experiment

Parameters	BHN-18	CO-5	PHULE-1	BG	COFS-31
Crude Protein	2.37	4.60	3.15	3.26	5.19
Ether Extract	0.90	1.39	1.17	0.86	1.18
Total Ash	2.99	6.59	4.50	6.50	7.13
Organic Matter	22.43	66.44	44.23	58.25	90.17
NDF	19.23	55.80	37.46	48.68	74.62
ADF	11.17	34.93	23.66	33.53	52.13
ME (MJ/ha/yr)	204.35	604.44	387.55	421.18	663.33
DOMDM	15853	50808	25363	26527	45071

***DOMDM = Dry matter yield (t) X Organic matter (%) X digestibility of organic matter (%)**

Discussion

V. DISCUSSION

5.1 Biomass yield

5.1.1 Leguminous fodders

The biomass yield of leguminous fodder in the present study were 299.62, 290.04, 78.37, 76.34 and 115.15 t/ha/yr for *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro), *Stylosanthes hamata* and *Medicago sativa* (Lucerne), respectively. The results are in agreement with Fernandes *et al.* (2005) for *Medicago sativa* (Lucerne) with 120 t/ha/yr whereas lower yields of 100.7, 15-20 and 20 t/ha/yr were noticed by Sanchez *et al.* (2006) for fodder *Moringa oleifera*, IGFRI (2011) for fodder *Macroptihum atropurpureum* (Siratro) and Jayaprakash *et al.* (2016) for fodder *Stylosanthes hamata*, respectively. There are not many studies on this aspect for other fodders. The differences in the biomass yields for respective leguminous fodder varieties might be due change in agronomical practices, soil fertility, soil moisture, fertilizer application and harvesting patterns (Reddy *et al.*, 2003).

5.1.2 Nou-legumiuous fodders

The biomass yield of non-leguminous fodders were 353.08, 289.19, 252.75, 224.57 and 189.74 t/ha/yr obtained for CO-5, COFS-31, Bundel guinea, Phule-1 and BHN-18 respectively. The results obtained are in agreement with Narayana and Dabadghao (1972) for hybrid napiers, Jayanthi (2003) for CO-3 with reported values of 135 to 215 and 375.3 t/ha/yr, respectively. Whereas lower yields of 201.1 and 150 t/ha/yr were noticed by lyanar *et al.* (2015) for fodder COFS-31 and Wasnik *et al.* (2014) for fodder Bundel guinea, respectively. The difference in the biomass yield of non-leguminous fodder varieties might be due to climatic condition, nature of soil, type of fertilizer, irrigation pattern, agronomical practices and harvesting time (Reddy *et al.*, 2003).

5.2 Chemical composition of different fodders

5.2.1 Leguminous fodders

5.2.1.1 Proximate principles

Crude protein content for fodder *Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* were 21.6, 23.65, 12.27, 13.73 and 15.07 per cent, respectively. The results are in agreement with the findings of Fernandes *et al.* (2005) for *Medicago sativa* (Lucerne), Nouman *et al.* (2013) for *Moringa oleifera,* Jayaprakash *et al.* (2016) for *Stylosanthes hamata,* Njarui *et al.* (2003) for *Macroptilium atropurpureum* (Siratro) and Devendra (1991) for *Sesbania grandiflora* with values of 20.30, 15.31, 13.90, 14.71 and 22.61 per cent, respectively.

Ether extract content of *Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* were 3.63, 3.68, 4.63, 2.45 and 2.02 per cent, respectively. The results of the present study are in agreement with studies of Fernandes *et al.* (2005) for *Medicago sativa* (Lucerne), Nouman *et al.* (2013) for *Moringa oleifera,* Jayaprakash *et al.* (2016) for *Stylosanthes hamata* and Devendra (1991) for *Sesbania grandiflora* with the values of 2.71, 3.0, 2.52 and 2.10 per cent, respectively.

Total ash present in fodder *Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* werell.ll, 8.51, 8.96, 10.03 and 7.28 per cent, respectively. The results obtained are similar to the results found by Fernandes *et al.* (2005) for *Medicago sativa* (Lucerne), Nouman *et al.* (2013) for *Moringa oleifera,* Njarui *et al.* (2003) for *Macroptilium atropurpureum* (Siratro) and Devendra (1991) for *Sesbania grandiflora* with values of 10.21, 12.00, 13.31 and 9.30 per cent, respectively whereas the per cent of TA was higher (7.28%) in present study for *Stylosanthes hamata* compared study by Jayaprakash *et al.* (2013) with value of 3.72. The variation in most of the chemical composition as compared the other studies done elsewhere as discussed above might be due to the present study was conducted during rainy season. This might have lead to the proper growth and development of crop (Chauhan *etal.*, 1987; Fernandes *et al.*, 2005).

5.2.L2 Cell wall fractions

The per cent of neutral detergent fibre values for fodder *Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* in the present study were 50.17, 33.01, 45.72, 47.78 and 54.42, respectively. The results in the present study are in accordance with Fernandes *et al.* (2005) for *Medicago sativa* (Lucerne), Hang *et al.* (2005) for *Sesbania grandiflora,* Munpangwa *etal.* (1997) for *Macroptilium atropurpureum* (Siratro) with values of 47.50, 37.8 and 47.70 respectively whereas lower per cent of 21.99 by Sanchez *et al.* (2006) for *Moringa oleifera* and higher per cent of 65.00 by Iji *et al.* (1995) were noticed for fodder *Stylosanthes hamata*, respectively.

Acid detergent fibre content for fodder *Medicago sativa* (Lucerne), *Sesbania grandiflora*, *Moringa oleifera*, *Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* were 30.20, 28.44, 37.73, 37.85 and 41.57 per cent, respectively. The findings in present study are in concurrence with results of Fernandes *et al.* (2005) for *Medicago sativa* (Lucerne), Hang *et al.* (2005) for *Sesbania grandiflora* and Munpangwa *et al.* (1997) for *Macroptilium atropurpureum* (Siratro) with values 38.00, 30.80 and 32.60 respectively whereas higher per cent of 53.04 by Iji *et al.* (1995) for *Stylosanthes hamata* and lower per cent of 12.00 were observed Nouman *et al.* (2013) for fodder *Moringa oleifera*, respectively.

The level of acid detergent lignin for fodder *Medicago sativa* (Lucerne), *Sesbania grandiflora*, *Moringa oleifera*, *Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* were 6.85, 4.83, 5.36, 8.68 and 7.05 per cent, respectively. The results are coinciding with the findings of Fernandes *et al.* (2005) for *Medicago sativa* (Lucerne), Kaitho and Kariuki (1998) for *Sesbania grandiflora*, Makkar and Becker (1996) for *Moringa oleifera* and Munpangwa *et al.* (1997) for *Macroptilium atropurpureum* (Siratro) with values of 8.3, 2.9, 2.2 and 9.2, respectively. The cell wall fractions recorded during the study were in the normal range and are in agreement with reports of several workers and this might be due to the adoption of standard agronomical practices in growing the fodder crops (Rao, 2004).

5.2.2 Non-leguminous fodder

5.2.2.1 Proximate principles

Crude protein content for fodder BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 were 8.83, 5.93, 6.26, 5.03 and 5.30 per cent, respectively. The results of present study are in concurrence with the study conducted by Jagadamba (2008) for BHN-18, Rao (2004) for guinea variety and lyanar *et al.* (2015) for COFS-31 were 5.48, 5.20 and 9.86 per cent, respectively.

Ether extract for fodder BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 were 3.35, 1.79, 2.33, 1.33 and 1.20 per cent, respectively. The same values are observed by Rao (2004) for guinea variety and Senthilkumar *et al.* (2009) for COFS variety with values of 1.60 and 2.60 respectively whereas BHN-18 noted higher values compared to Jagadamba (2008).

The per cent of total ash for fodder BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 were 16.60, 14.26, 12.01, 10.10 and 7.92, respectively. The results of present study are in agreement with Jagadamba (2008) for BITN-18, Premaratne and Premalal (2006) for CO-3, Rao (2004) for guinea variety and Senthilkumar *et al.* (2009) for COFS variety with 13.81, 12.8, 12 and 10.86, respectively.

5.2.2.2 Cell wall fractions

The neutral detergent fibre for fodder BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 were 71.53, 72.01, 74.52, 75.12 and 76.15 per cent, respectively. The results of present study were in agreement with Jagadamba (2008) for BHN-18 and guinea variety and Premaratne and Premalal (2006) for CO-3 with values of 73.75, 71.92 and 74 per cent respectively. Whereas lower per cent of 66.78 was observed by Senthilkumar *et al.* (2009) for COFS variety.

The acid detergent fibre for fodder BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 were 41.55, 45.08, 47.07, 51.75 and 53.20 per cent, respectively. The results of present study are in agreement with Jagadamba (2008) for BHN-18, Premaratne et al. (2006) for CO-3 and Senthilkumar *et al.* (2009) for COFS variety with values of 48.92, 42 and 48.40 per cent, respectively.

The per cent of acid detergent lignin for fodder BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 were 8.51, 5.04, 9.89, 9.50 and 11.50 per cent, respectively. The results of present study are in agreement with Jagadamba (2008) for BHN-18 and Premaratne and Premalal (2006) for CO-3 with value of 8.75 and 6 per cent, respectively. There are not many studies on this aspect for other fodders. Some of the fodders have shown different fibre fractions that might be due to fact that young stems are generally high quality, but the quality decreases faster than leaves, because epidermis and fibrous cells change into secondary cellular wall and lignin content increases with the age (Sanchez *etal.*, 2006).

5.3 Digestible organic matter in dry matter

5.3.1 Leguminous fodders

The digestible organic matter in dry matter (DOMDM) is comparable to the total digestible nutrient (TDN), an expression of energy in ruminant feedstuffs (Van Soest, 1994). The DOMDM could be therefore considered as the most vital parameter to evaluate the nutritional value of fodders. DOMDM is calculated as a product of OM content (per cent) and the digestibility of OM (per cent). The yield of DOMDM (per ha) can therefore be considered as yield of energy in fodders. Based on the yield of DOMDM *Sesbania grandiflora* could be considered as the forage of prime nutritional value, followed by Moringa oleifera, Medicago sativa (Lucerne), Stylosanthus hamata and Macroptilium atropurpureum (Siratro) from the five selected leguminous fodders.

5.3.2 Non-leguminous fodders

The digestible organic matter in dry matter (DOMDM) is comparable to the total digestible nutrient (TDN), an expression of energy in ruminant feedstuffs (Van Soest, 1994). The DOMDM could be therefore considered as the most vital parameter to evaluate the nutritional value of fodders. DOMDM is calculated as a product of OM content (per cent) and the digestibility of OM (per cent). The yield of DOMDM (per ha) can therefore be considered as yield of energy in fodders. Based on the yield of DOMDM CO-5 could be considered as the forage of prime nutritional value, followed by COFS-31, Bundel guinea, Phule-1 and BHN-18 from the five selected leguminous fodders.

5.4 *In vitro* gas studies

5.4.1 Metabolizable Energy

5.4.1.1 Leguminous fodders

Metabolizable energy content for *Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* were 9.28, 9.49, 9.01, 9.58 and 8.41 MJ/kg, respectively. The results are similar to the findings of Makkar and Becker (1996) for *Moringa oleifera* with value of 9.5 MJ/kg. There are not much research has been conducted in this aspect for other fodders.

5.4.1.2 Non-leguminous fodders

Content of metabolizable energy for fodder BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 were 7.6, 7.8, 7.71, 6.50 and 6.77, respectively. The results of present studies are in concurrence with findings of Garg *et al.,* (2012) for hybrid napiers, Bundel guinea and fodder sorghum variety with values of 7.46 to 7.53, 7.53 and 8.02 MJ/kg, respectively.

Summary

VI. SUMMARY

A fodder museum consisting of wide varieties of fodders was established under Department of Livestock production and Management, Veterinary College Hebbal, Bengaluru for training, teaching and providing good quality root slips to farmers at minimum cost. The main objective of this study was to identify one best variety of fodder among the five verities of leguminous and five varieties of non-leguminous fodder family which is best suited for this region with good nutritive values for the animals with the following objectives

1. To calculate the yield of fodder in tonnes per hectare per year.
2. To evaluate chemical composition of ten varieties for proximate principles and fibre fractions.
3. To evaluate metabolizable energy of ten variety fodders.

Highest tonnage per hectare was recorded for Sesbania grandiflora (299.62) followed by Moringa oleifera (290.04), Medicago sativa (Lucerne) (115.15), Macroptilium atropurpureum (Siratro) (79.37) and Stylosanthes hamata (76.34). Tonnage per cut per hectare was in order of 99.87, 96.68, 26.45, 25.44 and 9.59 for Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum, Stylosanthes hamata and Medicago sativa (Lucerne), respectively among leguminous fodder varieties.

Highest tonnage per hectare was recorded for CO-5 (353.08) followed by COFS-31 (289.19), Bundel guinea (252.75), Phule-1 (224.57) and BHN-18 (189.74). Tonnage per cut per hectare was in the order of 96.39, 88.27, 84.25, 74.85 and 63.24 for COFS-31, CO-5, Bundel guinea, Phule-1 and BHN-18, respectively among five non-leguminous fodder varieties.

The proximate composition of five variety leguminous fodders revealed that CP content varies from 12.27 to 23.65 per cent. Sesbania grandiflora recorded highest CP content of 23.65 followed by Medicago sativa (Lucerne) (20.30), Stylosanthes hamata (15.07), Macroptilium atropurpureum (13.73) and Moringa oleifera (12.27), respectively.

The fibre fraction estimation revealed that NDF content ranged from 33.01 to 54.42 per cent. Stylosanthes hamata recorded highest NDF content of (54.42) followed by Medicago sativa (Lucerne) (50.17), Macroptilium atropurpureum (47.78), Moringa oleifera (45.72) and Sesbania grandiflora (33.01), respectively.

The proximate composition of five variety non-leguminous fodders revealed the CP content ranges from 5.03 to 8.83 per cent. BHN-18 recorded highest CP content of 8.83 followed by Phule-1 (6.26), CO-5 (5.93), COFS-31 (5.30) and Bundel guinea (5.03), respectively.

The fibre fraction estimation of five variety of non-leguminous fodders revealed that NDF values ranges from 71.53 to 76.15 per cent. COFS-31 recorded highest NDF content of 76.15 followed by Bundel guinea (75.12), Phule-1 (74.52), CO-5 (72.01) and BHN-18 (71.53), respectively.

The metabolizable energy for five variety leguminous fodders ranges from 8.41 to 9.58 MJ/kg. Macroptilium atropurpureum (Siratro) recorded highest ME values of 9.58

followed by Sesbania grandiflora (9.494), Medicago sativa (Lucerne) (9.29), Moringa oleifera (9.01) and Stylosanthes hamata (8.41), respectively.

The organic matter digestibility of five variety leguminous fodders ranges from 60.71 to 69.67 g/kg DM. Sesbania grandiflora recorded highest organic matter digestibility value of 69.67 g/kg DM followed by Medicago sativa (Lucerne) (67.53 g/kg DM), Macroptilium atropurpureum (67.40 g/kg DM), Stylosanthes hamata (62.25 g/kg DM) and Moringa oleifera (60.71 g/kg DM), respectively.

Yield of crude protein in five leguminous fodders ranged from 2.24 to 15.57 t/ha/yr. *Sesbania grandiflora* showed highest crude protein yield of 15.57 t/ha/yr followed by *Moringa oleifera*, *Medicago sativa* (Lucerne), *Stylosanthes hamata* and *Macroptilium atropurpureum* (Siratro) with values of 7.36, 5.36, 3.37 and 2.27 t/ha/yr, respectively.

Yield of NDF in five leguminous fodders ranged from 7.8 to 27.47 t/ha/yr. *Moringa oleifera* showed highest NDF yield of 27.74 t/ha/yr followed by *Sesbania grandiflora*, *Medicago sativa* (Lucerne), *Stylosanthes hamata* and *Macroptilium atropurpureum* (Siratro) with the values of 21.67, 13.25, 12.18 and 7.8 t/ha/yr, respectively.

ME yield of leguminous fodder varieties *viz. Medicago sativa* (Lucerne), *Sesbania grandiflora, Moringa oleifera, Macroptilium atropurpureum* (Siratro) and *Stylosanthes hamata* is presented in Table 4.9. Yield of ME in five leguminous fodders ranged from 156.32 to 622.85 MJ/ha/yr. *Sesbania grandiflora* showed highest ME yield of 622.85 MJ/ha/year followed by *Moringa oleifera*, *Medicago sativa* (Lucerne), *Stylosanthes hamata* and *Macroptilium atropurpureum* (Siratro) with values of 541.26, 244.99, 188.22 and 156.32 MJ/ha/yr, respectively.

The metabolizable energy for five variety of non-leguminous fodders ranges from 6.50 to 7.8 MJ/kg. CO-5 recorded highest ME value of 7.8 followed by BHN-18 (7.6), Phule-1 (7.71), COFS-31 (6.77) and Bundel guinea (6.50), respectively.

The organic matter digestibility of five variety of non-leguminous fodders ranges from 49.56 to 79.58 g/kg DM. CO-5 recorded highest organic matter digestibility value of 79.58 g/kg DM followed by BHN-18 (66.43 g/kg DM), Phule-1 (58.24 g/kg DM), COFS-31 (52.18 g/kg DM) and Bundel guinea (49.56 g/kg DM), respectively.

Crude protein yield for non-leguminous fodder crops ranged from 2.37 to 5.19 t/ha/yr. COFS-31 showed the highest crude protein yield of 5.19 t/ha/yr followed by CO-5 (4.60 t/ha/yr), Bundel guinea (3.26 t/ha/yr), Phule-1 (3.15 t/ha/yr) and BHN-18 (2.37 t/ha/yr).

NDF yield for non-leguminous fodder crops ranged from 19.23 to 74.62 t/ha/yr. COFS-31 showed highest NDF yield with value of 74.62 t/ha/yr followed by CO-5, Bundel guinea, Phule-1 and BHN-18 with values of 55.80, 48.68, 37.46 and 19.23 t/ha/yr, respectively.

Yield of energy in non-leguminous fodder varieties *viz.* BHN-18, CO-5, Phule-1, Bundel guinea and COFS-31 is presented in Table 4.10. Energy yield for non-leguminous fodder crops ranged from 232.31 to 663.33 MJ/ha/yr. COFS-31 showed highest ME yield of 827.57 MJ/ha/year followed by CO-5, Bundel guinea, Phule-1 and BHN-18 with values of 663.33, 421.18, 387.55 and 204.35 t/ha/yr, respectively.

Based on the results of the present study the following conclusions can be drawn

1. Among the selected leguminous fodders *Sesbania grandiflora* is high yielding (299.62 t/ha/yr), highest DOMDM yield (40016 t/ha/yr), highest CP content and CP yield (23.65% and 15.57 t/ha/yr) compared to other fodders grown this region and can be recommended for feeding the livestock followed by other fodder *viz. Moring oleifera*, *Medicago sativa* (Lucerne), *Stylosanthus hamata* and *Macroptilium atropurpureum* in decreasing order.

2. Among the selected non-leguminous fodders CO-5 is high yielding (353.08 t/ha/yr), highest DOMDM (50808 t/ha/yr), with 5.93% of CP, 4.60 t/ha/yr of crude protein yield is well suited for feeding and increasing the animal productivity followed by other fodders viz. COFS-31, Bundel guinea, Phule-1 and BHN-18 in decreasing order.

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VIII. ABSTRACT

A study was conducted in fodder museum maintained under Department of Livestock Production and Management to evaluate total ten varieties of fodders including five leguminous and five non-leguminous fodder crops for their yield, chemical composition, energy content and DOMDM. Yield was recorded in tonnes/ha/yr, chemical composition and Hohenheim gas test was carried out by using the grounded sample as per the standard recommended procedures for each. The study revealed that among leguminous fodder variety *Sesbania grandiflora* showed highest biomass yield of 299.62 t/ha/yr with crude protein, NDF percent, protein yield, DOMDM and metabolizable energy of 23.65 %, 33.01 %, 15.57 t/ha/yr, 40016t/ha/yr and 9.49 MJ/kg is well suited for growing in this area followed by other fodder *viz. Moring oleifera*, *Medicago sativa* (Lucerne), *Stylosanthus hamata* and *Macroptilium atropurpureum* in decreasing order. Whereas among the five non-leguminous fodder crops CO-5 showed highest yield of 353.08 t/ha/yr with crude protein, NDF, protein yield, DOMDM and Metabolizable energy content of 5.93%, 72.01%, 4.60 t/ha/yr, 50808T/ha/yr and 7.8 MJ/kg, respectively is recommended in this region for feeding more number of animals with small area for cultivation followed by other fodders viz. COFS-31, Bundel guinea, Phule-1 and BITN-18 in decreasing order.

Abstract

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ನಮ್ಮ ussj.d^) ಸಾಮಾನ್ಯವಾಗಿ 23ti?i:^ddri^r^ *€jsdai* eS^oio^ s^o^d: ಮೇವಿನ ■adri^Fid, dddo efodoiracn?d>Sc3tid. «5dd g>Sc2Sd Qcdris/<3 ©.Bf dz^ ^,^do ddd: dj3cdstiradris/?d, dj3oQdi3d,Oiid ddcdd ddrl^d;, s;ddd: rbo^h e^ad, djeS dB rtodd^) sod: Bddd *io^d^* assrd dd^? ddKs^^d:, sjcj,r^ uosoidd doB: ddFdci dsoridia sodod dofdd dojs.XiOdod^) d^d: e^d^odd doedociodB:. ddo e)d,oddd(3 s&edd ddri^ gB:da, os^jiiodd^ djsfdsciodri^/ ^drora, d^ಜಪ್ಪ (dddr) doB: d.d.ddd.Q.ddd. «5odri^ ddjsrad sod «i>d,odd drodoDodB:. ds e^d.odddi^ doddjodd sfefdd ಸ್ಯಾಂಪಲ್‌ಗಳನ್ನು 2od^ ^draf^B d^drid ^ssd esc^^^odd S^rirodaoiodB:. Q^ds;^ (derdd^d^j^) doedd dsjjds/S eidd eB deSd ei'odd JiFF.LJ) *d?d/d^a^/ddF* ^,d:do, 33v.L§3 dBdB ^*sgs* d(3,cd?d, 3.3^00 dBBB eod.d.s:^., 093.932. dFd/d^cd/ddr dra,fdFd gsddo, %'OOOL d?d/co^o^/ddF d.d.eodd.d.eodd. d:B: F.iVF sodd.d/^.d. dddsrorbdoBd dS Bjseadd^ciઘds/di3 ಒಳ್ಳೆಯ doedd dd sood: BddoBB d:d, dd:B djsd:, d)djsf?j3oB?j^ ddesd doB: Xiuo^ ^,*<5*^ _^,d:d(3d sood: e^d^oddOod ^oddsooQd. s:^ds;J(FroFd-dcrddodxf) doedd d(dd«^d *Sj:e-93* dddjoB: 3v933v.OC5 dFd/d^cd/ddr ^sddo, 93.F3v ^BBB ^250 sira,cd?d, 2_2.CO ^BBB soFd.d.sOSid., 'V.LO dFd/d^cd/ddr sdra.cdFd gsddo, 93Oiaoia d?d/co^o^/ddF d.d.eodd.d.sodd. d:B: *S..*^ sddd.d/S.d. dddsrorddoBd BS cdraoQd: BddoBd Ai-Zs^-cOs^.d^f.-SwO, zooodfsd hfOoiro,.d:d-Q doB: d.sdza^.eOFd.-Oe; dddsd Bdಆd suti,s^ srossddodd dfdsrarbBdod: r ಈ esd odddd BoddzooQd. Bs doedd «5d oddQod *ddB* d:?dd d«?riBd e^rid d:B: soBdB ddcdd d^BBS ^js-93 ddcdd ds/dB: B^ cijoddS d^odB: dj3^ doB: dd: ^B:dQodd:^ ^jseds^dOod B^BOd ಆರ್ಥಿಕ cdraBodd:, ^dd: dosdo: e)dj3^:o^B sood: B^d: sooQd.

Appendices

APPENDIX I

Proximate analysis of leguminous fodders

Sl. No.	Fodder varieties	DM	CP	TA	OM	EE
1.	*Medicago sativa* (Lucerne)-I	91.74263	19.50332	10.31401	89.68599	3.613008703
2.	*Medicago sativa* (Lucerne)-II	91.61769	21.37757	12.83474	87.16526	3.62595528
3.	*Medicago sativa* (Lucerne)-III	90.46536	20.00596	10.18097	89.81903	3.672659792
4.	*Macroptilium atropurpureum* (Siratro)-I	93.02933	14.20286	10.21242	89.78758	2.461605895
5.	*Macroptilium atropurpureum* (Siratro)-II	94.6869	14.85909	10.42999	89.57001	2.419250035
6.	*Macroptilium atropurpureum* (Siratro)-III	92.66253	12.11774	9.456188	90.54381	2.489447547
7.	*Stylosanthes hamata hamata-I*	93.50099	14.89138	7.303849	92.69615	2.028217803
8.	*Stylosanthes hamata hamata-W*	93.6867	15.07587	7.316681	92.68332	2.024991495
9.	*Stylosanthes hamata hamala-*	94.03713	15.25434	7.23261	92.76739	2.017119842
10.	*Sesbania grandiflora grandiflora-I*	93.12754	25.86976	8.865244	91.13476	3.713557765
11	*Sesbania grandiflora grandiflora-^l*	94.09195	26.51958	8.718582	91.28142	3.676496124
12.	*Sesbania grandiflora grandiflora-}!!*	94.47925	27.29607	7.971173	92.02883	3.661098763
13.	*Moringa oleifera oleifera-I*	92.28735	12.2461	8.519527	91.48047	4.655307878
14.	*Moringa oleifera oleifera-^I*	92.2783	12.25621	9.083494	90.91651	4.633119184
15.	*Moringa oleifera oleifera-^H*	92.97887	12.30773	9.304125	90.69588	4.61998957

APPENDIX II

Cell wall fractions of leguminous fodders

SI. No.	Fodder varieties	NDF	NDA	ADF	ADL	ADFA
1.	*Medicago sativa* (Lucerne)-I	49.5929363	0.982276	30.05272659	6.821733442	1.370707909
2.	*Medicago sativa* (Lucerne)-II	50.14779592	0.805535	30.08336144	6.828687519	1.383012389
3.	*Medicago sativa* (Lucerne)-III	50.76536793	0.815454	30.45365049	6.912740445	1.400035668
4.	*Macroptilium atropurpureum* (Siratro)-I	47.96920743	0.042716	37.43187853	7.891677825	2.337660006
5.	*Macroptilium atropurpureum* (Siratro)-II	47.1814462	0.041958	37.89895819	8.982344739	2.864848639
6.	*Macroptilium atropurpureum* (Siratro)-III	48.2004338	0.042865	38.21008057	9.181600678	2.15025777
7.	*Sty'losanthes hamata hamata-V*	54.89093057	0.299017	41.6800872	7.071109983	1.258508262
8.	*Sty'losanthes hamata hamata-Vl*	54.80734697	0.298561	41.58341471	7.054709303	1.255589288
9.	*Sty'losanthes hamata hamata-W.*	53.55772559	0.297539	41.43689319	7.029851634	1.25116514
10.	*Sesbania grandiflora grandiflora-l*	33.4335672	0.598543	28.12597562	4.993712623	1.589851548
11.	*Sesbania grandiflora grandiflora-M*	33.19161238	0.592228	28.80233924	4.785450704	2.240733093
12.	*Sesbania grandiflora grandiflora-Ml*	32.40333906	0.548139	28.37945752	4.715189334	2.648454963
13.	*Moringa oleifera oleifera-V*	45.6910944	0.50384	37.4515711	5.186987496	1.552838053
14.	*Moringa oleifera oleifera-\i*	45.9069789	0.536311	38.03025341	5.478183212	1.768535088
15.	*Moringa oleifera oleifera-\dl*	45.55231453	0.532168	37.71456368	5.423433818	1.82916692

APPENDIX III

Proximate analysis of non-leguminous fodders

Sl. No.	Fodder varieties	DM	CP	TA	OM	EE
1.	BHN-18-I	93.20142	10.83006	21.07289	78.92711	3.37044958
2.	BHN-18-II	92.20655	8.314244	14.30347	85.69653	3.345071303
3.	BHN-18-III	92.39565	7.352606	14.43531	85.56469	3.337637243
4.	CO-5-I	93.33327	5.819175	14.25676	85.74324	1.789832684
5.	CO-5-II	93.47944	5.735192	14.26341	85.73659	1.796570462
6.	CO-5-III	93.3427	6.252568	14.26341	85.73659	1.789936971
7.	Phule-I	93.61713	5.92715	12.09255	87.90745	2.381374354
8.	Phule-II	93.74844	6.548923	11.97112	88.02888	2.378857456
9.	Phule-III	93.75701	6.306865	11.95965	88.04035	2.378210875
10.	Bundel Guinea-I	94.13714	5.139479	9.789188	90.21081	1.408033613
11	Bundel Guinea-II	95.78541	4.828867	10.03269	89.96731	1.384236114
12.	Bundel Guinea-III	95.70471	5.136799	10.48519	89.51481	1.402409647
13.	COFS-I	94.15364	6.015814	7.546397	92.4536	1.274455744
14.	COFS-II	94.97845	5.169675	8.977901	91.0221	1.26387296
15.	COFS-III	93.60689	4.720133	7.391356	92.60864	1.282371884

APPENDIX IV

Cell wall fractions of non-leguminous fodders

Sl. No.	Fodder varieties	NDF	NDA	ADF	ADL	ADFA
1.	BHN-18-I	71.29523924	1.858725	41.32010588	8.368979744	5.072549095
2.	BHN-18-II	71.7365288	1.58841	41.73841695	8.436497621	5.126534195
3.	BHN-18-III	71.56052438	1.584512	41.60598522	8.392472789	5.123747772
4.	CO-5-I	72.03287827	2.035485	44.83646948	5.043285533	7.321994693
5.	CO-5-II	71.9531707	2.033233	45.18741051	5.324157122	7.744022613
6.	CO-5-III	72.03926976	2.035666	45.20856703	5.098251323	7.738981206
7.	Phule-I	75.34776255	2.33529	47.45523385	9.684690786	5.798300442
8.	Phule-II	74.07074517	2.312369	47.37051532	10.08395049	5.787949284
9.	Phule-III	74.14169332	2.254774	46.38183057	10.93893037	5.739943162
10.	Bundel Guinea-I	75.90845148	1.220245	52.35242699	9.507299423	4.204964709
11.	Bundel Guinea-II	74.67472092	1.241819	51.43009666	9.488207753	4.110009708
12.	Bundel Guinea-III	74.78752209	1.24335	51.45263241	10.39378871	4.111810409
13.	COFS-31-I	75.91996854	1.227339	53.28629922	11.759852	5.33381269
14.	COFS-31-II	76.13760208	1.230001	52.80512099	11.65365999	5.285648114
15.	COFS-31-III	76.39766489	1.170305	53.51465055	11.82114669	5.250293079

APPENDIX V

Cumulative gas production at different intervals-leguminous fodders

Time interval (h)	**2**	**4**	**6**	**8**	**12**	**16**	**24**	**36**	**48**	**60**	**72**	**96**
Medicago sativa (Lucerne)	6.65	11.33	18.49	25.66	33.54	36.71	41.15	45.75	48.97	50.01	50.99	51.64
Sesbania grandiflora	7.34	12.36	20.58	28.31	35.73	37.98	40.87	44.09	46.49	46.79	47.39	47.96
Moringa oleifera	10.25	15.71	23.15	29.07	35.21	37.62	40.74	44.07	46.39	47.42	48.27	49.16
Macroptilium atropurpureum (Siratro)	8.94	13.39	19.91	27.93	36.76	40.88	45.88	49.96	52.38	53.46	54.29	55.11
Stylosanthes hamata	7.07	10.13	16.57	23.49	30.81	34.03	39.20	43.85	47.16	48.48	49.44	50.25

APPENDIX VI

Cumulative gas production-Non-leguminous fodders

Time interval (h)	**2**	**4**	**6**	**8**	**12**	**16**	**24**	**36**	**48**	**60**	**72**	**96**
BHN-18 (Bangalore hybrid napier)	3.66	6.71	9.77	16.56	27.25	34.94	44.24	51.95	56.01	58.42	60.17	61.47
CO-5 (Coimbatore-5)	9.59	14.14	18.91	25.06	33.28	38.78	47.94	56.02	60.11	63.40	65.07	68.04
Phule-1	6.41	8.03	12.20	17.69	25.78	30.73	37.03	43.06	47.09	48.53	50.14	51.67
Bundel Guinea	4.97	5.87	8.81	14.29	20.22	23.58	28.80	34.12	37.63	39.88	41.71	43.69
COFS-31 (Coimbatore fodder sorghum)	5.78	7.75	9.82	14.86	21.30	25.03	31.47	39.02	44.21	47.78	50.28	53.22