

**EVALUATION OF FORAGE QUALITY OF GRASSES AND
LEGUMES AT DIFFERENT GROWTH STAGES**

by

Mr. Borade Suresh Devidas

(Reg. No. 018/266)

A Thesis submitted to the
**MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHMEDNAGAR
MAHARASHTRA, INDIA**

in partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

BIOCHEMISTRY



DEPARTMENT OF BIOCHEMISTRY

**POST GRADUATE INSTITUTE
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2021

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
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for a Degree or
Diploma

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Date : / /2021

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This is to certify that the thesis entitled, “**EVALUATION OF FORAGE QUALITY OF GRASSES AND LEGUMES AT DIFFERENT GROWTH STAGES**” submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M.S.) in partial fulfillment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **BIOCHEMISTRY**, embodies the results of a piece of *bona fide* research work carried out by **Mr. BHORADE SURESH DEVIDAS** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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Place: M.P.K.V., Rahuri

(Suresh D. Bhorade)

Date: / /2021

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LIST OF ABBREVIATION

ADF	: Acid detergent fibre
Ca	: Calcium
C.D.	: Critical difference
CF	: Crude fibre
CP	: Crude protein
DM	: Dry matter
EE	: Ether extract
F.R.B. D	: Factorial randomized block design
<i>Et al.</i>	: And others
Fig.	: Figure
g	: Gram
GDP	: Gross domestic product
ha	: Hectare
HCl	: Hydrochloric acid
H	: Hour (s)
IVDMD	: <i>In vitro</i> dry matter digestibility
i.e.	: That is
Mg	: Magnesium
mg	: Milligram (10^{-3} g)
ml	: Milliliter (10^{-3} liter)
NDF	: Neutral detergent fibre
nm	: Nanometer (10^{-9} meter)
%	: Percent
S.E.	: Standard Error
viz.	: Namely
v/v	: Volume by volume
w/v	: Weight by volume
Zn	: Zinc

ABSTRACT

EVALUATION OF FORAGE QUALITY OF GRASSES AND LEGUMES AT DIFFERENT GROWTH STAGES

by

MR. BHORADE SURESH DEVIDAS

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RAHURI – 413 722

2021

Research Guide	:	Dr. S.V. Damame
Department	:	Biochemistry

The present research work entitled, “Evaluation of forage quality of grasses and legumes at different growth stages” was carried out to evaluate the proximate composition and forage quality of different grasses and legumes, in relation to dry matter, crude protein, crude fibre, ether extract, ash, total carbohydrate, cell wall constituents, *in vitro* dry matter digestibility, calcium, magnesium and zinc.

Among the four cereal grasses evaluated, marvel (*Dichanthium annulatum*) (Forssk.) Staf recorded the highest mean dry matter, total carbohydrates, ether extract, *in vitro* dry matter digestibility, ash, calcium, magnesium and zinc with 44.25, 63.56, 1.12, 57.06, 11.70, 0.19, 0.33 per cent and 6.95 ppm, respectively. It also recorded the lowest crude fibre, neutral detergent fibre, acid detergent fibre and lignin of 27.47, 63.77, 40.30 and 4.9 per cent, respectively. While, madras anjan (*Cenchrus ciliaris* L.) recorded the highest mean crude protein content of 7.37 per cent and the lowest mean hemi-cellulose content of 22.17 per cent among the grasses. Among the four legumes evaluated stylo (*Stylosanthes seabrana*) B.L. Maass & t Mannatje recorded the highest mean dry matter, crude protein, ether extract, total carbohydrates, *in vitro* dry matter digestibility, calcium, magnesium and zinc with 40.25, 15.23, 1.90, 57.22, 60.75, 2.10, 0.29 per cent and 11.07 ppm, respectively. It also recorded the lowest crude fibre, neutral

detergent fibre, acid detergent fibre, hemi-cellulose and lignin 8.76, 25.22, 46.93, 40.3, and 11.3 per cent, respectively. While, ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb recorded the highest ash content of 7.47 per cent than other legumes.

As regard to growth stages, the per cent dry matter, crude fibre, ether extract, neutral detergent fibre, acid detergent fibre, hemi-cellulose and lignin in grasses as well as legumes were increased with the advancement of growth stages. The crude protein, ash, calcium, magnesium, zinc and *in vitro* dry matter digestibility were decreased with advancement of growth stages.

In conclusion, based on the biochemical parameters studied, marvel (*Dichanthium annulatum*) (Forssk.) Staf within cereal grasses and stylo (*Stylosanthus seabrana*) B.L. Maass & t Mannatje within legumes forages studied were found better for most of the forage quality parameters. Among growth stages studied forage quality of all forage grasses and legumes at pre flowering stage was much higher, followed by 50 per cent and post flowering stage. Overall, cutting of forages at 50 % flowering stage would be always preferred because of higher dry matter yield with optimum forage quality traits.

1. INTRODUCTION

Agriculture is the backbone of Indian economy and livestock sector as an integral part of agriculture. India contributing about 2.14 per cent of the world's geographical area, has merely 8.3 m ha (4.4 %) cropped area under forage crops and there is hardly any scope of its future expansion because of the existing pressure on agricultural land for food and cash crops. The land use pattern in India is predominantly based on the grains, fibres and cash crops productions.

India account for worlds 15 per cent of the total livestock population which is dependent upon 2 per cent worlds geographical area. Livestock contribution to national GDP of India is 4.11 per cent which is a major source of employment and ultimate livelihood for 70 per cent population in rural living areas. (Kumar *et al.*, 2019). The total livestock population in India was 536.76 million in 2019 which includes 303.75 million bovines (cattle, buffaloes, mithun and yak), 74.26 million sheep, 148.88 million goat, 9.06 million pigs, 0.25 million camels and 0.54 million other livestock. In Maharashtra total livestock population was 33.1 million. There is an increase in total livestock population by 4.82 % in India and 1.83 % in Maharashtra over last census of 2019 (20th Livestock census of India 2019).

Livestock plays an important role in sustainable livelihood, nutritional and environmental security and growth of agriculture. Livestock has contributed a major role in generating cash income through the production of milk, butter, meat, egg, hides, skin, wool and manure (Dhungana *et al.*, 2012). The major advances made in the livestock sector in the past decades are major reasons for growth rate recorded in agricultural sector. In spite of having huge livestock population, the milk productivity is very low as compared to the world average and much below the developed countries. Nutrition is one of the most critical constraints to increase animal productivity in developing countries (ILRI, 1995). The level of crude protein, the essential amino acids and metabolizable energy in the recipes for livestock and poultry has a significant impact on productivity and depends on the breed, genetic potential, nutrition and maintenance technology (Stepurin and Vrancean, 2008).

Multiplicity of factors affects the rate of change in nutrient composition with advancing plant development and maturity stages. These factors may include any

one or a combination of the following: plant type, climate, season, weather, soil type and fertility, soil moisture, leaf stem ratio, physiological and morphological characteristics and others, and may vary with annuals vs. perennials, grasses vs. legumes, etc. The inherent nutrient composition within plants varies between crops, between what are classified as cool-season or warm-season plants, temperate zone and tropical crops, and other influencing parameters. It is evident, however, that most plants show a similarity in declining nutrient composition with advancing development towards maturation (Kilcher,1981) in an over simplified classification the important nutrients are found as proteins, carbohydrates, and fats. The utilization of these by animals is referred to as the digestible energy (DE), nutritive value of the plant.

There is a wide gap between demand and supply of quality feed and forage. Increasing human population and growing preference for cultivating food and commercial crops are sparing only a limited area for forage production (Radotra and Katoch, 2002). In most parts of tropics and sub-tropical countries, the grazing of available native grassland largely supports the production of ruminants (Aregheore, 2001). In the developing countries like India where many grazing animals are reared, natural grasslands have remained the source of nutrient for livestock. In India, the traditional feeding systems, make maximum use of local resources like crop residues, tree leaves, pods, seeds, etc. (Pradhan *et al.*, 1991). At present our animals are being fed with low grade roughages such as paddy straw, wheat straw and *jowar kadbi* without any processing. This results in lower nutrients availability to the animals. Therefore, it is necessary to increase the forage production by selecting best forage crops, varieties and nutritional qualities which is the only way, in present situation to meet out the nutritional requirement of our livestock and to increase the animal production for human consumption.

Chronic shortage of feeds and forages together with poor nutritive value of available feeds has lowered the productivity and fertility of Indian livestock. Even in future, the diversion of area under other food or commercial crops towards forage crop production would not be possible because of preferential human food and other national economic compulsion, this gap in requirement and availability would further aggravate due to increase in livestock population. One of the main impediments in the way of

improvement of animal husbandry sector is insufficient quantity of quality forage. Cereal forage and crop residue are major sources of forage, but the nutritive value of these forages is not adequate for getting high milk production.

The latest status of the deficit of green and dry forage are 35.6 and 10.95 per cent, respectively in India (Kumar *et al.*, 2019). Due to tremendous hike in concentrate feed cost alternative feeds may provide nutrients needed by cattle at a lower cost than traditional feeds. One such alternative feed for livestock is tree forage/shrubs feeding because tree forages contain high levels of crude protein, ether extract, gross energy minerals and many show high levels of digestibility. Forage legume tree leaves and shrubs always a role in the animal production system. However, anti-nutritive factors (tannins, mimosine) can be a problem in some species (Paterson *et al.*, 1998).

Very little attention is given for forage production or it is almost neglected. Forages are one of the cheapest sources of nutrients as they not only meet the requirements of bulk to be fed to the cattle, but also supply desired amount of protein, energy, minerals as well as vitamins to a large extent when they are properly managed, fertilized and harvested at proper stage of growth. The factors that have been reported to affect the nutrient value of herbaceous plants are seasonal variability (Snyman, 1998), management aspects (Van der Westhuizen *et al.*, 2005), species variation (Arzani *et al.*, 2008) and grazing pressure (Henkin *et al.*, 2011). It is essential to have forage crops which will produce heavy tonnage of succulent green leafy material as well as good nutritional composition.

The accuracy with which animal performance is predicted depends upon the knowledge of energy requirement and nutritive value of feeds and forage consumed. Thus, we need to analyze the forage grasses for their nutritive value by which we can be able to formulate high nutritive, energetic and low-cost feed. At present more emphasis is given on the breeding programme of the forage grasses, keeping the nutritive aspect aside. Analyzing the forage grasses, we can determine their total digestibility, energy supply and other nutrients required to the animals. This analytical aspect is also helpful in breeding programme of forage grasses to formulate high nutritive varieties. The digestibility of feeds is related to their chemical composition. In a statistical study of digestibility data, Schneider and Lucas (1950) found that 25 to 45 per cent variance in

digestibility between samples of a given feed is associated with proximate composition. As we know that two feeding stuffs are not similar in their chemical composition and physical characteristics, in practical, substitution of one feeding stuff is made with other depending upon the market price and availability in that region. Deficiency of any mineral element in animal diet will cause other more severe systematic adverse effects before the digestibility is influenced. Knowing proximate composition, we can justify for the feeds having similar nutritional properties in formulating substitutions. The utility of forage grasses as a source of nutrients depends upon their green forage yield, chemical composition and nutritive value.

In India, the proximate analysis of the forage and feeds was started during early twenties at Pusa. This work was continued in the Animal Nutrition Division, Indian Veterinary Research Institute (IVRI), Izatnagar (1939); National Dairy Research Institute (NDRI), Karnal (1956); Regional Stations at Bangalore, Anand, Bombay, Palampur and University Departments of Animal Nutrition. The work up to 1948 on chemical composition was reviewed in the monogram entitled, Animal Nutrition Research in India and from 1929 to 1954 by Kehar (Anon, 1962) in the book entitled, 'Research in Animal Husbandry'. The AICRP on Forage Crops & Utilization was started at Mahatma Phule Krishi Vidyapeeth, Rahuri from 1972. Under this scheme, several new strains of forage grasses are developed for higher yield. However, their detailed chemical composition and nutritive value during different growth stages are not determined.

Therefore, present study was carried out to evaluate the forage quality and proximate composition of some of the grasses and legumes forages at different growth stages. This study will be helpful to recommend proper stage of harvesting for higher nutritive value in selected forage crops.

The objectives of present study are as follows:

1. To find out forage quality of grasses and legumes at different growth stages.
2. To find out micronutrient content in grasses and legumes at different growth stages.

2. REVIEW OF LITERATURE

The grasses and legumes are an important forage crops for livestock as it contains appreciable amount of nutrients. Accordingly, efforts have been made to evaluate some grasses and legumes for their forage quality and micronutrients. In this chapter an attempt has been made to review some of the previous, important and related references available on this topic.

2.1 Chemical composition

2.1.1 Dry matter

Dry matter is one of the important factors for assessing forage quality. Higher dry matter is a positive aspect for higher feed yield. DM is the percentage of forage estimated by subtracting the per cent moisture from 100. The ration formulations per nutrient requirements of animals are expressed on a DM basis. Also, animal intake is regulated more by DM intake than volume of feed consumed.

Khan *et al.* (2013) carried out an experiment on some terrestrial weeds at seed production stage and reported that 91.09 per cent dry matter content in marvel (*Dichanthium annulatum*) (Forssk.) staf. Sultan *et al.* (2008) studied nutritional composition of different free rangeland grasses at early bloom and maturity stage reported 33.7 and 41.8 per cent dry matter content in marvel (*Dichanthium annulatum*) (Forssk.) staf at above growth stages, respectively. Surana *et al.* (2013) reported chemical composition of Marvel-6-40 and Marvel-8 with respect to dry matter content was 30.25 and 29.37 per cent, respectively.

Manzoor *et al.* (2013) studied nutritive value and *in-situ* digestibility of irrigated grasses reported 21.75 per cent dry matter content in madras anjan (*Cenchrus ciliaris* L.) at pre-flowering stage. Sultan *et al.* (2007) observed that highest dry matter content in madras anjan (*Cenchrus ciliaris* L.) at maturity stage was 38.8 per cent and lowest dry matter content at early bloom stage was 27.9 per cent they concluded dry matter content increased with maturity stages of gasses. Rafay *et al.* (2013) reported 96.00 per cent dry matter content in madras anjan (*Cenchrus ciliaris* L.). Khan *et al.* (2017) studied nutritive values of tropical forages at early, medium and late growth stages. The dry matter content in madras anjan (*Cenchrus ciliaris* L.) was 15.6, 20.8 and

21.1 per cent, respectively and they concluded the dry matter content progressively increased with maturity of grasses.

Jayprakash *et al.* (2016) studied biomass yield and chemical composition of dashrath grass (*Desmanthus virgatus*) and (*Stylosanthes hamata*). It was reported that dry matter content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and stylo (*Stylosanthes hamata* L.) Taub was 29.14 and 34.12 per cent, respectively. It was concluded that *Desmanthus virgatus* and *Stylosanthes hamata* had relatively high protein, ether extract and energy content and thus have the potential to be a good alternate feed source for ruminant animals. Musco *et al.* (2016) reported 87.41 per cent dry matter content in stylo (*Stylosanthes hamata* L.) Taub.

Edgar *et al.* (2017) reported that 21.98 per cent dry matter content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Suksombat and Buakeeree (2006) recorded dry matter content at three different cutting intervals i.e. 30, 40 and 50 days after sowing. They showed lowest dry matter content of 31.77 per cent at 30 days cutting interval and highest dry matter content of 35.36 per cent at 50 days cutting interval and 32.58 per cent at 40 days cutting interval in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.).

Garg *et al.* (2012) conducted experiment to assess nutritional characteristics of some ruminant feedstuffs by using *in vitro* gas production technique reported that, dry matter content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb was 28.22 and 24.80 per cent, respectively. Ahmed and Ahmed (2015) found that 96.74 per cent dry matter content in siratro (*Macroptilium atropurpureum*) (DC.) Urb.

2.1.2 Crude protein

The crude protein estimation gives quick idea about the nutritive value of forage. Protein is the source of amino acids and nitrogen in feeds. Protein is needed by livestock for growth and milk production. It is also needed by rumen bacteria, which digest much of the feed for ruminant animals like cattle, sheep and goats.

Khan *et al.* (2013) carried out an experiment on some terrestrial weeds at seed production stage reported 16.30 per cent crude protein content in marvel (*Dichanthium annulatum*) (Forssk.) Staf. Sultan *et al.* (2008) studied nutritional

composition of different free rangeland grasses at early bloom and maturity stage reported 6.4 and 4.3 per cent crude protein content in marvel (*Dichanthium annulatum*) (Forssk.) staf at above growth stages, respectively. Surana *et al.* (2013) reported chemical composition of Marvel-6-40 and Marvel-8 with respect to crude protein content was 6.41 and 6.56 per cent, respectively.

Kauthale *et al.* (2017) carried out experiment on nutritional evaluation of selected forage species reported crude protein content in pawana (*Sehima nervosum*) (Rottler) Stapf, marvel (*Dichanthium annulatum*) (Forssk.) Staf, dongari grass (*Crysopogan fulvus*) (Spreng) Chiov and stylo (*Stylosanthes hamata* L.) Taub were 4.31, 4.97, 4.23, and 10.17 per cent, respectively.

Manzoor *et al.* (2013) studied nutritive value and *in-situ* digestibility of irrigated grasses reported crude protein content in madras anjan (*Cenchrus ciliaris* L.) was 11.13 per cent at pre-flowering stage. Sultan *et al.* (2007) observed that lowest crude protein content of 5.4 per cent in madras anjan (*Cenchrus ciliaris* L.) at maturity stage and highest crude protein content of 8.7 per cent at early bloom stage, they concluded protein content decreased with maturity stage of grasses. Rafay *et al.* (2013) reported that 4.37 per cent crude protein content in madras anjan (*Cenchrus ciliaris* L.). Khan *et al.* (2017) reported nutritive values of tropical forage, madras anjan (*Cenchrus ciliaris* L.) at early, medium and late growth stages, the crude protein content was 9.32, 8.32 and 5.52 per cent, respectively. It was concluded that crude protein content progressively decreased with enhancement of maturity of grass. Teka *et al.* (2012) observed that maturity of madras anjan (*Cenchrus ciliaris* L.) led to decrease in protein content. The resultant values of crude protein content were 8.56 and 5.94 per cent at early and late stage, respectively. Rasool *et al.* (2013) found that 9.70 per cent crude protein in madras anjan (*Cenchrus ciliaris* L.). Melesse *et al.* (2017) studied the nutritional composition of grasses reported crude protein content in madras anjan (*Cenchrus ciliaris* L.) was 8.2 per cent at pre-flowering stage.

Musco *et al.* (2016) reported 12.62 per cent crude protein content in stylo (*Stylosanthes hamata* L.) Taub. Gupta *et al.* (2011) reported 13.5 per cent crude protein content in stylo (*Stylosanthes hamata* L.) Taub. Ratnawaty *et al.* (2013) reported 18.17

per cent crude protein content when harvested on 120 days after planting in stylo (*Stylosanthes seabrana*) B.L Maass & t Mannatje.

Jayprakash *et al.* (2016) studied biomass yield and chemical composition of hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and stylo (*Stylosanthes hamata* L.) Taub. It was reported that crude protein content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and stylo (*Stylosanthes hamata* L.) Taub was 22.66 and 13.90 per cent, respectively. It was concluded that *Desmanthus virgatus*, *Stylosanthes hamata* had relatively high protein, ether extract and energy content and thus have the potential to be a good alternate feed source for ruminant animals. Das *et al.* (2015) reported 19.1 per cent crude protein in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Edgar *et al.* (2017) reported that 24.65 per cent crude protein content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Suksombat and Buakeeree (2006) recorded crude protein content at three different cutting intervals i.e. 30, 40 and 50 days after sowing. They showed highest crude protein content was 18.62 per cent at 30 days cutting interval and lowest crude protein content was 14.37 per cent at 50 days cutting interval and 15.81 per cent at 40 days cutting interval in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.).

Garg *et al.* (2012) conducted experiment on nutritional characteristics of some ruminant feedstuffs by using *in vitro* gas production technique reported, crude protein content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb was 18.75 and 13.06 per cent, respectively.

Kumar *et al.* (2016) conducted experiment on enhanced quality forage production through grass-legume intercropping under arid eco-system of Kachchh, Gujarat. It was reported that crude protein content in madras anjan (*Cenchrus ciliaris* L.), marvel (*Dichanthium annulatum*) (Forssk.) and stylo (*Stylosanthes hamata* L.) Taub were 6.80, 6.50 and 15.78 per cent, respectively. It was concluded that marvel grass based intercropping systems are the best grass-legume intercropping system for enhanced quality forage production for overall development of livestock sector.

Ahmed and Ahmed (2015) reported 17.45 per cent crude protein content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb. Tokia *et al.* (2006)

studied amino acid profiles of tropical legumes. It was found that 17.9 and 19.1 per cent crude protein content in ran mung or siratro (*Macroptilium atropurpureum*) at pre-flowering and flowering stages of their first growth, respectively. Jingura *et al.* (2001) reported 16.75 per cent crude protein content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb. Ahmed *et al.* (2015) reported 17.45 per cent crude protein content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb.

2.1.3 Crude fibre

Crude fibre is the insoluble carbohydrate remaining in the feed analysis process after the sample is boiled in weak acid and alkali. Crude fibre is the poorly digested component of a feed. It is made up of plant structural carbohydrate such as cellulose and hemi-cellulose, it also contains some lignin.

Khan *et al.* (2013) carried out an experiment on some terrestrial weeds at seed production stage reported 28.91 per cent crude fibre content in marvel (*Dichanthium annulatum*) (Forssk.) Staf. Surana *et al.* (2013) reported chemical composition of Marvel -6-40 and Marvel-8 with respect to crude fibre content was 38.60 and 44.35 per cent, respectively.

Kauthale *et al.* (2017) carried out experiment on nutritional evaluation of selected forage species reported crude fibre content in pawana (*Sehima nervosum*) (Rottler) Stapf, marvel (*Dichanthium annulatum*) (Forssk.) Staf, dongari grass (*Crysopogan fulvus*) (Spreng) Chiov and stylo (*Stylosanthes hamata* L.) Taub were 29.22, 24.56, 35.73 and 27.09 per cent, respectively. Jayprakash *et al.* (2016) studied biomass yield and chemical composition of hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and stylo (*Stylosanthes hamata* L.) Taub. It was reported that crude fibre content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and stylo (*Stylosanthes hamata* L.) was 22.50 and 25.28 per cent, respectively. It was concluded that *Desmanthus virgatus*, *Stylosanthes hamata* had relatively high protein, ether extract and energy content and thus have the potential to be a good alternate feed source for ruminant animals.

Rafay *et al.* (2013) reported 30.89 per cent crude fibre content in madras anjan (*Cenchrus ciliaris* L.). Rasool *et al.* (2013) found 31.34 per cent crude fibre in madras anjan (*Cenchrus ciliaris* L.). Melesse *et al.* (2017) studied the nutritional

composition of grasses reported crude fibre content in madras anjan (*Cenchrus ciliaris* L.) was 32.2 per cent at pre-flowering stage.

Ratnawaty *et al.* (2013) reported that 38.23 per cent crude fibre content when harvested on 120 days after planting in stylo (*Stylosanthes seabrana*) B.L Maass & t Mannatje. Garg *et al.* (2012) conducted experiment on nutritional characteristics of some ruminant feedstuffs by using *in vitro* gas production technique reported, crude fibre content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb was 22.42 and 23.29 per cent, respectively. Kumar *et al.* (2016) conducted experiment on enhanced quality forage production through grass-legume intercropping under arid eco-system of Kachchh, Gujarat. It was reported that crude fibre content in madras anjan (*Cenchrus ciliaris* L.), marvel (*Dichanthium annulatum*) (Forssk.) and, stylo (*Stylosanthes hamata* L.) were 33.91, 29.21 and 25.43 per cent, respectively. It was concluded that marvel grass based intercropping systems are the best grass-legume intercropping system for enhanced quality forage production for overall development of livestock sector.

Suksombat and Buakeeree (2006) recorded crude fibre content at three different cutting intervals i.e. 30, 40 and 50 days after sowing. The lowest crude fibre content was 19.91 per cent at 30 days cutting interval, the highest of 28.55 per cent at 50 days cutting interval and 26.27 per cent at 40 days cutting interval in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.).

Ahmed and Ahmed (2015) reported 34.66 per cent crude fibre in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb.

2.1.4 Ether extract

Ether extract, also termed as crude fat, is the amount of fat and fat- soluble components in a feed. In addition to fats and oils, it includes plant pigments and fat-soluble vitamins, but it does not tell us how much of each vitamin or fatty acid is present. If a feed is high in fat, it may be susceptible to rancidity, which causes off-flavors, low palatability, and potential toxic effects.

Surana *et al.* (2013) reported chemical composition of Marvel-6-40 and Marvel-8 with respect to ether extract content was 0.93 and 0.89 per cent, respectively.

Kauthale *et al.* (2017) carried out experiment on nutritional evaluation of selected forage species reported ether extract content in pawana (*Sehima nervosum*) (Rottler) Stapf, marvel (*Dichanthium annulatum*), dongari grass (*Crysopogan fulvus*) and stylo (*Stylosanthes hamata* L.) were 0.59, 0.78, 0.76 and 0.76 per cent, respectively.

Rafay *et al.* (2013) reported 1.50 per cent ether extract in madras anjan (*Cenchrus ciliaris* L.). Khan *et al.* (2017) studied nutritive values of tropical forage, madras anjan (*Cenchrus ciliaris* L.) at early, medium and late growth stages, the ether extract content was 7.37, 4.07 and 2.08 per cent, respectively. It was concluded that ether extract content progressively decreased with maturity of grasses. Melesse *et al.* (2017) studied the nutritional composition of grasses reported ether extract content in madras anjan (*Cenchrus ciliaris* L.) was 1.45 per cent at pre-flowering stage.

Jayprakash *et al.* (2016) studied biomass yield and chemical composition of hedge lucerne (*Deshmanthus virgatus* L.) or dashrath grass and stylo (*Stylosanthes hamata* L.) Taub. It was reported that ether extract content in hedge lucerne and stylo (*Stylosanthes hamata* L.) Taub was 2.29 and 2.53 per cent, respectively. It was concluded that *Desmanthus virgatus*, *Stylosanthes hamata* had relatively high protein, ether extract and energy content and thus have the potential to be a good alternate feed source for ruminant animals. Ratnawaty *et al.* (2013) reported that 2.36 per cent ether extract content when harvested on 120 days after planting in stylo (*Stylosanthes seabrana*) B.L Maass & t Mannatje. Musco *et al.* (2016) reported 1.88 per cent ether extract content in stylo (*Stylosanthes hamata* L.) Taub. Gupta *et al.* (2011) reported 1.20 per cent ether extract content in stylo (*Stylosanthes hamata* L.) Taub.

Garg *et al.* (2012) conducted experiment on nutritional characteristics of some ruminant feedstuffs by using *in vitro* gas production technique reported, ether extract content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb was 2.79 and 1.61 per cent, respectively. Das *et al.* (2015) reported 1.9 per cent ether extract in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Suksombat and Buakeeree (2006) recorded ether extract content at three different cutting intervals *i.e.* 30, 40 and 50 days after sowing. They showed highest ether extract content was 2.97 per cent at 30 days cutting interval and lowest ether extract content was 2.62 per cent at 50 days cutting interval and

2.75 per cent at 40 days cutting interval in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.).

Ahmed and Ahmed (2015) found that 2.25 per cent ether extract content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb.

2.1.5 Total carbohydrate

Carbohydrates are initially synthesized in plants by photosynthesis. Carbohydrate are important for providing energy, store energy in the form of starch and glycogen, supply carbon for synthesis of other compounds and form structural components in cells and tissues.

Khan *et al.* (2017) studied nutritive values of tropical forages at early, medium and late growth stages. The total carbohydrate content in madras anjan (*Cenchrus ciliaris* L.) was 66.1, 71.2 and 77.5 per cent, respectively. It was concluded that total carbohydrate content progressively increased with maturity of grasses.

Gupta *et al.* (2011) reported 77.00 per cent total carbohydrate content in stylo (*Stylosanthes hamata* L.) Taub.

Das *et al.* (2015) reported 69.7 per cent total carbohydrate content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.).

2.2 Cell wall constituents

2.2.1 Neutral detergent fibre

Neutral detergent fibre (NDF) is the best indicator of how much forage will be eaten by an animal. NDF is an estimate of the plants cell wall content. The NDF fraction contains hemi-cellulose, cellulose, lignin, heat damaged protein and keratin. NDF is closely associated with total potential intake of the forage by the animal.

Khan *et al.* (2013) carried out an experiment on some terrestrial weeds at seed production stage and reported that 72.61 per cent neutral detergent fibre content in marvel (*Dichanthium annulatum*) (Forssk.) Staf. Surana *et al.* (2013) reported chemical composition of Marvel-6-40 and Marvel-8 with respect to neutral detergent fibre content was 72.40 and 72.30 per cent, respectively. Sultan *et al.* (2008) studied nutritional composition of different free rangeland grasses at early bloom and maturity stage and reported 57.00 and 66.00 per cent neutral detergent fibre content in marvel (*Dichanthium annulatum*) at above growth stages, respectively. Manzoor *et al.* (2013) studied nutritive

value and *in-situ* digestibility of irrigated grasses reported neutral detergent fibre content in madras anjan (*Cenchrus ciliaris* L.) was 67.5 per cent at pre-flowering stage. Melesse *et al.* (2017) studied the nutritional composition of grasses reported neutral detergent fibre content in madras anjan (*Cenchrus ciliaris* L.) was 38.00 per cent at pre-flowering stage. Sultan *et al.* (2007) observed the lowest neutral detergent fibre content of 64.00 per cent in madras anjan (*Cenchrus ciliaris* L.) at early bloom stage and the highest of 69.00 per cent at maturity stage. It was concluded that neutral detergent fibre content was increased with maturity stages of grasses. Teka *et al.* (2012) observed maturity of madras anjan (*Cenchrus ciliaris* L.) led to increase in neutral detergent fibre content. The resultant values of neutral detergent fibre content were 75.89 and 75.90 per cent at early and late stage, respectively. Rafay *et al.* (2013) reported that 73 per cent neutral detergent fibre in madras anjan (*Cenchrus ciliaris* L.). Khan *et al.* (2017) studied nutritive values of tropical forages at early, medium and late growth stages. The neutral detergent fibre content in madras anjan (*Cenchrus ciliaris* L.) was 53.1, 63.4 and 67.4 per cent, respectively and they concluded the neutral detergent fibre content progressively increased with maturity of grasses.

Ratnawaty *et al.* (2013) reported 58.56 per cent neutral detergent fibre in stylo (*Stylosanthes seabrana*) B.L Maass & t Mannatje when harvested on 120 days after planting. Musco *et al.* (2016) reported 49.91 per cent neutral detergent fibre content in stylo (*Stylosanthes hamata* L.) Taub. Gupta *et al.* (2011) reported that 54.16 per cent neutral detergent fibre content in stylo (*Stylosanthes hamata* L.) Taub

Ly *et al.* (2001) reported neutral detergent fibre content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) was 41.4 per cent. Das *et al.* (2015) reported that 49.7 per cent neutral detergent fibre in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Edgar *et al.* (2017) reported 34.82 per cent neutral detergent fibre content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Garg *et al.* (2012) reported nutritional characteristics of some ruminant feedstuffs by using *in vitro* gas production technique. The neutral detergent fibre content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb was 42.45 and 55.60 per cent, respectively.

Tokia *et al.* (2006) studied amino acid profiles of tropical legumes found that 51.9 and 52.2 per cent neutral detergent fibre in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb at pre-flowering and flowering stages of their first growth respectively. Jingura *et al.* (2001) reported 49.54 per cent neutral detergent fibre content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb.

2.2.2 Acid detergent fibre

The acid detergent fibre (ADF) fraction contains cellulose, lignin and heat-damaged protein. ADF is a laboratory estimate of the less digestible cellulose or lignin, or “woody” fibre, in the plant. ADF is the best indicator of the fibre requirement for healthy rumen fermentation. ADF should be greater than 19 per cent in total ration for a dairy cow. If it is not, milk butter fat may be depressed. ADF is more closely related to digestibility of the forage.

Khan *et al.* (2013) carried out an experiment on some terrestrial weeds at seed production stage reported 49.24 per cent acid detergent fibre content in marvel (*Dichanthium annulatum*) (Forssk.) Staf. Sultan *et al.* (2008) studied nutritional composition of different free rangeland grasses at early bloom and maturity stage and reported 31.00 and 34.00 per cent acid detergent fibre content in marvel (*Dichanthium annulatum*) (Forssk.) staf at above growth stages, respectively. Surana *et al.* (2013) reported chemical composition of Marvel-6-40 and Marvel-8 with respect to acid detergent fibre content was 54.30 and 56.95 per cent, respectively.

Sultan *et al.* (2007) observed the lowest acid detergent fibre content of 31.00 per cent in madras anjan (*Cenchrus ciliaris* L.) at early bloom stage, the highest of 33.00 per cent at maturity stage. It was concluded acid detergent fibre content is increase with maturity stages of grasses. Manzoor *et al.* (2013) studied nutritive value and *in-situ* digestibility of irrigated grasses reported acid detergent fibre content in madras anjan (*Cenchrus ciliaris* L.) was 46.3 per cent at pre-flowering stage. Teka *et al.* (2012) observed maturity of madras anjan (*Cenchrus ciliaris* L.) led to decrease in acid detergent fibre content. The resultant values of acid detergent fibre content were 47.03 and 44.47 per cent at early and late stage, respectively. Rafay *et al.* (2013) reported 38 per cent acid detergent fibre content in madras anjan (*Cenchrus ciliaris* L.). Khan *et al.* (2017) studied nutritive values of tropical forages at early, medium and late growth stages. The acid

detergent fibre content in madras anjan (*Cenchrus ciliaris* L.) was 30.3, 42.5 and 50.1 per cent, respectively. It was concluded the acid detergent fibre content progressively increased with maturity of grasses. Melesse *et al.* (2017) studied the nutritional composition of grasses reported acid detergent fibre content in madras anjan (*Cenchrus ciliaris* L.) was 60.1 per cent at pre-flowering stage.

Ratnawaty *et al.* (2013) reported 43.80 per cent acid detergent fibre content in stylo (*Stylosanthes seabrana*) B.L Maass & t Mannatje when harvested on 120 days after planting. Musco *et al.* (2016) reported 42.13 per cent acid detergent fibre content in stylo (*Stylosanthes hamata* L.) Taub. Gupta *et al.* (2011) reported 38.05 per cent acid detergent fibre content in stylo (*Stylosanthes hamata* L.) Taub.

Das *et al.* (2015) reported 37.7 per cent acid detergent fibre in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Edgar *et al.* (2017) reported 16.92 per cent acid detergent fibre content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Garg *et al.* (2012) conducted experiment to assess nutritional characteristics of some ruminant feedstuffs by using *in vitro* gas production technique reported that, acid detergent fibre content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb was 31.84 and 41.55 per cent, respectively.

Tokia *et al.* (2006) studied amino acid profiles of tropical legumes found that 37.6 and 35.4 per cent acid detergent fibre content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb at pre-flowering and flowering stages of their first growth, respectively. Jingura *et al.* (2001) reported 33.19 per cent acid detergent fibre content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb.

2.2.3 Hemi-cellulose

Hemi-cellulose is also one of the important components, which is less digestible fraction that normally have soluble and insoluble fractions. Hemi-cellulose is polysaccharide often associated with cellulose, but they have different compositions. The most important biological role of hemi-cellulose is their contribution to strengthening the cell wall by interaction with cellulose and, in some walls, with lignin. Hemi-cellulose is represented by difference between neutral detergent fibre (NDF) and acid detergent fibre (ADF).

Sultan *et al.* (2008) studied nutritional composition of different free rangeland grasses at early bloom and maturity stage and reported 26.00 and 32.00 per cent hemi-cellulose content in marvel (*Dichanthium annulatum*) (Forssk.) Staf at above growth stages, respectively. Surana *et al.* (2013) reported chemical composition of Marvel-6-40 and Marvel-8 with respect to hemi-cellulose content was 18.10 and 15.35 per cent, respectively.

Sultan *et al.* (2007) observed that lowest hemi-cellulose content in madras anjan (*Cenchrus ciliaris* L.) at early bloom stage was 33.00 per cent and highest hemi-cellulose content at maturity stage was 36.00 per cent and they concluded hemi-cellulose content is increase with maturity stages of grasses. Khan *et al.* (2017) studied nutritive values of tropical forages at early, medium and late growth stages. The hemi-cellulose content in madras anjan (*Cenchrus ciliaris* L.) was 21.6, 19.7 and 16.00 per cent, respectively and they concluded the hemi-cellulose content progressively decreased with maturity of grasses. Rafay *et al.* (2013) reported 38.00 per cent hemi-cellulose content in madras anjan (*Cenchrus ciliaris* L.). Melesse *et al.* (2017) studied the nutritional composition of grasses reported hemi-cellulose content in madras anjan (*Cenchrus ciliaris* L.) was 22.8 per cent at pre-flowering stage.

Ratnawaty *et al.* (2013) reported 14.76 per cent hemi-cellulose content when harvested on 120 days after planting in stylo (*Stylosanthes seabrana*) B.L Maass & t Mannatje. Gupta *et al.* (2011) reported 16.11 per cent hemi-cellulose content in stylo (*Stylosanthes hamata* L.) Taub.

Das *et al.* (2015) reported 12.0 per cent hemi-cellulose in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.).

Tokia *et al.* (2006) studied amino acid profiles of tropical legumes and found that 14.3 and 16.7 per cent hemi-cellulose in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb at pre-flowering and flowering stages of their first growth, respectively.

2.2.4 Lignin

Lignin is another component found in cell walls of forages. Lignin is the most complex component of grasses which is in association of crude fibre. Lignin is most

completely indigestible and therefore as lignifications of forages increases that leads to decreases in digestibility.

Sultan *et al.* (2008) studied nutritional composition of different free rangeland grasses at early bloom and maturity stage and reported 4.3 and 5.4 per cent lignin content in marvel (*Dichanthium annulatum*) (Forssk.) Staf at above growth stages, respectively.

Sultan *et al.* (2007) observed that lowest lignin content in madras anjan (*Cenchrus ciliaris* L.) at early bloom stage was 3.9 per cent and highest lignin content at maturity stage was 5.4 per cent and they concluded lignin content is increase with maturity stages of grasses. Teka *et al.* (2012) observed maturity of madras anjan (*Cenchrus ciliaris* L.) led to decrease in lignin content. The resultant values of lignin content were 9.47 and 7.24 per cent at early and late stage, respectively. Rafay *et al.* (2013) reported that 5.6 per cent lignin content in madras anjan (*Cenchrus ciliaris* L.). Melesse *et al.* (2017) studied the nutritional composition of grasses reported lignin content in madras anjan (*Cenchrus ciliaris* L.) was 2.67 per cent at pre-flowering stage. Manzoor *et al.* (2013) studied nutritive value and *in-situ* digestibility of irrigated grasses reported lignin content in madras anjan (*Cenchrus ciliaris* L.) was 4.8 per cent at pre-flowering stage.

Ratnawaty *et al.* (2013) reported 11.32 per cent lignin content when harvested on 120 days after planting in stylo (*Stylosanthes seabrana*) B.L. Maass & t Mannatje.

Musco *et al.* (2016) reported 11.74 per cent lignin content in stylo (*Stylosanthes hamata* L.) Taub. Gupta *et al.* (2011) reported 6.29 per cent lignin content in stylo (*Stylosanthes hamata* L.) Taub.

Das *et al.* (2015) reported 10.2 per cent lignin content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Edgar *et al.* (2017) reported that 8.93 per cent lignin content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.).

Tokia *et al.* (2006) studied amino acid profiles of tropical legumes and found that 6.9 and 7.0 per cent lignin content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb at pre-flowering and flowering stage of their first growth, respectively.

2.3 *In vitro* dry matter digestibility

Estimation of *in vitro* dry matter digestibility (IVDMD) is an important tool to judge nutritional quality of grasses and legumes in the laboratory. Digestibility is just a measure of how much of the nutrients in a sample an animal can actually extract and absorb. Highly digestible food provides a higher proportion of absorbed nutrients than a less digestible food; digestibility provides one measure of a food's nutritional value and quality.

Sultan *et al.* (2008) reported *in vitro* dry matter digestibility of marvel (*Dichanthium annulatum*) (Forssk.) Staf at early bloom stage were 51.4 per cent whereas, at maturity stage were 39.5 percent, respectively. Surana *et al.* (2013) reported *in vitro* dry matter digestibility of Marvel-6-40 and Marvel-8 was 58.00 and 56.00 per cent, respectively.

Manzoor *et al.* (2013) studied nutritive value and *in-situ* digestibility of irrigated grasses reported *in vitro* dry matter digestibility in madras anjan (*Cenchrus ciliaris* L.) was 73.3 per cent at pre-flowering stage. Sultan *et al.* (2007) observed that lowest *in vitro* dry matter digestibility in madras anjan (*Cenchrus ciliaris* L.) at early bloom stage was 58.6 per cent and highest *in vitro* dry matter digestibility at maturity stage was 36.6 per cent, they concluded *in vitro* dry matter digestibility is decreased with maturity stages of grasses. Rahim *et al.* (2008) reported *in vitro* dry matter digestibility in madras anjan (*Cenchrus ciliaris* L.) was 58.6 and 36.6 per cent at pre-flowering and flowering stage, respectively. Khan *et al.* (2017) studied nutritive values of tropical forages at early, medium and late growth stages. The *in vitro* dry matter digestibility in madras anjan (*Cenchrus ciliaris* L.) was 40.2, 32.8 and 25.9 per cent, respectively, they concluded the *in vitro* dry matter digestibility progressively decreased with maturity of grasses.

Ly *et al.* (2001) reported *in vitro* dry matter digestibility in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) was 27.2 per cent.

2.4 Minerals

2.4.1 Ash

The total mineral content of feedstuffs is called ash. The total ash is an inorganic component of plant and constituent major, minor and trace elements. These minerals are essentials for the maintenance of normal health, production and reproduction of the animals. Forages normally contain 3 to 12 per cent ash.

Khan *et al.* (2013) carried out an experiment on some terrestrial weeds at seed production stage and reported that 11.79 per cent ash content in marvel (*Dichanthium annulatum*) (Forssk.) Staf. Surana *et al.* (2013) reported chemical composition of Marvel-6-40 and Marvel-8 with respect to ash content was 11.05 and 11.7 per cent, respectively. Sultan *et al.* (2008) studied nutritional composition of different free rangeland grasses at early bloom and maturity stage and reported 6.2 and 7.2 per cent ash content in marvel (*Dichanthium annulatum*) (Forssk.) staf at above growth stages, respectively.

Manzoor *et al.* (2013) studied nutritive value and *in-situ* digestibility of irrigated grasses reported ash content in madras anjan (*Cenchrus ciliaris* L.) was 9.84 per cent at pre-flowering stage. Sultan *et al.* (2007) observed that lowest ash content in madras anjan (*Cenchrus ciliaris* L.) at early bloom stage was 6.6 per cent and highest ash content at maturity stage was 7.1 per cent. It was concluded that ash content is increased with maturity stages of grasses. Teka *et al.* (2012) observed maturity of madras anjan (*Cenchrus ciliaris* L.) led to decrease in ash content. The resultant values of ash content were 16.27 and 14.26 per cent at early and late stage, respectively. Rafay *et al.* (2013) reported 20.69 per cent ash content in madras anjan (*Cenchrus ciliaris* L.). Khan *et al.* (2017) studied nutritive values of tropical forages at early, medium and late growth stages. The ash content in madras anjan (*Cenchrus ciliaris* L.) was 15.6, 15.3 and 14.1 per cent, respectively and they concluded the ash content progressively decreased with the maturity of grasses. Rasool *et al.* (2013) studied assessment of nutritional status in selected indigenous and exotic rangeland grasses and found that 10.44 per cent ash content in madras anjan (*Cenchrus ciliaris* L.). Melesse *et al.* (2017) studied the nutritional composition of grasses reported ash content in madras anjan (*Cenchrus ciliaris* L.) was 15.4 per cent at pre-flowering stage.

Kumar *et al.* (2016) conducted experiment on enhanced quality forage production through grass-legume intercropping under arid eco-system of Kachchh, Gujarat and reported that ash content in madras anjan (*Cenchrus ciliaris* L.), marvel (*Dichanthium annulatum*) (Forssk.) Staf and stylo (*Stylosanthes hamata* L.) Taub were 10.00, 10.66 and 7.66 per cent, respectively. It was concluded marvel grass based intercropping systems are the best grass-legume intercropping system for enhanced quality forage production for overall development of livestock sector.

Kauthale *et al.* (2017) carried out experiment on nutritional evaluation of selected forage species from Wardha district of Maharashtra, India, they reported ash content in pawana (*Sehima nervosum*) (Rottler) Stapf, marvel (*Dichanthium annulatum*) (Forssk.) Staf, dongari grass (*Crysopogan fulvus*) (Spreng) Chiov and stylo (*Stylosanthes hamata* L.) Taub were 11.55, 8.67, 8.17 and 10.47 per cent, respectively.

Jayprakash *et al.* (2016) studied biomass yield and chemical composition of hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and stylo (*Stylosanthes hamata* L.) Taub. It was reported ash content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and stylo (*Stylosanthes hamata* L.) Taub was 4.37 and 3.72 per cent, respectively. It was concluded that *Desmanthus virgatus*, *Stylosanthes hamata* had relatively high protein, ether extract and energy content and thus have the potential to be a good alternate feed source for ruminant animals.

Musco *et al.* (2016) reported 10.53 per cent ash content in stylo (*Stylosanthes hamata* L.) Taub. Gupta *et al.* (2011) reported 8.75 per cent ash content in stylo (*Stylosanthes hamata* L.) Taub. Ratnawaty *et al.* (2013) reported 9.07 per cent ash content when harvested on 120 days after planting in stylo (*Stylosanthes seabrana*) B.L Maass & t Mannatje.

Das *et al.* (2015) reported 9.3 per cent ash in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Garg *et al.* (2012) conducted experiment to assess nutritional characteristics of some ruminant feedstuffs by using *in vitro* gas production technique reported, ash content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb was 6.27 and 8.11 per cent, respectively. Suksombat and Buakeeree (2006) recorded ash content at three different cutting intervals i.e. 30, 40 and 50 days after sowing. They showed highest ash

content was 7.26 per cent at 30 days cutting interval and lowest ash content was 6.00 per cent at 50 days cutting interval and 6.21 per cent at 40 days cutting interval in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.).

Ahmed and Ahmed (2015) found that 11.30 per cent ash content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb. Jingura *et al.* (2001) reported 12.29 per cent ash content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb.

2.4.2 Calcium

Calcium is necessary for the proper growth and functioning of root tips and meristems. The calcium concentration in whole plant increased with growth and development, as well as in leaves and stems. Animals need Ca for skeletal growth, milk production, nerve impulse transmission and the maintenance of enzyme systems.

Sultan *et al.* (2008) reported calcium content in marvel (*Dichanthium annulatum*) (Forssk.) Staf at early bloom stage were 0.14 per cent whereas, at maturity stage were 0.13 percent, respectively.

Manzoor *et al.* (2013) studied nutritive value and *in-situ* digestibility of irrigated grasses reported calcium content in madras anjan (*Cenchrus ciliaris* L.) was 1.6 per cent at pre-flowering stage. Rahim *et al.* (2008) studied mineral profile, palatability and digestibility of marginal land grasses reported calcium content in madras anjan (*Cenchrus ciliaris* L.) at pre-flowering and flowering stages was 0.46 and 0.41 per cent, respectively. Melesse *et al.* (2017) studied the nutritional composition of grasses reported 0.43 per cent calcium content in madras anjan (*Cenchrus ciliaris* L.) at pre-flowering stage.

Jayprakash *et al.* (2016) studied biomass yield and chemical composition of hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and stylo (*Stylosanthes hamata* L.) Taub. It was reported that calcium content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and stylo (*Stylosanthes hamata* L.) Taub was 2.15 and 2.11 per cent, respectively. It was concluded that *Desmanthus virgatus*, *Stylosanthes hamata* had relatively high protein, ether extract and energy content and thus have the potential to be a good alternate feed source for ruminant animals. Gupta *et al.* (2011) reported 0.78 per cent calcium content in stylo (*Stylosanthes hamata* L.) Taub.

Kumar *et al.* (2016) conducted experiment on enhanced quality forage production through grass-legume intercropping under arid eco-system of Kachchh, Gujarat reported that calcium content in madras anjan (*Cenchrus ciliaris* L.), marvel (*Dichanthium annulatum*) (forssk.) Staf and stylo (*Stylosanthes hamata* L.) Taub were 0.17, 0.14 and 0.73 per cent, respectively. It was concluded that marvel grass based intercropping systems are the best grass-legume intercropping system for enhanced quality forage production for overall development of livestock sector.

Jingura *et al.* (2001) reported 0.98 per cent calcium content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb.

2.4.3 Magnesium

Magnesium is required as a cofactor in a large number of enzymes involved in energy transport, particularly those utilizing ATP. Magnesium is an important mineral for grazing cattle because of the association with Grass Tetany. It helps to maintain normal nerve and muscle functions, support healthy immune system.

Sultan *et al.* (2008) reported magnesium content in marvel (*Dichanthium annulatum*) (Forssk.) Staf at early bloom stage were 0.032 per cent whereas, at maturity stage were 0.030 per cent, respectively.

Manzoor *et al.* (2013) studied nutritive value and *in-situ* digestibility of irrigated grasses reported magnesium content in madras anjan (*Cenchrus ciliaris* L.) was 0.26 per cent at pre-flowering stage. Rahim *et al.* (2008) studied mineral profile, palatability and digestibility of marginal land grasses reported magnesium content in madras anjan (*Cenchrus ciliaris* L.) at pre-flowering and flowering stages was 0.005 and 0.010 per cent respectively. Melesse *et al.* (2017) studied the nutritional composition of grasses reported 0.29 per cent magnesium content in madras anjan (*Cenchrus ciliaris* L.) at pre-flowering stage.

Gupta *et al.* (2011) reported 0.34 per cent magnesium content in stylo (*Stylosanthes hamata* L.) Taub.

2.4.4 Zinc

Zinc as an essential metal, is necessary for the correct function of an organism. It is involved in biochemical processes that affect the immune response of an

organism. It also involved in protein synthesis, carbohydrate metabolism, and many other biochemical reactions.

Rahim *et al.* (2008) studied mineral profile, palatability and digestibility of marginal land grasses reported zinc content in madras anjan (*Cenchrus ciliaris* L.) at pre-flowering and flowering stage was 5.5 and 2.0 ppm respectively. Melesse *et al.* (2017) studied the nutritional composition of grasses reported 1.86 per cent zinc content in madras anjan (*Cenchrus ciliaris* L.) at pre-flowering stage.

Sultan *et al.* (2008) reported zinc content in marvel (*Dichanthium annulatum*) (Forssk.) Staf at early bloom stage were 8.0 ppm whereas, at maturity stage were 4.5 ppm, respectively.

Gupta *et al.* (2011) reported 61.00 ppm zinc content in stylo (*Stylosanthes hamata* L.) Taub.

3. MATERIAL AND METHODS

The present investigation entitled “Evaluation of forage quality of grasses and legumes at different growth stages” was carried out at AICRP on forage crops and Utilization, MPKV, Rahuri and Department of Biochemistry, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri.

3.1 Material

3.1.1 Plant material

Four grasses viz., marvel (*Dichanthium annulatum*) (Forssk.) Staf, dongari grass (*Cryopogan fulvus*) (Spreng) Chiov, madras anjan (*Cenchrus ciliaris* L.), and pawana (*Sehima nervosum*) (Rottler) Stapf and four legumes viz., stylo (*Stylosanthus seabrana*) B.L. Maass & t Mannatje, stylo (*Stylosanthus hamata* L.) Taub, hedge lucerne or dashrath grass (*Desmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb were grown at Grass Breeding scheme, MPKV, Rahuri. The grasses and legumes were analyzed at pre-flowering, 50 % flowering and post flowering stages for biochemical parameters and forage quality parameters. The plant samples were collected from field at respective growth stages, cut into small pieces and partially sun dried. Thereafter, samples dried in oven at 70°C temperature till constant weight and powder was prepared by using multiplex plant grinder and then analyzed for biochemical composition and micronutrients.

3.1.2 Chemicals

All the chemicals used in the study were of analytical grade obtained from following suppliers.

1. Sisco Research Laboratories Pvt. Ltd., Mumbai-400009.
2. Qualigens Fine Chemicals Ltd., Mumbai

3.2 Methods

3.2.1 Dry matter

The dry matter was estimated by using following formula.

$$\text{Dry matter \%} = 100 - \text{Moisture per cent.}$$

For moisture content, 250 g plant sample collected from field, cut into small pieces and partially sun dried. Thereafter, samples dried in oven at 70°C temperature till constant weight.

Moisture was estimated by using following formula.

$$\text{Moisture \%} = \frac{\text{Weight of sample before drying} - \text{Weight of sample after drying}}{\text{Weight of sample before drying}} \times 100$$

3.2.2 Crude protein

The protein content was determined by Micro-Kjeldahl method (A.O.A.C., 1990).

Reagents:

1. Concentrated sulphuric acid (Sp. gr. 1.84, purity 98.08 % nitrogen free).
2. Catalyst mixture: Potassium sulphate (99 g), mercuric oxide (4.1 g) and copper sulphate (8 g) were weighed, mixed and ground into a fine powder.
3. Sodium hydroxide (40 %, w/v): 40 g of sodium hydroxide pellets and 4 g of sodium thiosulphate were dissolved in distilled water separately, mixed and the volume was made to 100 ml with distilled water.
4. Boric acid (2 %, w/v): 2 g of boric acid was dissolved in distilled water and the volume was made 100 ml with distilled water.
5. Sulphuric acid (0.01 N): Stock 1 N sulphuric acid solution was prepared by dissolving 27.15 ml of sulphuric acid (Sp. gr. 1.84, purity, 98%) in distilled water and the volume was made 1000 ml. Working solution of 0.01 N sulphuric acid was prepared by diluting 10 ml stock solution of 1 N sulfuric acid to make final volume of 1000 ml.
6. Hydrogen peroxide: 30 % (v/v) commercially available in the market.
7. Mixed indicator: Mixed indicator was prepared by dissolving 99 mg of bromocresol green and 66 mg of methyl red in 50 ml each in 95 per cent alcohol separately and both solutions were mixed together and transferred to a bottle provided with a stopper. 20 ml of mixed indicator was added in one-liter solution of 2 % boric acid.

Procedure:

Powdered sample of 200 mg was accurately weighed and transferred to a digestion flask. One gram of catalyst mixture was added and mixed thoroughly with the sample. Five ml of concentrated sulphuric acid and 5 ml of hydrogen peroxide were carefully added and the sample was digested in a digestion chamber. Initially, the flasks were heated slowly for 10 to 15 min and then the temperature was raised gradually so that

the contents boiled briskly. The digestion was continued until the sample became clear and colourless. Then flasks were cooled to room temperature and after cooling, the contents were transferred to volumetric flasks. The digestion flasks were washed 3-4 times with distilled water. All the washings were transferred to volumetric flasks and the volume was made to 50 ml.

Ten ml of boric acid solution was pipette into 100 ml beaker and 6-8 drops of mixed indicator solution were added. The beaker was placed under condenser of the distillation unit. At the end of distillation, the tip of the condenser was washed with distilled water to collect all ammonia. The distillate was then titrated with standard sulphuric acid (0.02 N) solution. Before distillation, the colour of boric acid plus indicator was pink which changed to blue green during distillation and finally to pink red at the end of titration. Blank titration without sample was also carried out. The percentage nitrogen content was calculated from the quantity of standard sulphuric acid required for the titration of the sample. The protein content was calculated by multiplying the nitrogen content by a factor of 6.25.

$$\% \text{ Nitrogen} = \frac{(S-B) \times N \times 14.007}{\text{Weight of sample (g)}} \times \frac{\text{Volume made}}{\text{Volume taken}} \times 100$$

Where,

S = ml of sulphuric acid required for sample titration

B = ml of sulphuric acid required for blank titration

N = Normality of H₂SO₄ (0.02 N)

3.2.3 Ether extract

The crude fat content was determined by the ether extraction using Soxhlet apparatus (A.O.A.C, 1990).

3.2.4 Crude fibre

The crude fibre content was estimated by using standard procedure of (A.O.A.C. 1990).

Reagent:

1. Sulphuric acid solution (1.25 %): 1.25 ml concentrated sulphuric acid diluted to 100 ml
2. Sodium hydroxide solution (1.25 %): 1.25 g NaOH in 100 ml distilled water.

Procedure:

Firstly, 2 g of finely powdered sample was boiled with 200 ml of sulphuric acid for 30 min with bumping chips. The residue was then filtered through muslin cloth and washed with boiling water until washings were no longer acidic. That residue was then boiled with 200 ml of sodium hydroxide solution for 30 min. Again, filtered through muslin cloth and washed with 25 ml of boiling 1.25 % H₂SO₄ solution, three 50 ml portions of water and 25 ml alcohol. The residue was then removed and transferred to pre-weighed crucible. The residue was dried gradually from 40°C -100°C and then 2 hours at 105 °C temperature, cooled in desiccator and weighed. Per cent crude fibre was then calculated by using following formula.

$$\text{Crude fibre (\%)} = \frac{(\text{Weight of crucible} + \text{Weight of fibre}) - (\text{Weight of crucible})}{\text{Weight of sample}} \times 100$$

3.2.5 Total Carbohydrate

Carbohydrate content in the forage grass samples was determined by Standard difference method by A.O.A.C. (1990). The total carbohydrate was estimated by using following formulae.

$$\text{Total carbohydrate (\%)} = [100 - (\text{moisture} + \text{lipids} + \text{crude proteins} + \text{ash} + \text{crude fibre})]$$

3.2.6 Cell wall constituent**3.2.6.1 Neutral detergent fibre (NDF)**

The NDF content in sample was determined by the method of Van Soest (1963).

Reagents:

1. Neutral detergent solution:
 - i. Distilled water 1000 ml
 - ii. Sodium lauryl sulphate 30 g
 - iii. Disodium ethylene diamine tetra acetic acid dehydrate crystal (EDTA) 18.61 g
 - iv. Sodium borate decahydrate 6.81 g
 - v. Disodium hydrogen phosphate 4.56 g
 - vi. 2-ethoxy ethanol (ethylene glycol monoethyl ether) 10 ml

EDTA and sodium borate decahydrate were poured in a large beaker. Small quantity of distilled water was added and agitated. Then, this was added to the

solution containing sodium lauryl sulphate and 2-ethoxy ethanol. Na_2HPO_4 was taken in a beaker with small quantity of distilled water and heated to dissolve it. Then, added to the solution containing other ingredients and PH was adjusted to 7.

2. Decahydronaphthalene (reagent grade)
3. Acetone
4. Sodium sulphate (anhydrous, reagent grade)

Procedure

One-gram sample was taken into the beaker of refluxing apparatus. To this, 100 ml cold neutral detergent solution and 0.5 g sodium sulphite were added and heated for 10 minutes. Heat was reduced as the boiling began, to avoid foaming and reflux it for 60 min. This solution was transferred to previously weighed glass funnel. The glass funnel was attached to vacuum pump. Initially low vacuum was used and later increased when more force was needed. Sample in the crucible was twice washed with hot water (90- 100⁰C) and acetone.

The crucibles were dried at 100⁰C for 8 hours cooled in desiccators and final weight was recorded.

$$\text{NDF \%} = \frac{\text{Wt. of crucible plus fibre} - \text{Tared wt. of oven dried crucible}}{\text{Weight of sample}} \times 100$$

3.2.6.2 Acid detergent fibre (ADF)

ADF content in sample was determined by the method of Van Soest (1963).

Reagents:

1. Acid detergent solution: Twenty grams of CTAB (Cetyltrimethylammonium bromide) was dissolved in 1000 ml of 1 N H_2SO_4 .
2. Decahydronaphthalene – Reagent grade
3. Acetone

Procedure:

One gram of sample was weighed into the beaker of the refluxing apparatus. To this, 100 ml acid detergent solution was added and heated up to boiling for 10 minutes. Heat was reduced to avoid foaming, from the onset of boiling; it was refluxed for 60 minutes. Sample was filtered through previously weighed glass funnel by

using light suction. Two washings with hot water (90-100⁰C) and acetone were given. The acid detergent fibre was made free of acetone and dried at 100⁰C for 8 hours, cooled in desicator and weighed.

$$\text{ADF \%} = \frac{\text{Weight of crucible plus fibre} - \text{Tarred weight of oven dried sample}}{\text{Weight of sample}} \times 100$$

3.2.6.3 Hemi-cellulose

This was determined by working out the difference between neutral detergent fibre and acid detergent fibre as described by Van Soest (1993).

$$\text{Hemi-cellulose (\%)} = \text{NDF (\%)} - \text{ADF (\%)}$$

3.2.6.4 Lignin

The lignin content was determined as per jute titration method given by Hussain *et al.* (2002).

Reagents:

1. Potassium permanganate solution (0.1N): 15.8 g potassium permanganate dissolved in distilled water and makes the volume 1000 ml.
2. Sulphuric acid solution (4N): 108.6 ml of conc. Sulphuric acid dissolved in distilled water and make the volume 1000 ml.
3. Potassium iodide solution (1N): 166 g potassium iodide dissolved in distilled water and make the volume 1000 ml.
4. Sodium thiosulphate solution (0.1N): 24.81 g sodium thiosulphate dissolved in distilled water and make the volume 1000 ml.
5. Starch indicator solution (0.2%) 0.2 g starch indicator dissolved in 100 ml distilled water.

Procedure:

1. 0.1 gm of leaves sample were dispersed in 6 ml distilled water and ground to fine paste by using mortar and pestle.
2. The disintegrated sample was transferred to 250 ml conical flask and distilled water was added to make the total volume 120 ml.

3. Fifteen ml of potassium permanganate solution and 15 ml of sulphuric acid solution were mixed together and added immediately to the disintegrated fibre sample.
4. Thus, total volume was allowed to proceed at 25°C temperature for exactly 10 minutes in temperature bath maintained at 25°C.
5. Then 3ml of potassium iodide solution was added and the free iodine was titrated with standard sodium thiosulphate solution using starch as an indicator. Colour changed from dark pink to colorless.
6. A blank titration was made using the same volume of water and reagents.
The Kappa Number was then calculated from the following equation.

$$\text{Kappa Number (K)} = \frac{P \times F}{W}$$

Where,

- P = Milli liter of 0.1 N potassium permanganate consumed by the experimental sample.
 W = Weight in gram of moisture free sample.
 F = Factor for correction to 50% permanganate consumption, which has been shown in Table 3.

Using table 3 as a guide

	0	1	2	3	4	5	6	7	8	9
10	0.911	0.913	0.915	0.918	0.920	0.923	0.925	0.927	0.929	0.931
20	0.934	0.936	0.938	0.941	0.943	0.945	0.947	0.949	0.952	0.954
30	0.958	0.960	0.962	0.964	0.966	0.968	0.970	0.973	0.975	0.977
40	0.979	0.981	0.983	0.985	0.987	0.989	0.992	0.994	0.996	0.998
50	1.000	1.002	1.004	1.006	1.009	1.011	1.013	1.015	1.017	1.019
60	1.022	1.024	1.026	1.028	1.030	1.033	1.035	1.037	1.040	1.042
70	1.044									

% Lignin = Kappa No × 0.155

3.2.7 *In vitro* dry matter digestibility (IVDMD)

IVDMD was determined by the method of Tilley and Terry (1963).

The rumen liquor of goat was collected from Aayub Mutton Shop, Rahuri for IVDMD study. The rumen liquor was strained through four-layer muslin cloth. The composition of buffer solution used in the present study was as below:

Chemical	g/L
NaHCO ₃	9.80
Na ₂ HPO ₄	3.39
KCl	0.57
NaCl	0.47
CaCl ₂	0.04
MgSO ₄	0.12

All these ingredients, except, CaCl₂ were weighed and dissolved in one-liter water. CaCl₂ was added, just before using the solution. The pH of buffer was adjusted to 6.7.

Procedure:

One-gram sample was taken into 100 ml flask containing 40 ml artificial saliva and 10 ml Strained Rumen Liquor (SRL) and immediately flushed with CO₂ gas for 30 seconds to ensure anaerobic condition. The beaker was closed tightly with rubber cork, fitted with gas release valve and then incubated at 39⁰C temperature for 48 hours in the incubator.

At the end of incubation period, the microbial activity was stopped by addition of 2 ml 6 N HCl to each flask. Add 0.1 gm pepsin powder and incubate flask for another 24 hours. The content was filter through pre weighed oven dry filter paper. Residue with filter paper dried in oven at 100⁰C for 24 hours and weighed. Difference in weight was calculate.

$$\% \text{ IVDMD} = \frac{\text{DM disappearance}}{\text{Weight of sample}} \times 100$$

3.2.8 Minerals

3.2.8.1 Ash

The ash content was estimated by the method described in A.O.A.C. (1990).

Procedure:

Five grams of the powdered sample was accurately weighed into a pre weighed silica crucible. It was then carbonized in silica crucible on a burner followed by heating at about 600⁰C for 6 hours in the muffle furnaces to obtain completely white

colored ash. The crucible was allowed to cool in the furnaces. The crucible was then transferred to desiccators and weighed as quickly as possible to prevent moisture absorption. The ash was calculated using the following formula

$$\text{Ash \%} = \frac{\text{Weight of crucible with ash (g)} - \text{Weight of crucible (g)}}{\text{Weight of sample (g)}} \times 100$$

3.2.8.2 Micronutrients *viz.*, Ca, Mg, Zn

The micronutrients were determined by Atomic absorption Spectrophotometer. Plant sample of 1.0 gm was digested by 9:4 mixture of nitric acid and perchloric acid (HNO₃: HClO₄).

Procedure:

Digested sample of plant was directly measured on the Atomic absorption Spectrophotometer by using the Hallow Cathode Lamp of Ca, Mg and Zn.

3.2.9 Statistical analysis

The data obtained in various analyses were analyzed for statistical significance using Factorial Randomized Block Design (FRBD) by the method of Panse and Sukhatme (1985).

4. RESULT AND DISCUSSION

Experiments were conducted to investigate the “Evaluation of forage quality of grasses and legumes at different growth stages.” The results of these investigations are presented and discussed in this chapter.

4.1 Chemical composition

4.1.1 Dry matter content

The data on per cent dry matter content in different cereal grasses and legumes forages at different growth stages depicted in Table 1. It was observed that, per cent dry matter content was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, per cent dry matter was ranged between 30.20 to 56.09 per cent. The mean per cent dry matter was significantly higher in cereal grasses (42.57 %) than legumes (37.51 %).

Among the cereal grasses and legumes genotypes, a cereal grass *Cenchrus ciliaris* recorded significantly higher per cent DM at pre flowering stage (38.99 %) and 50 % flowering stage (41.96 %), whereas marvel (*Dichanthium annulatum*) recorded significantly higher DM content at post flowering stage (56.09 %). However, marvel (*Dichanthium annulatum*) recorded the highest mean per cent DM of three growth stages (44.25 %).

Within the legumes, *Stylosanthes seabrana* recorded the highest mean per cent DM of all growth stages (40.25 %). However, *Deshmanthus virgatus* recorded the highest DM at pre flowering stage (37.54 %) and post flowering stage (45.63 %) and *Stylosanthes seabrana* recorded the highest per cent DM of 50 % flowering stage (37.96 %).

Among the different growth stages, per cent DM was increased with the advancement of growth stages in both cereal grasses and legumes. The mean per cent DM of all genotypes was the significantly higher at post flowering stage (46.81 %), followed by 50 % flowering stage (38.24 %) and lowest at pre flowering (35.07 %). At 50 % flowering stage, cereal grasses recorded higher mean per cent DM (39.95 %) than legumes (36.53 %).

Table 1. Dry matter (%) in cereal grasses and legumes forages at different growth stages.

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
Cereal					
1	Marvel (<i>Dichanthium annulatum</i>)	36.04	40.61	56.09	44.25
2	Dongari grass (<i>Crysopogan fulvus</i>)	34.55	36.77	53.18	41.5
3	Madras anjan (<i>Cenchrus ciliaris</i>)	38.99	41.96	50.04	43.66
4	Pawana (<i>Sehima nervosum</i>)	35.6	40.47	46.55	40.87
	Mean	36.30	39.95	51.47	42.57
Legume					
5	<i>Stylosanthes seabrana</i>	37.24	37.96	45.54	40.25
6	<i>Stylosanthes hamata</i>	30.20	36.66	37.77	34.88
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	37.54	36.09	45.63	39.75
8	Ran mung (<i>Macroptilium atropurpureum</i>)	30.44	35.39	39.69	35.17
	Mean	33.86	36.53	42.16	37.51
	General Mean	35.07	38.24	46.81	
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.187	0.524		
	Stage (S)	0.114	0.321		
	G x S	0.323	0.908		
	Grasses Vs Legumes	0.191	0.537		

The values reported for per cent dry matter are in agreement with the literature values. The dry matter content in madras anjan (*Cenchrus ciliaris* L.) was 21.75 per cent at pre-flowering stage (Manzoor *et al.*, 2013). Khan *et al.* (2017) studied nutritive values of tropical forages at early, medium and late growth stages. The dry matter content in madras anjan (*Cenchrus ciliaris* L.) was 15.6, 20.8 and 21.1 per cent, respectively and they concluded the dry matter content progressively increased with maturity of grasses. Sultan *et al.* (2007) observed that highest dry matter content in madras anjan (*Cenchrus ciliaris* L.) at maturity stage was 38.8 per cent and lowest dry matter content at early bloom stage was 27.9 per cent and they concluded dry matter content increased with maturity stages of grasses. Surana *et al.* (2013) reported chemical composition of Marvel-6-40 and Marvel-8 with respect to dry matter content was 30.25 and 29.37 per cent, respectively. Sultan *et al.* (2008) reported dry matter content was increased with the advancement of growth stages in marvel (*Dichanthium annulatum*) i.e. at early bloom and maturity stage per cent DM was 33.7 and 41.8 per cent, respectively.

The dry matter content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and stylo (*Stylosanthes hamata* L.) Taub were 29.14 and 34.12 per cent, respectively (Jayprakash *et al.*, 2016). Edgar *et al.* (2017) reported 21.98 per cent dry matter content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Suksombat and Buakeeree (2006) recorded dry matter content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) at three different cutting intervals i.e. 30, 40 and 50 days after sowing. They showed lowest dry matter content was 31.77 per cent at 30 days cutting interval and highest dry matter content was 35.36 per cent at 50 days cutting interval and 32.58 per cent at 40 days cutting interval. Garg *et al.* (2012) conducted experiment to assess nutritional characteristics of some ruminant feedstuffs by using *in vitro* gas production technique reported that, dry matter content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb was 28.22 and 24.80 per cent, respectively.

4.1.2 Crude protein content

The data on per cent crude protein content in different cereal grasses and legumes forages at different growth stages depicted in Table 2. It was observed that, per cent crude protein content was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, per cent crude protein was ranged between 4.38 to 17.94 per cent. The mean per cent crude protein was significantly higher in legumes (13.50 %) than cereals (6.64 %).

Among the cereal grasses and legumes genotypes, a legume forage, *Stylosanthes seabrana* recorded the highest mean per cent crude protein (15.53 %) of all growth stage. However, dashrath grass (*Deshmanthus virgatus*) recorded highest crude protein (17.94 %) at pre flowering stage and *Stylosanthes seabrana* recorded the highest crude protein at 50 % flowering stage (15.75 %) and post flowering stage (14.00 %), respectively.

Within the cereal grasses, a cereal grass *Cenchrus ciliaris* recorded significantly higher per cent crude protein at pre flowering stage (10.72 %) and marvel (*Dichanthium annulatum*) contain higher per cent crude protein at 50 % flowering stage (7.66 %), and post flowering stage (4.94 %). However, *Cenchrus ciliaris* recorded the highest mean per cent crude protein of three growth stages (7.37 %).

Among the different growth stages, per cent crude protein was decreased with the advancement of growth stages in both cereal grasses and legumes. The mean per cent crude protein of all genotypes was the higher at pre flowering stage (9.02 %), followed by 50 % flowering stage (6.18 %) and significantly lowest at post flowering (4.73 %). At 50% flowering stage, legumes recorded higher mean per cent crude protein (13.17 %) than cereal grasses (6.18 %).

The values reported for per cent crude protein are in agreement with the literature values. The crude protein content in marvel (*Dichanthium annulatum*) (Forssk.) at early bloom and maturity stage were 6.4 and 4.3 per cent, respectively (Sultan *et al.*, 2008). Kauthale *et al.* (2017) reported crude protein content in pawana (*Sehima nervosum*) (Rottler) Stapf, marvel (*Dichanthium annulatum*) (Forssk.) Staf, dongari grass (*Crypsopogan fulvus*) (Spreng) Chiov and stylo (*Stylosanthes hamata* L.) Taub were 4.31, 4.97, 4.23, and 10.17 per cent, respectively.

Table 2. Crude protein (%) in cereal grasses and legumes forages at different growth stages

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
Cereal					
1	Marvel (<i>Dichanthium annulatum</i>)	7.22	7.66	4.94	6.60
2	Dongari grass (<i>Cryopogan fulvus</i>)	9.84	5.25	4.38	6.49
3	Madras anjan (<i>Cenchrus ciliaris</i>)	10.72	6.56	4.81	7.37
4	Pawana (<i>Sehima nervosum</i>)	8.31	5.25	4.81	6.12
	Mean	9.02	6.18	4.73	6.64
Legume					
5	<i>Stylosanthes seabrana</i>	16.84	15.75	14.00	15.53
6	<i>Stylosanthes hamata</i>	14.01	12.03	10.06	12.04
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	17.94	13.34	11.81	14.36
8	Ran mung (<i>Macroptilium atropurpureum</i>)	14.22	11.59	10.50	12.10
	Mean	15.75	13.17	11.59	13.50
	General Mean	12.38	9.67	8.16	10.07
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.045	0.127		
	Stage (S)	0.028	0.078		
	G x S	0.078	0.219		
	Grasses Vs Legumes	0.168	0.473		

Surana *et al.* (2013) reported chemical composition of Marvel-6-40 and Marvel-8 with respect to crude protein content was 6.41 and 6.56 per cent, respectively. Manzoor *et al.* (2013) studied nutritive value and *in-situ* digestibility of irrigated grasses reported crude protein content in madras anjan (*Cenchrus ciliaris* L.) was 11.13 per cent at pre-flowering stage. Sultan *et al.* (2007) concluded protein content decreased with maturity stage of grasses, they observed that lowest crude protein content of 5.4 per cent in madras anjan (*Cenchrus ciliaris* L.) at maturity stage and highest crude protein content of 8.7 per cent at early bloom stage. Kumar *et al.* (2016) conducted experiment on enhanced quality forage production through grass-legume intercropping under arid eco-system of Kachchh, Gujarat. It was reported that crude protein content in madras anjan (*Cenchrus ciliaris* L.), marvel (*Dichanthium annulatum*) (Forssk.) Staf and stylo (*Stylosanthes hamata* L.) Taub were 6.80, 6.50 and 15.78 per cent, respectively. It was concluded that marvel grass based intercropping systems are the best grass-legume intercropping system for enhanced quality forage production for overall development of livestock sector.

Jingura *et al.* (2001) reported that crude protein content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb. was 16.75 per cent. Garg *et al.* (2012) conducted experiment on nutritional characteristics of some ruminant feedstuffs by using *in vitro* gas production technique reported, crude protein content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb was 18.75 and 13.06 per cent, respectively. Tokita *et al.* (2006) studied amino acid profiles of tropical legumes. It was found that 17.9 and 19.1 per cent crude protein content in ran mung or siratro (*Macroptilium atropurpureum*) at pre-flowering and flowering stages of their first growth, respectively.

4.1.3 Crude fibre content

The data on per cent crude fibre content in different cereal grasses and legumes forages at different growth stages depicted in Table 3. It was observed that, per cent crude fibre content was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, per cent crude fibre was ranged between 23.40 to 35.73 per cent. The mean per cent crude fibre was significantly lowest in legumes (28.81 %) than cereal grasses (31.28 %).

Table 3. Crude fibre (%) in cereal grasses and legumes forages at different growth stages.

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
	Cereal				
1	Marvel (<i>Dichanthium annulatum</i>)	24.53	27.09	30.80	27.47
2	Dongari grass (<i>Crysopogan fulvus</i>)	30.78	32.81	35.73	33.11
3	Madras anjan (<i>Cenchrus ciliaris</i>)	29.22	31.97	34.42	31.87
4	Pawana (<i>Sehima nervosum</i>)	30.89	32.22	35.02	32.71
	Mean	28.85	31.02	33.99	31.28
	Legume				
5	<i>Stylosanthes seabrana</i>	23.40	25.08	27.19	25.22
6	<i>Stylosanthes hamata</i>	25.49	28.27	31.06	28.27
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	28.33	31.62	34.68	31.54
8	Ran mung (<i>Macroptilium atropurpureum</i>)	27.50	30.12	33.11	30.24
	Mean	26.18	28.77	31.51	28.81
	General Mean	27.52	29.90	32.75	30.06
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.040	0.112		
	Stage (S)	0.024	0.069		
	G x S	0.069	0.195		
	Grasses Vs Legumes	0.168	0.472		

Among the cereal grasses and legumes genotypes, a legume forage, *Stylosanthes seabrana* recorded significantly lowest per cent crude fibre content at pre flowering stage (23.40 %), 50 % flowering stage (25.08 %) and post flowering stage (27.19 %). It also recorded the lowest mean per cent crude fibre (25.22 %) of all growth stage. Within the cereal grasses, marvel (*Dichanthium annulatum*) recorded significantly lowest per cent crude fibre at pre flowering stage (24.53 %), 50 % flowering stage (27.09 %) and post flowering stage (30.80 %). marvel (*Dichanthium annulatum*) also recorded the lowest mean per cent crude fibre of three growth stages (27.47 %).

Among the different growth stages, per cent crude fibre was increased with the advancement of growth stages in both cereal grasses and legumes. The mean per cent crude fibre of all genotypes was the lowest at pre flowering (27.52 %), followed by 50 % flowering stage (29.90 %) and significantly higher at post flowering stage (32.75 %).

The values reported for per cent crude fibre are in agreement with the literature values. Melesse *et al.* (2017) reported crude fibre content in madras anjan (*Cenchrus ciliaris* L.) was 32.2 per cent at pre-flowering stage. Crude fibre content in pawana (*Sehima nervosum*) (Rottler) Stapf, marvel (*Dichanthium annulatum*) (Forssk.) Staf, dongari grass (*Crysopogan fulvus*) (Spreng) Chiov and stylo (*Stylosanthes hamata* L.) Taub were 29.22, 24.56, 35.73 and 27.09 per cent, respectively (Kauthale *et al.*, 2017). Khan *et al.* (2013) carried out an experiment on some terrestrial weeds at seed production stage reported that 28.91 per cent crude fibre content in marvel (*Dichanthium annulatum*) (Forssk.) Staf.

Previous research workers reported crude fibre content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb were 22.42 and 23.29 per cent, respectively (Garg *et al.*, 2012). Jayprakash *et al.* (2016) studied biomass yield and chemical composition of hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and stylo (*Stylosanthes hamata* L.) Taub. It was reported that crude fibre content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and stylo (*Stylosanthes hamata* L.) Taub was 22.50 and 25.28 per cent, respectively. Ratnawaty *et al.* (2013) reported that 38.23 per cent crude fibre content when harvested on 120 days after planting in stylo (*Stylosanthes seabrana*) B.L.

Maass & Mannatje. Suksombat and Buakeeree (2006) recorded crude fibre content at three different cutting intervals *i.e.* 30, 40 and 50 days after sowing. The lowest crude fibre content was 19.91 per cent at 30 days cutting interval, the highest of 28.55 per cent at 50 days cutting interval and 26.27 per cent at 40 days cutting interval in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Ahmed and Ahmed (2015) reported 34.66 per cent crude fibre in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb.

4.1.4 Ether extract content

The data on per cent ether extract content in different cereal grasses and legumes forages at different growth stages depicted in Table 4. It was observed that, per cent ether extract content was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, per cent ether extract was ranged between 0.63 to 2.01 per cent. The mean per cent ether extract was significantly higher in legumes (1.60 %) than cereals (0.93 %).

Among the cereal grasses and legumes genotypes, a legume forage, *Stylosanthes seabrana* recorded the highest ether extract (1.72 %), (1.97 %) and (2.01 %) at pre flowering, 50 % flowering and post flowering stage, respectively. It also recorded the highest mean per cent ether extract of all growth stages (1.90 %). Within the cereal grasses, a cereal grass marvel (*Dichanthium annulatum*) recorded significantly highest per cent ether extract at pre flowering stage (0.83 %), 50 % flowering stage (1.20 %), and post flowering stage (1.33 %), respectively. It also recorded the highest mean per cent ether extract (1.12 %) of three growth stages.

Among the different growth stages, per cent ether extract was increased with the advancement of growth stages in both cereal grasses and legumes. The mean per cent ether extract of all genotypes was the lowest at pre flowering (0.73 %), followed by 50 % flowering stage (0.98 %) and significantly higher at post flowering stage (1.09 %).

The values reported for per cent ether extract are in agreement with the literature values. Khan *et al.* (2017) reported ether extract content in madras anjan (*Cenchrus ciliaris* L.) at early, medium and late growth stages were 7.37, 4.07 and 2.08 per cent, respectively. Ether extract content in pawana (*Sehima nervosum*) (Rottler) Stapf, marvel (*Dichanthium annulatum*) (Forssk.) Staf, dongari grass (*Crysopogan fulvus*)

Table 4. Ether extract (%) in cereal grasses and legumes forages at different growth stages.

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
Cereal					
1	Marvel (<i>Dichanthium annulatum</i>)	0.83	1.20	1.33	1.12
2	Dongari grass (<i>Crysopogan fulvus</i>)	0.80	0.98	1.05	0.95
3	Madras anjan (<i>Cenchrus ciliaris</i>)	0.69	0.87	0.93	0.83
4	Pawana (<i>Sehima nervosum</i>)	0.63	0.89	1.06	0.86
	Mean	0.73	0.98	1.09	0.93
Legume					
5	<i>Stylosanthes seabrana</i>	1.72	1.97	2.01	1.90
6	<i>Stylosanthes hamata</i>	1.23	1.73	1.46	1.47
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	1.38	1.59	1.89	1.62
8	Ran mung (<i>Macroptilium atropurpureum</i>)	1.18	1.37	1.67	1.41
	Mean	1.37	1.66	1.75	1.60
	General Mean	1.06	1.33	1.43	1.27
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.019	0.055		
	Stage (S)	0.012	0.033		
	G x S	0.034	0.095		
	Grasses Vs Legumes	0.167	0.469		

(Spreng) Chiov and stylo (*Stylosanthes hamata* L.) Taub were 0.59, 0.78, 0.76 and 0.76 per cent, respectively (Kauthale *et al.*, 2017). Surana *et al.* (2013) reported chemical composition of Marvel-6-40 and Marvel-8 with respect to ether extract content was 0.93 and 0.89 per cent, respectively.

Previous investigators reported ether extract content in stylo (*Stylosanthes seabrana*) B.L Maass & t Mannatje when harvested on 120 days after planting were 2.36 per cent (Ratnawaty *et al.*, 2013). Jayprakash *et al.* (2016) studied biomass yield and chemical composition of hedge lucerne (*Deshmanthus virgatus* L.) or dashrath grass and stylo (*Stylosanthes hamata* L.) Taub. It was reported that ether extract content in hedge lucerne and stylo (*Stylosanthes hamata* L.) Taub was 2.29 and 2.53 per cent, respectively. Suksombat and Buakeeree (2006) recorded ether extract content at three different cutting intervals i.e. 30, 40 and 50 days after sowing. They showed highest ether extract content was 2.97 per cent at 30 days cutting interval and lowest ether extract content was 2.62 per cent at 50 days cutting interval and 2.75 per cent at 40 days cutting interval in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Ahmed and Ahmed (2015) found that 2.25 per cent ether extract content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb.

4.1.5 Total carbohydrate

The data on total carbohydrate content in different cereal grasses and legumes forages at different growth stages depicted in Table 5. It was observed that, per cent total carbohydrate content was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, per cent total carbohydrate was ranged between 47.73 to 65.81 per cent. The mean per cent total carbohydrate was significantly higher in cereals (59.65 %) than legumes (54.37 %).

Among the cereal grasses and legumes genotypes, a cereal grass *Dichanthium annulatum* recorded significantly higher per cent total carbohydrate at pre flowering stage (65.81 %), 50 % flowering stage (62.84 %) and post flowering stage (62.03 %), respectively. It also recorded the highest mean per cent total carbohydrate of three growth stages (63.56 %). Within the legumes, *Stylosanthes seabrana* recorded the highest mean per cent total carbohydrate of all growth stages (57.22 %). However,

Table 5. Total carbohydrate (%) in cereal grasses and legumes forages at different growth stages.

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
Cereal					
1	Marvel (<i>Dichanthium annulatum</i>)	65.81	62.84	62.03	63.56
2	Dongari grass (<i>Crysopogan fulvus</i>)	57.25	59.50	57.49	58.08
3	Madras anjan (<i>Cenchrus ciliaris</i>)	57.78	58.75	58.01	58.18
4	Pawana (<i>Sehima nervosum</i>)	58.46	60.24	57.71	58.81
	Mean	59.82	60.33	58.81	59.65
Legume					
5	<i>Stylosanthes seabrana</i>	55.62	58.39	57.67	57.22
6	<i>Stylosanthes hamata</i>	56.96	56.06	55.04	56.02
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	51.43	49.45	47.73	49.54
8	Ran mung (<i>Macroptilium atropurpureum</i>)	55.46	55.40	53.32	54.73
	Mean	54.86	54.82	53.44	54.37
	General Mean	57.35	57.58	56.13	57.02
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.012	0.034		
	Stage (S)	0.007	0.021		
	G x S	0.021	0.058		
	Grasses Vs Legumes	0.167	0.469		

Stylosanthes hamata recorded the highest total carbohydrate at pre flowering stage (56.96 %) and *Stylosanthes seabrana* recorded the highest total carbohydrate at 50 % flowering stage (58.39 %) and post flowering stage (57.67 %).

Among the different growth stages, per cent total carbohydrate was decreased with the advancement of growth stages in both cereal grasses and legumes. The mean per cent total carbohydrate of all genotypes was the highest at 50 % flowering stage (57.58 %) followed by pre flowering stage (57.35 %), and significantly lowest at post flowering stage (56.13 %). The values reported for per cent total carbohydrate are in agreement with the literature values. Khan *et al.* (2017) reported total carbohydrate content in madras anjan (*Cenchrus ciliaris* L.) at early, medium and late growth stages were 66.1, 71.2 and 77.5 per cent, respectively.

Total carbohydrate content in stylo (*Stylosanthes hamata* L.) Taub was 77.00 per cent (Gupta *et al.*, 2011). The total carbohydrate content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) was 69.7 per cent (Das *et al.*, 2015).

4.2 Cell wall constituents

4.2.1 Neutral detergent fibre

The data on per cent neutral detergent fibre content in different cereal grasses and legumes forages at different growth stages depicted in Table 6. It was observed that, per cent neutral detergent fibre content was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, per cent neutral detergent fibre was ranged between 40.20 to 73.61 per cent. The mean per cent neutral detergent fibre was significantly lower in legumes (50.10 %) than cereals (66.45 %).

Among the cereal grasses and legumes forages, a legume forage, *Stylosanthes seabrana* recorded the lowest neutral detergent fibre at pre flowering stage (40.20 %), 50 % flowering stage (48.70%) and at post flowering stage (51.90 %). *Stylosanthes seabrana* also recorded the lowest mean per cent neutral detergent fibre content (46.93 %) of three growth stages. Within the cereal grasses, madras anjan (*Cenchrus ciliaris*) recorded significantly lowest per cent neutral detergent fibre at pre flowering stage (55.30%), whereas marvel recorded significantly lowest neutral detergent fibre content at 50 % flowering stage (63.50 %) and post flowering stage (65.90%).

Table 6. Neutral detergent fibre (%) in cereal grasses and legumes forages at different growth stages.

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
Cereal					
1	Marvel (<i>Dichanthium annulatum</i>)	61.90	63.50	65.90	63.77
2	Dongari grass (<i>Cryspogan fulvus</i>)	62.00	71.40	73.61	69.00
3	Madras anjan (<i>Cenchrus ciliaris</i>)	55.30	68.10	70.20	64.53
4	Pawana (<i>Sehima nervosum</i>)	64.00	69.51	72.10	68.54
	Mean	60.80	68.12	70.45	66.45
Legume					
5	<i>Stylosanthes seabrana</i>	40.20	48.70	51.90	46.93
6	<i>Stylosanthes hamata</i>	42.80	48.90	52.80	48.17
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	51.20	51.40	55.50	52.70
8	Ran mung (<i>Macroptilium atropurpureum</i>)	50.20	54.80	52.81	52.60
	Mean	46.10	50.95	53.25	50.10
	General Mean	53.45	59.54	61.85	
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.014	0.040		
	Stage (S)	0.009	0.024		
	G x S	0.024	0.068		
	Grasses Vs Legumes	0.167	0.469		

Marvel also recorded the lowest mean per cent neutral detergent fibre of three growth stages (63.77 %).

Among the different growth stages, per cent neutral detergent fibre was increased with the advancement of growth stages in both cereal grasses and legumes. Mean per cent neutral detergent fibre of all genotypes was the lowest at pre flowering stage (53.45 %), increased at 50 % flowering stage (59.54 %) and significantly higher at post flowering stage (61.85 %).

The values reported for per cent neutral detergent fibre are in agreement with the literature values of several research workers. Khan *et al.* (2013) reported that 72.61 per cent neutral detergent fibre content in marvel (*Dichanthium annulatum*) (Forssk.) Staf. Surana *et al.* (2013) reported chemical composition of Marvel-6-40 and Marvel-8 with respect to neutral detergent fibre content was 72.40 and 72.30 per cent, respectively.

Melesse *et al.* (2017) studied the nutritional composition of grasses reported neutral detergent fibre content in madras anjan (*Cenchrus ciliaris* L.) was 38.00 per cent at pre-flowering stage. Teka *et al.* (2012) observed maturity of madras anjan (*Cenchrus ciliaris* L.) led to increase in neutral detergent fibre content. The resultant values of neutral detergent fibre content were 75.89 and 75.90 per cent at early and late stage, respectively. The neutral detergent fibre content in madras anjan (*Cenchrus ciliaris* L.) was 64.00 per cent at early bloom stage, it was increased to 69.00 per cent at maturity stage (Sultan *et al.*, 2007).

Musco *et al.* (2016) reported 49.91 per cent neutral detergent fibre content in stylo (*Stylosanthes hamata* L.) Taub. Gupta *et al.* (2011) reported that 54.16 per cent neutral detergent fibre content in stylo (*Stylosanthes hamata* L.) Taub. Neutral detergent fibre content in stylo (*Stylosanthes seabrana*) B.L Maass & t Mannatje was 58.56 per cent when harvested on 120 days after planting. (Ratnawaty *et al.*, 2013). Garg *et al.* (2012) reported nutritional characteristics of some ruminant feedstuffs by using *in vitro* gas production technique. The neutral detergent fibre content in dashrath grass (*Deshmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb was 42.45 and 55.60 per cent, respectively. The neutral detergent fibre content reported for hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) were 41.4 per

cent (Ly *et al.*, 2001), 49.7 per cent (Das *et al.*, 2015) and 34.82 per cent (Edgar *et al.*, 2017).

4.2.2 Acid detergent fibre

The data on per cent acid detergent fibre content in different cereal grasses and legumes forages at different growth stages depicted in Table 7. It was observed that, per cent acid detergent fibre content was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, per cent acid detergent fibre was ranged between 30.40 to 49.20 per cent. The mean per cent acid detergent fibre was significantly lowest in legumes (37.68 %) than cereals (43.08 %).

Among the cereal grasses and legumes genotypes, a legume forage, *Stylosanthes seabrana* recorded the lowest mean per cent acid detergent fibre of all growth stages (35.63 %). The *Stylosanthes hamata* recorded the lowest acid detergent fibre at pre flowering stage (30.40 %), whereas, *Stylosanthes seabrana* recorded the lowest acid detergent fibre at 50 % flowering stage (35.30 %) and post flowering stage (40.40%).

Within the cereal grasses, marvel (*Dichanthium annulatum*) recorded significantly lowest per cent acid detergent fibre at pre flowering stage (36.20 %), 50 % flowering stage (39.90 %) and post flowering stage (44.80 %). It also recorded the lowest mean per cent acid detergent fibre of three growth stages (40.30 %).

Among the different growth stages, per cent acid detergent fibre was increased with the advancement of growth stages in both cereal grasses and legumes. The mean per cent acid detergent fibre of all genotypes was the lowest at pre flowering (35.53%), increased at 50 % flowering stage (40.92 %) and significantly higher at post flowering stage (44.69 %).

The values reported for per cent acid detergent fibre are in agreement with the literature values. Khan *et al.* (2013) reported 49.24 per cent acid detergent fibre content in marvel (*Dichanthium annulatum*) (Forssk.) Staf. Manzoor *et al.* (2013) studied nutritive value and *in-situ* digestibility of irrigated grasses reported acid detergent fibre content in madras anjan (*Cenchrus ciliaris* L.) was 46.3 per cent at pre-flowering stage. Teka *et al.* (2012) observed maturity of madras anjan (*Cenchrus ciliaris* L.) led to decrease in acid detergent fibre content. The resultant values of acid detergent fibre

Table 7. Acid detergent fibre (%) in cereal grasses and legumes forages at different growth stages.

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
Cereal					
1	Marvel (<i>Dichanthium annulatum</i>)	36.20	39.90	44.80	40.30
2	Dongari grass (<i>Cryspogan fulvus</i>)	43.11	47.30	49.20	46.54
3	Madras anjan (<i>Cenchrus ciliaris</i>)	37.50	42.80	46.80	42.37
4	Pawana (<i>Sehima nervosum</i>)	37.11	44.10	48.10	43.11
	Mean	38.48	43.52	47.22	43.08
Legume					
5	<i>Stylosanthes seabrana</i>	31.20	35.30	40.40	35.63
6	<i>Stylosanthes hamata</i>	30.40	38.80	40.61	36.60
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	32.40	40.70	45.39	39.50
8	Ran mung (<i>Macroptilium atropurpureum</i>)	36.30	38.50	42.20	39.00
	Mean	32.57	38.32	42.15	37.68
	General Mean	35.53	40.92	44.69	
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.065	0.183		
	Stage (S)	0.040	0.112		
	G x S	0.113	0.318		
	Grasses Vs Legumes	0.170	0.477		

content were 47.03 and 44.47 per cent at early and late stage, respectively. Rafay *et al.* (2013) reported 38 per cent acid detergent fibre in madras anjan (*Cenchrus ciliaris* L.). The acid detergent fibre content in madras anjan (*Cenchrus ciliaris* L.) was 31.00 per cent at early bloom stage and increased up to 33.00 per cent maturity stage (Sultan *et al.*, 2007).

The acid detergent fibre content was 43.80 per cent in stylo (*Stylosanthes seabrana*) B.L Maass & t Mannatje when harvested on 120 days after planting (Ratnawaty *et al.*, 2013). Musco *et al.* (2016) reported acid detergent fibre content was 42.13 per cent in stylo (*Stylosanthes hamata* L.) Taub. Das *et al.* (2015) reported 37.7 per cent acid detergent fibre in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). Edgar *et al.* (2017) reported 16.92 per cent acid detergent fibre content in dashrath grass (*Deshmanthus virgatus* L.). Garg *et al.* (2012) conducted experiment to assess nutritional characteristics of some ruminant feedstuffs by using *in vitro* gas production technique reported that, acid detergent fibre content in dashrath grass (*Deshmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb was 31.84 and 41.55 per cent, respectively. Jingura *et al.* (2001) reported 33.19 per cent acid detergent fibre content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb. The acid detergent fibre content in ran mung (*Macroptilium atropurpureum*) (DC.) Urb were 37.6 and 35.4 per cent at pre-flowering and flowering stages of their first growth, respectively (Tokita *et al.* 2006).

4.2.3 Hemi-cellulose

The data on per cent hemi-cellulose content in different cereal grasses and legumes forages at different growth stages depicted in Table 8. It was observed that, per cent hemi-cellulose content was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, per cent hemi-cellulose was ranged between 9.00 to 26.90 per cent. The mean per cent hemi-cellulose was significantly lower in legumes (12.42 %) than cereals (23.38 %).

Among the cereal grasses and legumes genotypes, the legume forage, *Stylosanthes seabrana* recorded the lowest mean per cent hemi-cellulose of all growth stage (11.30 %). The lowest hemi-cellulose at pre flowering stage recorded by

Table 8. Hemi-cellulose (%) in cereal grasses and legumes forages at different growth stages

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
	Cereal				
1	Marvel (<i>Dichanthium annulatum</i>)	25.70	23.61	21.11	23.47
2	Dongari grass (<i>Crypsopogan fulvus</i>)	18.90	24.10	24.40	22.47
3	Madras anjan (<i>Cenchrus ciliaris</i>)	17.80	25.30	23.40	22.17
4	Pawana (<i>Sehima nervosum</i>)	26.90	25.40	24.00	25.43
	Mean	22.32	24.60	23.22	23.38
	Legume				
5	<i>Stylosanthes seabrana</i>	9.00	13.40	11.50	11.30
6	<i>Stylosanthes hamata</i>	12.40	10.10	12.20	11.57
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	18.80	10.70	10.09	13.20
8	Ran mung (<i>Macroptilium atropurpureum</i>)	13.90	16.30	10.60	13.60
	Mean	13.52	12.62	11.10	12.42
	General Mean	17.92	18.62	17.16	
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.165	0.464		
	Stage (S)	0.101	0.284		
	G x S	0.286	0.804		
	Grasses Vs Legumes	0.186	0.523		

Stylosanthes seabrana (9.00%), at 50% flowering stage by *Stylosanthes hamata* (10.10 %) and at post flowering stage by dashrath grass (*Deshmanthus virgatus*) (10.09 %).

Within the cereal grasses, madras anjan (*Cenchrus ciliaris*) recorded significantly lowest per cent hemi-cellulose at pre flowering stage (17.80 %), whereas, marvel (*Dichanthium annulatum*) at 50 % flowering stage (23.61 %) and post flowering stage (21.11%). However, madras anjan (*Cenchrus ciliaris*) recorded the lowest mean per cent hemi-cellulose of three growth stages (22.17 %).

Among the different growth stages, per cent hemi-cellulose was increased with the advancement of growth stages in both cereal grasses and legumes. The mean per cent hemi-cellulose of all genotypes was the lowest at post flowering (17.16 %), increased at pre flowering stage (17.92 %) and significantly higher at 50% flowering stage (18.62 %).

The values reported for per cent hemi-cellulose are in agreement with the literature values. Melesse *et al.* (2017) reported hemi-cellulose content in madras anjan (*Cenchrus ciliaris* L.) was 22.8 per cent at pre-flowering stage. Hemi-cellulose content in marvel (*Dichanthium annulatum*) (Forssk.) staf at early bloom and maturity stage were 26.00 and 32.00 per cent, respectively (Sultan *et al.*, 2008).

The hemi-cellulose content in stylo (*Stylosanthes seabrana*) B.L Maass & t Mannatje was 14.76 per cent when harvested on 120 days after planting (Ratnawaty *et al.*, 2013). Gupta *et al.* (2011) recorded 16.11 per cent hemi-cellulose content in stylo (*Stylosanthes hamata* L.). Das *et al.* (2015) reported 12.0 per cent hemi-cellulose in dashrath grass (*Deshmanthus virgatus* L.). Tokita *et al.* (2006) reported increase in hemi-cellulose content in ran mung (*Macroptilium atropurpureum*) (DC.) Urb with advancement of growth stages, at pre-flowering it was 14.3 % increased to 16.7 % at flowering stage.

4.2.4 Lignin

The data on per cent lignin content in different cereal grasses and legumes forages at different growth stages depicted in Table 9. It was observed that, per cent lignin content was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, per cent lignin content was ranged between 3.83 to

11.40 per cent. The mean per cent lignin was significantly lowest in cereals (5.01 %) than legumes (9.18 %).

Among the cereal grasses and legumes genotypes, a cereal grass marvel (*Dichanthium annulatum*) recorded the lowest lignin content at pre flowering stage (3.79 %) and post flowering stage (5.74 %) and dongari grass (*Crysopogan fulvus*) recorded the lowest lignin content at 50 % flowering stage (5.14 %). However, marvel (*Dichanthium annulatum*) recorded the lowest mean per cent lignin of three growth stages (4.90 %).

Within the legumes, *Stylosanthes seabrana* recorded the lowest lignin content at pre flowering stage (7.14 %), 50% flowering stage (8.39 %) and post flowering stage (10.73 %). It also recorded lowest mean per cent lignin content of three growth stages (8.76%).

Among the different growth stages, per cent lignin was increased with the advancement of growth stages in both cereal grasses and legumes. The mean per cent lignin of all genotypes was the lowest at pre flowering (5.96 %), increased at 50 % flowering stage (6.98%) and significantly higher at post flowering stage (8.38 %).

The values reported for per cent lignin content are in agreement with the literature values. Sultan *et al.* (2008) recorded lignin content in marvel (*Dichanthium annulatum*) (Forssk.) staf at early bloom and maturity stage were 4.3 and 5.4 per cent, respectively. Manzoor *et al.* (2013) reported lignin content in madras anjan (*Cenchrus ciliaris* L.) was 4.8 per cent at pre-flowering stage. The lignin content in madras anjan (*Cenchrus ciliaris* L.) at early bloom stage was 3.9 per cent and 5.4 per cent at maturity stage (Sultan *et al.*, 2007).

Musco *et al.* (2016) reported 11.74 per cent lignin content in *Stylosanthes hamata*. Gupta *et al.* (2011) reported 6.29 per cent lignin in stylo (*Stylosanthes hamata* L.) Taub. The lignin content in stylo (*Stylosanthes seabrana*) B.L. Maass & t Mannatje were 11.32 per cent lignin content when harvested on 120 days after planting (Ratnawaty *et al.*, 2013). Das *et al.* (2015) reported 10.2 per cent lignin content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.). The lignin content increased with advancement of maturity, as 6.9 and 7.0 per cent in siratro (*Macroptilium atropurpureum*) (DC.) Urb at pre-flowering and flowering stage of their first growth, respectively (Tokita *et al.*, 2006).

Table 9. Lignin (%) in cereal grasses and legumes forages at different growth stages.

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
Cereal					
1	Marvel (<i>Dichanthium annulatum</i>)	3.79	5.16	5.74	4.90
2	Dongari grass (<i>Cryspogan fulvus</i>)	3.93	5.14	5.97	5.01
3	Madras anjan (<i>Cenchrus ciliaris</i>)	4.00	5.60	5.90	5.17
4	Pawana (<i>Sehima nervosum</i>)	3.83	5.40	5.76	5.00
	Mean	3.88	5.32	5.84	5.02
Legume					
5	<i>Stylosanthes seabrana</i>	7.14	8.39	10.73	8.76
6	<i>Stylosanthes hamata</i>	7.30	8.56	10.93	8.93
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	8.56	8.60	11.23	9.46
8	Ran mung (<i>Macroptilium atropurpureum</i>)	9.10	8.98	10.74	9.61
	Mean	8.02	8.63	10.90	9.19
	General Mean	5.96	6.98	8.38	
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.090	0.254		
	Stage (S)	0.055	0.155		
	G x S	0.156	0.440		
	Grasses Vs Legumes	0.173	0.485		

4.3 *In vitro* dry matter digestibility

The data on per cent *in vitro* dry matter digestibility in different cereal grasses and legumes forages at different growth stages depicted in Table 10. It was observed that, per cent *in vitro* dry matter digestibility was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, per cent *in vitro* dry matter digestibility was ranged between 50.03 to 64.98 per cent. The mean per cent *in vitro* dry matter digestibility was significantly higher in legumes (59.13 %) than cereals (54.87 %).

Among the cereal grasses and legumes genotypes, a legume forage, *Stylosanthes hamata* recorded the highest *in vitro* dry matter digestibility at pre flowering stage (64.88 %) and *Stylosanthes seabrana* recorded the highest *in vitro* dry matter digestibility at 50 % flowering stage (61.01 %) and at post flowering stage (56.98%). *Stylosanthes seabrana* recorded the highest mean per cent *in vitro* dry matter digestibility (60.75 %) of all growth stage.

Within cereal grasses, marvel (*Dichanthium annulatum*) recorded significantly higher per cent *in vitro* dry matter digestibility at pre flowering stage (60.30 %), 50 % flowering stage (57.38%) and post flowering stage (53.51 %). It also recorded the highest mean per cent *in vitro* dry matter digestibility (57.06 %) of three growth stages.

Among the different growth stages, per cent *in vitro* dry matter digestibility was decreased with the advancement of growth stages in both cereal grasses and legumes. The mean per cent *in vitro* dry matter digestibility of all genotypes was the highest at pre flowering (63.16 %), followed by 50 % flowering stage (58.62 %) and significantly lowest at post flowering stage (55.60 %).

The values reported for per cent *in vitro* dry matter digestibility are in agreement with the literature values. *In vitro* dry matter digestibility in madras anjan (*Cenchrus ciliaris* L.) was 73.3 per cent at pre-flowering stage. (Manzoor *et al.*, 2013). Sultan *et al.* (2007) reported decline in *in vitro* dry matter digestibility with advancement of maturity madras anjan (*Cenchrus ciliaris* L.). The lowest IVDMD in madras anjan at early bloom stage was 58.6 per cent and it was declined to 36.6 per cent at maturity stage.

Table 10. *In vitro* dry matter digestibility (%) in cereal grasses and legumes forages at different growth stages

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
Cereal					
1	Marvel (<i>Dichanthium annulatum</i>)	60.30	57.38	53.51	57.06
2	Dongari grass (<i>Cryspogan fulvus</i>)	54.85	51.53	50.03	52.14
3	Madras anjan (<i>Cenchrus ciliaris</i>)	59.28	55.09	51.93	55.43
4	Pawana (<i>Sehima nervosum</i>)	59.59	54.06	50.90	54.85
	Mean	58.50	54.51	51.59	54.87
Legume					
5	<i>Stylosanthes seabrana</i>	64.25	61.01	56.98	60.75
6	<i>Stylosanthes hamata</i>	64.88	58.25	56.83	59.99
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	63.30	56.75	53.03	57.69
8	Ran mung (<i>Macroptilium atropurpureum</i>)	60.22	58.49	55.56	58.09
	Mean	63.16	58.62	55.60	59.13
	General Mean	60.83	56.57	53.60	
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.046	0.130		
	Stage (S)	0.028	0.079		
	G x S	0.080	0.224		
	Grasses Vs Legumes	0.168	0.473		

Surana *et al.* (2013) reported *in vitro* dry matter digestibility of Marvel-6-40 and Marvel-8 was 58.00 and 56.00 per cent, respectively. *In vitro* dry matter digestibility in marvel (*Dichanthium annulatum*) (Forssk.) Staf at early bloom stage was 51.4 per cent whereas, at maturity stage decreased up to 39.5 percent (Sultan *et al.*, 2008).

Ly *et al.* (2001) reported *in vitro* dry matter digestibility in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) was 27.2 per cent.

4.4 Mineral contents

4.4.1 Ash

The data on per cent ash content in different cereal grasses and legumes forages at different growth stages depicted in Table 11. It was observed that, per cent ash content was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, per cent ash was ranged between 4.90 to 13.50 per cent. The mean per cent ash was significantly higher in cereal grasses (10.75 %) than legumes (6.73 %).

Among the cereal grasses and legumes genotypes, a cereal grass madras anjan (*Cenchrus ciliaris*) recorded significantly higher per cent ash content at pre flowering stage (13.50 %), whereas, marvel (*Dichanthium annulatum*) recorded significantly higher ash content at 50 % flowering stage (11.15 %) and post flowering stage (11.00 %). However, marvel (*Dichanthium annulatum*) recorded the highest mean per cent ash content of three growth stages (11.70 %).

Within the legumes, *Stylosanthes seabrana* recorded the highest ash at pre flowering stage (8.96 %) and 50% flowering stage (7.45%). Whereas, ran mung (*Macroptilium atropurpureum*) recorded the highest ash content at post flowering stage (7.40 %). It also recorded the highest mean per cent ash of all growth stages (7.47 %).

Among the different growth stages, per cent ash content was decreased with the advancement of growth stages in both cereal grasses and legumes. The mean per cent ash of all genotypes was the highest at pre flowering (10.23 %), followed by 50 % flowering stage (8.32 %) and significantly lowest at post flowering stage (7.70 %). At 50 % flowering stage, cereal grasses recorded highest mean per cent ash (10.28 %) than legumes (6.36 %).

Table 11. Ash (%) in cereal grasses and legumes forages at different growth stages.

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
Cereal					
1	Marvel (<i>Dichanthium annulatum</i>)	12.95	11.15	11.00	11.70
2	Dongari grass (<i>Cryspogan fulvus</i>)	12.20	9.90	9.25	10.45
3	Madras anjan (<i>Cenchrus ciliaris</i>)	13.50	9.93	9.20	10.88
4	Pawana (<i>Sehima nervosum</i>)	11.25	10.15	8.65	10.01
	Mean	12.47	10.28	9.52	10.75
Legume					
5	<i>Stylosanthes seabrana</i>	8.96	7.45	5.65	7.35
6	<i>Stylosanthes hamata</i>	7.65	5.25	5.55	6.15
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	7.25	5.80	4.90	5.98
8	Ran mung (<i>Macroptilium atropurpureum</i>)	8.05	6.95	7.40	7.47
	Mean	7.97	6.36	5.87	6.73
	General Mean	10.23	8.32	7.70	
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.010	0.027		
	Stage (S)	0.006	0.017		
	G x S	0.017	0.48		
	Grasses Vs Legumes	0.167	0.468		

The values reported for per cent ash are in agreement with the literature values. The ash content in pawana (*Sehima nervosum*) (Rottler) Stapf, marvel (*Dichanthium annulatum*) (Forssk.) Staf, dongari grass (*Crysopogan fulvus*) (Spreng) Chiov and stylo (*Stylosanthes hamata* L.) Taub were 11.55, 8.67, 8.17 and 10.47 per cent, respectively (Kauthale *et al.*, 2017). Khan *et al.* (2013) reported 11.79 per cent ash content in marvel (*Dichanthium annulatum*) (Forssk.) Staf. Manzoor *et al.* (2013) studied nutritive value and *in-situ* digestibility of irrigated grasses reported ash content in madras anjan (*Cenchrus ciliaris* L.) was 9.84 per cent at pre-flowering stage.

Das *et al.* (2015) reported 9.3 per cent ash in dashrath grass (*Deshmanthus virgatus* L.). Garg *et al.* (2012) reported ash content in dashrath grass (*Deshmanthus virgatus* L.) and siratro (*Macroptilium atropurpureum*) (DC.) Urb were 6.27 and 8.11 per cent, respectively. Ahmed and Ahmed (2015) found that 11.30 per cent ash content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb.

4.4.2 Calcium

The data on per cent calcium content in different cereal grasses and legumes forages at different growth stages depicted in Table 12. It was observed that, per cent calcium content was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, per cent calcium content was ranged between 0.10 to 2.16 per cent. The mean per cent calcium was significantly higher in legumes (1.79 %) than cereal grasses (0.16 %).

Among the cereal grasses and legumes genotypes, a legume forage, *Stylosanthes seabrana* recorded the highest mean per cent calcium content (2.10 %) of all growth stages. *Stylosanthes seabrana* recorded the highest calcium at pre flowering stage (2.16 %) and post flowering stage (2.03 %). Whereas, *Stylosanthes hamata* recorded highest calcium content at 50 % flowering stage (2.13%).

Within cereal grasses, marvel (*Dichanthium annulatum*) recorded significantly higher per cent calcium at pre flowering stage (0.23 %), 50 % flowering stage (0.19 %) and post flowering stage (0.15%). marvel (*Dichanthium annulatum*) also recorded the highest mean per cent calcium content of three growth stages (0.19 %).

Table 12. Calcium (%) in cereal grasses and legumes forages at different growth stages.

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
Cereal					
1	Marvel (<i>Dichanthium annulatum</i>)	0.23	0.19	0.15	0.19
2	Dongari grass (<i>Cryspogan fulvus</i>)	0.14	0.17	0.10	0.14
3	Madras anjan (<i>Cenchrus ciliaris</i>)	0.19	0.16	0.13	0.16
4	Pawana (<i>Sehima nervosum</i>)	0.21	0.17	0.10	0.16
	Mean	0.20	0.16	0.12	0.16
Legume					
5	<i>Stylosanthes seabrana</i>	2.16	2.11	2.03	2.10
6	<i>Stylosanthes hamata</i>	2.09	2.13	1.97	2.06
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	2.08	2.0	1.93	2.00
8	Ran mung (<i>Macroptilium atropurpureum</i>)	1.10	1.03	0.98	1.04
	Mean	1.85	1.81	1.72	1.79
	General Mean	1.03	0.98	0.93	
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.018	0.049		
	Stage (S)	0.011	0.030		
	G x S	0.030	NS		
	Grasses Vs Legumes	0.167	0.469		

Among the different growth stages, per cent calcium content was decreased with the advancement of growth stages in both cereal grasses and legumes. The mean per cent calcium content of all genotypes was the highest at pre flowering (1.03 %), followed by 50 % flowering stage (0.98 %) and lowest at post flowering stage (0.93 %).

The values reported for per cent calcium content are in agreement with the literature values. Kumar *et al.* (2016) conducted experiment on enhanced quality forage production through grass-legume intercropping under arid eco-system of Kachchh, Gujarat reported that calcium content in madras anjan (*Cenchrus ciliaris* L.), marvel (*Dichanthium annulatum*) (forssk.) Staf and stylo (*Stylosanthes hamata* L.) Taub were 0.17, 0.14 and 0.73 per cent, respectively. Sultan *et al.* (2008) reported calcium content in marvel (*Dichanthium annulatum*) (Forssk.) Staf at early bloom stage was 0.14 per cent which slightly declined at maturity stage 0.13 percent.

Jayprakash *et al.* (2016) reported calcium content in hedge lucerne or dashrath grass (*Deshmanthus virgatus* L.) and stylo (*Stylosanthes hamata* L.) Taub.were 2.15 and 2.11 per cent, respectively. Gupta *et al.* (2011) reported 0.78 per cent calcium content in stylo (*Stylosanthes hamata* L.) Taub. Jingura *et al.* (2001) reported 0.98 per cent calcium content in ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb.

4.4.3 Magnesium

The data on per cent magnesium content in different cereal grasses and legumes forages at different growth stages depicted in Table 13. It was observed that, per cent magnesium content was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, per cent magnesium was ranged between 0.14 to 0.36 per cent. The mean per cent magnesium was significantly higher in legumes (0.25%) than cereal grasses (0.24 %).

Among the cereal grasses and legumes genotypes, a legume forage, *Stylosanthes seabrana* recorded the highest magnesium content at pre flowering stage (0.32 %), 50% flowering stage (0.29 %) and post flowering stage (0.26 %). It also recorded the highest mean per cent magnesium (0.29 %) of all growth stage. Within the cereal grasses, a cereal grass marvel (*Dichanthium annulatum*) recorded significantly

Table 13. Magnesium (%) in cereal grasses and legumes forages at different growth stages.

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
Cereal					
1	Marvel (<i>Dichanthium annulatum</i>)	0.36	0.34	0.27	0.33
2	Dongari grass (<i>Cryopogan fulvus</i>)	0.23	0.20	0.16	0.20
3	Madras anjan (<i>Cenchrus ciliaris</i>)	0.23	0.25	0.19	0.22
4	Pawana (<i>Sehima nervosum</i>)	0.27	0.21	0.17	0.22
	Mean	0.26	0.25	0.19	0.24
Legume					
5	<i>Stylosanthes seabrana</i>	0.32	0.29	0.26	0.29
6	<i>Stylosanthes hamata</i>	0.31	0.27	0.24	0.28
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	0.29	0.24	0.18	0.23
8	Ran mung (<i>Macroptilium atropurpureum</i>)	0.22	0.27	0.14	0.21
	Mean	0.28	0.26	0.20	0.25
	General Mean	0.27	0.25	0.20	
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.006	0.017		
	Stage (S)	0.004	0.010		
	G x S	0.011	0.030		
	Grasses Vs Legumes	0.167	0.468		

higher per cent magnesium at pre flowering stage (0.36 %), 50 % flowering stage (0.34 %) and post flowering stage (0.27 %). It also recorded the highest mean per cent magnesium (0.33 %) of three growth stages.

Among the different growth stages, per cent magnesium content was decreased with the advancement of growth stages in both cereal grasses and legumes. The mean per cent magnesium of all genotypes was the highest at pre flowering stage (0.27 %), followed by 50 % flowering stage (0.25 %) and significantly lowest at post flowering stage (0.20 %).

The values reported for per cent magnesium are in agreement with the literature values. Sultan *et al.* (2008) reported magnesium content in marvel (*Dichanthium annulatum*) (Forssk.) Staf at early bloom stage was 0.032 per cent which declined at maturity stage (0.030 %). Manzoor *et al.* (2013) studied nutritive value and *in-situ* digestibility of irrigated grasses reported magnesium content in madras anjan (*Cenchrus ciliaris* L.) was 0.26 per cent at pre-flowering stage. Rahim *et al.* (2008) studied mineral profile of marginal land grasses reported magnesium content in madras anjan (*Cenchrus ciliaris* L.) at pre-flowering and flowering stages was 0.005 and 0.010 per cent, respectively. Gupta *et al.* (2011) reported magnesium content in stylo (*Stylosanthes hamata* L.) Taub was 0.34 per cent.

4.4.4 Zinc

The data on per cent zinc content in different cereal grasses and legumes forages at different growth stages depicted in Table 14. It was observed that, zinc content was significantly differed among the genotypes, growth stages and within cereal grasses and legumes. Overall, zinc content was ranged between 4.34 to 12.23 ppm. The mean zinc content was significantly higher in legumes (9.71 ppm) than cereal grasses (6.60 ppm).

Among the cereal grasses and legumes genotypes, a legumes forage, *Stylosanthes seabrana* recorded the highest zinc content at pre flowering stage (12.23 ppm), 50 % flowering stage (11.19 ppm) and post flowering stage (9.81 ppm). It also recorded the highest mean zinc (11.07 ppm) of all growth stage. Among the cereal grasses, dongari grass (*Crysopogan fulvus*) recorded significantly highest zinc content at pre flowering stage (8.63 ppm) and marvel (*Dichanthium annulatum*) recorded highest.

Table 14. Zinc (ppm) in cereal grasses and legumes forages at different growth stages.

Sr. No	Name of forage crops	Growth stages			Mean
		Pre-flowering	50% flowering	Post flowering	
Cereal					
1	Marvel (<i>Dichanthium annulatum</i>)	8.31	7.24	5.31	6.95
2	Dongari grass (<i>Crysopogan fulvus</i>)	8.63	6.77	4.90	6.76
3	Madras anjan (<i>Cenchrus ciliaris</i>)	7.92	6.57	5.29	6.59
4	Pawana (<i>Sehima nervosum</i>)	8.40	5.61	4.34	6.11
	Mean	8.29	6.54	4.96	6.60
Legume					
5	<i>Stylosanthes seabrana</i>	12.23	11.19	9.81	11.07
6	<i>Stylosanthes hamata</i>	11.42	9.87	8.03	9.77
7	Dashrath grass (<i>Deshmanthus virgatus</i>)	10.14	8.88	7.89	8.97
8	Ran mung (<i>Macroptilium atropurpureum</i>)	10.02	9.10	7.92	9.01
	Mean	10.95	9.76	8.41	9.71
	General Mean	9.63	8.15	6.69	
	Source	S.Em. ±	CD at 5 %		
	Genotype (G)	0.065	0.184		
	Stage (S)	0.040	0.112		
	G x S	0.113	318		
	Grasses Vs Legumes	0.170	0.477		

zinc content at 50 % flowering stage (7.24 ppm) and post flowering stage (5.31 ppm). However, the highest mean zinc content (6.95 ppm) of three growth stages was recorded by marvel (*Dichanthium annulatum*).

Among the different growth stages, mean zinc content was decreased with the advancement of growth stages in both cereal grasses and legumes. The mean zinc content of all genotypes was the highest at pre flowering stage (9.63 ppm), followed by 50 % flowering stage (8.15 ppm) and significantly lowest at post flowering stage (6.69 ppm).

The values reported for mean zinc content are in agreement with the literature values. Rahim *et al.* (2008) studied mineral profile of marginal land grasses reported decline in zinc content in madras anjan (*Cenchrus ciliaris* L.), at pre-flowering and flowering stage it was 5.5 and 2.0 ppm, respectively. Melesse *et al.* (2017) studied the nutritional composition of grasses reported 1.86 per cent zinc content in madras anjan (*Cenchrus ciliaris* L.) at pre-flowering stage. Gupta *et al.* (2011) reported zinc content in stylo (*Stylosanthes hamata* L.) Taub was 61.00 ppm

5. SUMMARY AND CONCLUSIONS

5.1 Summary

The cereal grasses and legumes are an important forage crops for livestock as it contains an appreciable amount of nutrients. Cereal grasses and legumes are the principle forage crops, which gives frequent cuttings and supplies green forage continuously with high yield potential, which save expenses on labour, preparatory tillage and planting material. Cereal grasses and legumes require optimum temperature for excellent growth and gives better performance in bright sunlight. This cereal grasses and legumes are best suited to high rainfall areas, drought-tolerant and grows well almost in tropical and subtropical areas of the world.

Four grasses viz., marvel (*Dichanthium annulatum*) (Forssk.) Staf, dongari grass (*Crysopogan fulvus*) (Spreng) Chiov, madras anjan (*Cenchrus ciliaris* L.) and pawana (*Sehima nervosum*) (Rottler) Stapf and four legumes viz., stylo (*Stylosanthus seabrana*) B.L. Maass & t Mannatje, stylo (*Stylosanthus hamata* L.) Taub, hedge lucerne or dashrath grass (*Desmanthus virgatus* L.) and ran mung or siratro (*Macroptilium atropurpureum*) (DC.) Urb were grown at Grass Breeding scheme, MPKV, Rahuri. These grasses and legumes were analyzed at pre-flowering, 50 % flowering and post flowering stages for biochemical and forage quality parameters. To maximize the milk production, proper body growth, and better health it is essential to feed the animals with quality green forage cut at proper growth stage. Cutting stage shows effects on the nutritional status of forages. Thus, present investigation was planned and conducted during 2018-19 at AICRP on Forage crops laboratory and Department of Biochemistry, PGI, M.P.K.V., Rahuri to understand forage quality and biochemical composition of some of the grasses and legumes forages cut at different growth stages. This study will be helpful to recommend proper stage of harvesting for higher nutritive value.

The results, obtained during the present investigations are summarized in this section.

Dry matter

The forage grasses were higher in dry matter content than legumes forage crops studied. The per cent mean dry matter content of cereal crops (42.57 %) was higher than legume forage crops (37.51 %) studied. Among the cereal grasses and legumes, a

cereal forage grass, marvel (*Dichanthium annulatum*) recorded the highest mean per cent dry matter (44.25 %) and among the legumes, *Stylosanthes seabrana* recorded the highest mean per cent dry matter (40.25 %) of all growth stages. The per cent DM was increased with the advancement of growth stage in both cereal grasses and legumes. Among the forage crops studied, marvel (*Dichanthium annulatum*) recorded the highest dry matter (56.09 %) at post flowering stage.

Crude protein

The per cent crude protein was decreased with the advancement of growth stages in both cereal grasses and legumes i.e. higher CP at pre flowering stage and lower at post flowering stage. It was observed that, mean crude protein per cent was the higher in legumes (13.50 %) than cereals (6.64 %) forage crops investigated. Among the cereal grasses and legumes studied a legume, *Stylosanthes seabrana* recorded the highest mean per cent crude protein (15.53 %), whereas among the cereal forage grass, madras anjan (*Cenchrus ciliaris*) recorded the highest mean per cent crude protein (7.37 %) of three growth stages. Among the forage crops studied, dashrath grass (*Deshmanthus virgatus*) recorded highest crude protein (17.94 %) at pre flowering stage.

Crude fibre

The cereal forage crops were higher in crude fibre content than legume forage crops studied. The crude fibre was increased with the advancement of growth stages. It was observed that, mean per cent crude fibre was the lowest in legumes (28.81 %) than cereals (31.28 %). Among the cereal grasses and legumes, a legume forage *Stylosanthes seabrana* recorded the lowest mean per cent crude fibre (25.22 %), whereas among the cereal grasses, marvel (*Dichanthium annulatum*) recorded the lowest mean crude fibre (27.47 %) of three growth stages. Among the forage crops studied, *Stylosanthes seabrana* recorded lowest crude fibre (23.40 %) at pre flowering stage.

Ether extract

It was observed that, mean per cent ether extract was the higher in legumes (1.60 %) than cereals (0.93 %). Among the cereal grasses, marvel (*Dichanthium annulatum*) recorded the highest mean per cent ether extract (1.12 %), while, among the legumes, *Stylosanthes seabrana* recorded the highest mean per cent ether extract (1.90 %) of three growth stages. It was found that per cent ether extract increased with the

advancement of growth stages in both cereal grasses and legumes. Among the forage crops studied *Stylosanthes seabrana* recorded the highest per cent ether extract (2.01 %) at post flowering stage.

Total carbohydrate

It was observed that, mean per cent total carbohydrate content was the higher in cereals (59.65 %) than legumes (54.37 %). Within all forage crops studied a cereal grass, marvel (*Dichanthium annulatum*) recorded the highest mean per cent total carbohydrate content (63.56 %), whereas among the legumes analyzed, *Stylosanthes seabrana* recorded the highest mean per cent total carbohydrate (57.22 %) content of all growth stages. Among the different growth stages studied, per cent total carbohydrate was decreased with the advancement of growth stage in both cereal grasses and legumes. Among the forage crops studied, marvel recorded highest total carbohydrate per cent (65.81 %) at pre flowering stage.

Cell wall constituents

As regards to cell wall constituents, it was observed that, ADF, NDF, hemi-cellulose and lignin content was lower in legumes than cereal forage crops and these constituents were increased with the advancement of growth stage. The lowest cell wall constituents were observed at pre flowering stage and highest at post flowering stage. Among the cereal and legumes forage crops, a legume forage crop *Stylosanthes seabrana* recorded the lowest mean per cent ADF of 35.63 per cent and also recorded the lowest mean NDF of 46.93 per cent than other three legumes. Among the cereal grasses, marvel (*Dichanthium annulatum*) recorded significantly lowest mean per cent NDF and ADF of 63.77 and 40.30 per cent, respectively. Among the all forage crops studied, a legume forage, *Stylosanthes seabrana* recorded the lowest mean percent hemi-cellulose of 11.30 per cent and the lowest was at pre flowering stage 9.00 per cent. Among the cereals, madras anjan recorded the lowest mean per cent hemi-cellulose content of 22.17 per cent.

Among the cereal and legumes forage crops, a cereal grass marvel (*Dichanthium annulatum*) recorded the lowest per cent lignin content of 4.90 per cent, whereas among the legumes, *Stylosanthes seabrana* recorded the lowest mean percent

lignin of 8.76 % of growth stages. Among all forage crops studied, marvel (*Dichanthium annulatum*) recorded lowest lignin per cent (3.79 %) at pre flowering stage.

Digestibility

Among the different growth stages studied, per cent IVDMD was decreased with the advancement of growth stage in both cereal grasses and legumes. It was observed that mean per cent IVDMD was the higher in legumes (59.13 %) than cereals (54.87 %). Among the cereal grasses, *Dichanthium annulatum* recorded the highest mean per cent IVDMD (57.06 %) and among the legumes, *Stylosanthes seabrana* recorded the highest mean per cent IVDMD (60.75 %) of all growth stages. Among the forage crops evaluated, *Stylosanthes hamata* recorded the highest IVDMD (64.88 %) at pre flowering stage.

Minerals

The forage grasses were higher in ash than legumes. Ash were higher at pre flowering stage and declined towards maturity of crop. A cereal grass, marvel (*Dichanthium annulatum*) recorded the highest mean ash content of 11.70 per cent while, within legumes forage crops, ran mung (*Macroptilium atropurpureum*) recorded highest mean ash content of 7.47 % of all growth stages.

The forage legumes were higher in calcium content than grasses. Calcium content was higher at pre flowering stage and declined towards the maturity of crop. Among the all forage crops studied, a legume forage crop *Stylosanthes seabrana* recorded the highest mean per cent calcium content of 2.10 per cent, while, marvel (*Dichanthium annulatum*) recorded the highest mean calcium content of 0.19 per cent of all growth stages which is higher than other cereal grasses.

There was no significant difference in magnesium content among the cereal grasses and legumes. However, marvel recorded the highest mean magnesium content of 0.33 per cent among the cereals while, among the legume forages, *Stylosanthes seabrana* recorded the highest mean magnesium content of 0.29 per cent of all growth stage.

The forage legumes were higher in zinc content than grasses. Zinc content was higher at pre flowering stage and declined towards maturity of crop. Among the all forage crops studied, a legume forage crop *Stylosanthes seabrana* recorded the highest

mean zinc content of 11.07 ppm, while among cereal grasses, marvel (*Dichanthium annulatum*) recorded the highest mean zinc content of 6.95 ppm of all growth stage.

5.2 Conclusions

Four grasses *viz.*, marvel, dongari grass, madras anjan and pawana and four legumes *viz.*, stylo (*Stylosanthes seabrana*), stylo (*Stylosanthes hamata* L.), hedge lucerne or dashrath grass and ran mung or siratro were evaluated for biochemical composition and forage nutritional parameters at different growth stages.

The per cent dry matter, crude fibre, ether extract, ADF, NDF, hemi-cellulose and lignin, in grasses as well as legumes were increased with advancement of growth stages. The per cent crude protein, ash, Ca, Mg, Zn and IVDMD were decreased with advancement of growth stages.

Among the four cereal grasses evaluated, marvel recorded the highest mean dry matter, total carbohydrates, ether extract, IVDMD, ash, Ca, Mg and Zn as well as lowest crude fibre, NDF, ADF and lignin. While, madras anjan recorded the highest mean crude protein content and the lowest mean hemi-cellulose content among the grasses. Among the four legumes evaluated stylo (*Stylosanthes seabrana*) recorded the highest dry matter, crude protein, ether extract, total carbohydrates, IVDMD, Ca, Mg and Zn as well as lowest crude fibre, NDF, ADF, hemi-cellulose and lignin. While, ran mung recorded the highest ash content than other legumes.

Based on the biochemical parameters studied, marvel (*Dichanthium annulatum*) in cereal and stylo (*Stylosanthes seabrana*) within legumes were found better for most of the forage quality parameters. Among growth stages studied forage quality at pre flowering stage is much better than other cutting stages, but cutting forage crops at 50 % flowering stage is always preferred due to judicious combination of forage yield and forage quality of grasses and legumes.

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7. VITAE

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