जीवनरुपी अकाशाला गवसणी घालताना ....

शिक्षणरुपी विजयपथ पूर्ण करण्यासाठी

पैशाला पैसा लावून शिक्षणाची उमीद निर्माण करणारे ....

आत्मविश्वास व संस्काराचे पंखात बळ निर्माण करुन

माझ्या जडणघडणीतील सर्वश्रेष्ठ `मुर्तीकार' ....

माझा प्रत्येक श्वास असणारे ति. सौ. आई व आबा

आणि अज्ञानरुपी समाजाचे महान `दिपस्तंभ' ....

माझे परमश्रध्दास्थान व आदर्श कर्मवीर आण्णा

यांच्या चरणी ही विनंम्र शोध शब्दांजली

....समाधान

EFFECT OF SUBSEQUENT CUTTINGS ON NUTRITIONAL QUALITY OF SOME FODDER GRASSES

by

Samadhan Vasantrao Khatkale
(Reg. No.20125)

A Thesis Submitted in Partial Fulfilment of the Requirements
for the Degree of

MASTER OF SCIENCE (AGRICULTURE)

in

BIOCHEMISTRY

DEPARTMENT OF BIOCHEMISTRY

POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722
2002

EFFECT OF SUBSEQUENT CUTTINGS ON NUTRITIONAL QUALITY OF SOME FODDER GRASSES

by

Samadhan Vasantrao Khatkale

(Reg. No.20125)

A Thesis Submitted in Partial Fulfilment of the Requirements

for the Degree of

MASTER OF SCIENCE (AGRICULTURE)

in

BIOCHEMISTRY

Approved by :

(Dr. U.D. Chavan)
Chairman, Advisory Committee

(Dr. J.K. Chavan)
Committee Member

(Dr. K.M. Pol)
Committee Member

POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI - 413 722

2002

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or other person to any other university or institute for a degree or diploma

(S.V. Khatkale)

Place : MPKV, Rahuri

Dated : 20 /12/2002.

Dr. U.D. Chavan
Assistant Professor,
Department of Biochemistry,
Mahatma Phule Krishi Vidyapeeth,
Rahuri - 413 722, Dist. Ahmednagar (M.S.)

CERTIFICATE

This is to certify that the thesis entitled, "**Effect of subsequent cuttings on nutritional quality of some fodder grasses**", submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** (AGRICULTURE) in **BIOCHEMISTRY**, embodies the results of a piece of *bona fide* research work carried out by **Mr. Samadhan Vasantrao Khatkale**, under my guidance and supervision and that no part of the thesis has been submitted for any other degree or publication in other form. The assistance and help received during the course of these investigations have been duly acknowledged.

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

Dated : 20 /12 / 2002

(U.D. Chavan)
Research Guide

Dr. D.M. Sawant
Associate Dean,
Post Graduate Institute,
Mahatma Phule Krishi Vidyapeeth,
Rahuri - 413 722, Dist. Ahmednagar (M.S.)

CERTIFICATE

This is to certify that the thesis entitled, "**Effect of subsequent cuttings on nutritional quality of some fodder grasses**", submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** (AGRICULTURE) in **BIOCHEMISTRY**, embodies the results of a piece of *bona fide* research work carried out by **Mr. Samadhan Vasantrao Khatkale** under the guidance and supervision of **Dr. U.D. Chavan,** Assistant Professor, Department of Biochemistry, M.P.K.V., Rahuri and no part of the thesis has been submitted to any other institute for degree or diploma or publication in other form.

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

Dated : / /2002

(D.M. Sawant)
Associate Dean

ACKNOWLEDGEMENTS

I consider myself very fortunate for getting an opportunity to complete thesis research work under the dynamic and able guidance of Dr. U.D. Chavan, Assistant Professor, Department of Agricultural Biochemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri . I am greatly indebted to him for the valuable guidance, concrete suggestions and constant inspiration and encouragement throughout the course of my research work and preparation of the manuscript of this investigation.

I wish to express my sincere and heartful thanks to Dr. J.K. Chavan, Head, Department of Food Science and Technology and Dr. K.M. Pol, Associate Professor of Plant Physiology, M.P.K.V., Rahuri, my advisory committee members, for their keen interest, scholastic guidance and constructive criticism on various aspects of research throughout the course of this investigation.

I would like to express my heartiest gratitude to Dr. S.V. Munjal, Associate Professor and Head, Department of Biochemistry, Prof. A.A. Kale, Prof. D.P. Kachare, Assistant Professor, Shri. S.V. Damame, Shri. S.R. Patil, Shri. R.E. Todmal, Senior Research Assistants, Department of Biochemistry, M.P.K.V., Rahuri. Prof. Wani from Statistics Department for Statistical analysis of data, Dr. Kharche providing atomic absorbance facility, Dr. Fulphagare for cell wall constituent analysis, Prof. D.S. Pawar and Shri. Anarase, Grass Breeding Scheme, M.P.K.V., Rahuri, Dr. S.B. Shinde, Assistant Professor, Department of Extension for their valuable co-operation, *untired help and timely suggestions during the course of this investigation and preparation of this dissertation.*

No words are enough to express my feeling, love and indebtedness and I wont forget the help given actually on the battle field by my friends Ulhas, Dada, Shameer, Sagar, Satish, Sudhir, Sandeep, Pandurang, S.P., Ganesh, Preetam, Anand, Faiz, Prashant, Sujeet, Mahadeo, Sneha, Santosh, Hanumant, Raju, Vijay, Deepak, Amol, Deva, any colleagues of the department Sudhakar, Sachin, Deepak, Gulab for their cooperation, constant encouragement and moral support during the course of this investigation and preparation of this manuscript.

Last but never the least, words are small trophies to express my deep sense of love and affection to my beloved parents, the Architects of my life Shri. Vasnatrao Khatkale and Sau. Subhdra Khatkale for providing valuable opportunities and their sacrifices in moulding me, blessings, encouragement and inspiration from them, help in building my educational carrier. I owe my lovable thanks to my beloved brother Vijay and sister Sangita, uncle Late. Nana and Dr. P.T. Patil and all teachers for their blessings, encouragement, patience and sympathetic attitude during my educational career.

Finally I pay my acknowledgement to the eminent scientists whose literature helped me to follow the right path of the work.

Place : MPKV, Rahuri (S.V. Khatkale)

Date : 20 / 12/2002

TABLE OF CONTENTS

	Page
CANDIDATE'S DECLARATION	ii
CERTIFICATES : 1. Research Guide	iii
2. Associate Dean (PGI)	iv
ACKNOWLEDGEMENTS	v
LIST OF TABLES	xi
LIST OF FIGURES	xii
ABBREVIATIONS	xiii
ABSTRACT	xiv
1. INTRODUCTION	1
2. REVIEW OF LITERATURE	5
2.1 Chemical composition	5
2.1.1 Dry matter	5
2.1.2 Crude fibre	7
2.1.3 Crude protein	8
2.1.4 Carbohydrate	9
2.2 Sugars	10
2.3 Ash	10
2.4 Minerals	11
2.5 Cell wall constituents	13
2.5.1 Cellulose	13
2.5.2 Hemicelluloses	14
2.5.3 Neutral detergent fibre	14
2.5.4 Acid detergent fibre	15

2.5.5 Lignin 15

2.5.6 Silica 16

2.6 *In vivo* dry matter digestibility (IVDMD) 16

2.7 Total Phenolics 17

2.8 Oxalates 18

3. MATERIAL AND METHODS 19

3.1 Material 19

3.1.1 Fodder grass samples 19

3.1.2 Chemicals 19

3.2 Methods 21

3.2.1 Dry matter 21

3.2.2 Crude oil 21

3.2.3 Crude fibre 21

3.2.4 Crude protein 21

3.2.5 Carbohydrate 21

3.2.6 Sugars 21

3.2.6.1 Reducing sugar 21

3.2.6.2 Total sugar 23

3.2.6.3 Non reducing sugar 23

3.2.7 Ash 21

3.2.8 Minerals 24

3.2.8.1 Calcium 24

3.2.8.2 Potassium 26

3.2.8.3 Phosphorus 27

3.2.8.4 Iron 21

3.2.9 Cell wall constituents 28

3.2.9.1 Cellulose 28

3.2.9.2 Hemicelluloses 28

3.2.9.3 Neutral detergent fibre (NDF) 29

3.2.9.4 Acid detergent fibre (ADF) 30

3.2.9.5 Lignin 31

3.2.9.6 Silica 31

3.2.10 *In vitro* dry matter digestibility 32

3.2.11 Total Phenolics 33

3.2.12 Oxalates 35

3.2.13 Statistical analysis 37

4. RESULTS AND DISCUSSION 38

4.1 Dry matter 38

4.2 Crude oil 41

4.3 Crude fibre 42

4.4 Crude protein 43

4.5 Carbohydrate 45

4.6 Sugars 46

4.7 Ash 49

4.8 Minerals 52

4.8.1 Calcium 52

4.8.2 Phosphorus 53

4.8.3 Potassium 54

4.8.4 Iron 55

4.9 Cell wall constituents 55

4.9.1 Cellulose 55
4.9.2 Hemicellulose 56
4.9.3 Neutral detergent fibre 59
4.9.4 Acid detergent fibre 60
4.9.5 Lignin 60
4.9.6 Silica 61
4.10 *In vitro* dry matter digestibility 62
4.11 Total Phenolics 62
4.12 Oxalates 65
4.13 Correlation 66
5. SUMMARY AND CONCLUSIONS 68
6. LITERATURE CITED 73
7. VITA 80

LIST OF TABLES

No.	Title	Page
1.	Various cultivars of fodder grasses and their different cutting stages	20
2.	Chemical composition of different cultivars of fodder grasses at different cutting stages	39
3.	Sugar content of different cultivars of fodder grasses at different cutting stages	47
4.	Ash and major mineral content of different cultivars of fodder grasses at different cutting stages	50
5.	Cell wall constituent and *in vitro* dry matter digestibility (IVDMD) of different cultivars of fodder grasses at different cutting stages	57
6.	Total phenolics and oxalates content of different cultivars of fodder grasses at different cutting stages	63
7.	Correlation coefficient (r) amongst different parameters means of fodder grasses	67

LIST OF FIGURES

No.	Title	Between pages
1.	Standard curve for estimation of sugars	22-23
2.	Standard curve for estimation of potassium	26-27
3.	Standard curve for estimation of phosphorus	28-29
4.	Standard curve for estimation of Total phenolics	35-36

LIST OF ABBREVIATIONS

ADF	:	Acid detergent fibre
^{0}C	:	Degree Celsius
C.D.	:	Critical difference
CF	:	Crude fibre
CP	:	Crude protein
DM	:	Dry matter
et al.	:	et alli (and others)
g	:	Grams
h	:	Hours
HC	:	Hemicellulose
IVDMD	:	*In vitro* dry matter digestibility
mg	:	Milligram
m ha		Million hectors
Min.	:	Minutes
ml	:	Millilitre
NDF	:	Neutral detergent fibre
nm	:	Nanometer
NRS	:	Non reducing sugar
RS	:	Reducing sugar
TS	:	Total sugar
viz.,	:	Videlicet (namely)
%	:	Per cent

ABSTRACT

EFFECT OF SUBSEQUENT CUTTINGS ON NUTRITIONAL QUALITY OF SOME FODDER GRASSES

by

Samadhan Vasantrao Khatkale

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

2002

Research Guide	:	Dr. U.D. Chavan
Department	:	Biochemistry

The present investigations were undertaken to evaluate the nutritional quality of four cultivars of fodder grasses at different cutting stages in relation to dry matter, crude fibre, crude protein carbohydrate, sugars, ash, minerals, cell wall constituents, *in vitro* dry matter digestibility, phenolics and oxalates. The four fodder grasses at different cutting stages were analysed and the data obtained was computed for statistical analysis in a Randomised Block Design (RBD).

The dry matter content ranged from 56.07 to 61.44 per cent. It was the highest in Cenchrus grass while lowest in Bajra x Napier hybrid grass. The crude fibre content ranged from 24.47 in Stylo to 32.19 in Guinea grass. The crude protein content raged from 4.98 to 17.01 per cent the lowest being in Cenchrus grass and the highest in Stylo grass Dry matter and crude fibre in fodder grasses increased with increasing cutting interval, while crude protein content decreases.

The total sugar content ranged from 61.02 to 73.07 mg/100 g It was highest in Stylo grass and lowest in Guinea grass. The ash content ranged from 6.14 to 14.76 per cent. The minerals like calcium, potassium and phosphorus content of fodder grasses varied from 0.41 to 0.83, 2.20 to 2.80, 0.25 to 0.35 per cent, respectively while iron content ranged from 71.88 to 103.33 mg/100 g. The cell wall constituents like cellulose, hemicellulose, neutral detergent fibre, acid detergent fibre, lignin and silica ranged from 24.89 to 27.48, 34.46 to 38.65, 67.80 to 71.16, 30.62 to 36.24, 6.18 to 7.99 and 1.27 to 2.61 per cent, respectively. The *in vitro* dry matter digestibility ranged from 41.80 in Bajra x Napier hybrid grass to 61.46 in Guinea grass. *In vitro* dry matter digestibility decreased with increasing cutting interval. The content total phenolics ranged from 17.25 to 65.18 mg/100 g. The oxalate content varied from 1.90 per cent in Bajra x Napier hybrid grass to 2.43 per cent in Cenchrus grass.

Among the four fodder grasses at their different cutting stages, the first cutting of Bajra x Napier hybrid grass, third cutting of Guinea grass, second cutting of Cenchrus and stylo grass appeared suitable for providing higher nutrients for animal feeding.

Pages 1 to 81

INTRODUCTION

1. INTRODUCTION

India is predominantly an agricultural country, contributing about 2.14 per cent of the world's geographical area. Livestock production is an integral part of Indian agriculture India has the largest cattle production in the world, i.e. about 1/5th of the world. The share of livestock production in agricultural income is increasing which is about 26 per cent (Singhal, 1999).

India has merely 8.3 m ha (4.4%) cropped area under fodder crops and there is hardly any scope for its future expansion because of the existing pressure on agricultural land for food and cash crops. However, problem of malnutrition is more serious due to large number of surplus unproductive livestock population coupled with inadequate feeds and fodder supply. Among the several factors involved in livestock production, feeding management is the most important one because feed alone accounts for 70 per cent cost of total livestock production Therefore, any improvement brought by feeding alone can lead to significant improvement in efficiency of livestock production (Chatterjee 1986). Livestock has been considered as an economic resource providing food, work and other products useful to humans.

To meet the requirement of growing human population, it is necessary to increase the production of milk, meat and other animal products. One of the ways by which this can be achieved is to increase the nutritive fodder production on a large scale.

The energy requirement of animals for maintenance, growth, fattening, gestation and lactation are of economic importance. The accuracy with which animal performance is predicted depends upon the knowledge of energy requirement and nutritive value of feed consumed. Hence we need to analyse the fodder grasses for their nutritive value by which we are able to formulate high nutritive value, energetic and low cost feed. 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 40 per cent variance in digestibility between samples of a given feed is associated with proximate composition.

At present more emphasis is given on the breeding programme of the fodder grasses, keeping the nutritive aspect aside. By analysing the fodder grasses we can determine their total digestibility, energy supply and other nutrients required for the animals. This analytical aspect is also helpful in breeding programme of fodder grasses to formulate high nutritive varieties. The high yielding varieties of fodder crop with high nutritive value can help to boost up animal production. This nutritive fodder can be fed to animals to reduce cost of feeding to the milch animal.

Forage crops play an important role in the general agricultural development inclusive of resource conservation, maintenance of soil fertility, conservation of soil and keeping the environmental balance A chronic quantitative and qualitative deficiency in scientific feeding of livestock when prevails, the genetic exploitation of farm animals is meaningless.

Deficiency of any mineral element in animal diet will cause other more severe systematic adverse effect before the digestibility is influenced. Knowing the proximate composition, we can justify the feeds having similar nutritional properties in formulating substitutions. As we know that two feeding stuffs are not similar in their chemical composition and physical characteristics, in practical, substitutions of one feeding stuff is made with the other depending upon the market price and availability in that region.

A large number of *allelocemicals* such as non-protein amino acids, cyanogens, glucosinolates, phenolic compounds, oxalic acid and alkaloids are reported from various species of fodder grasses. Their ecological significance for the fodder plants as protective agents against herbivorous animals and microbes was also discussed by Parihar *et al.* (1996).

Analysing the fodder grasses, we can determine antinutritional factors which may be harmful to the animals and may affect the keeping quality of feed and fodder. The utility of fodder grasses as a source of nutrients depends upon their green fodder yield, chemical composition and their nutritive value.

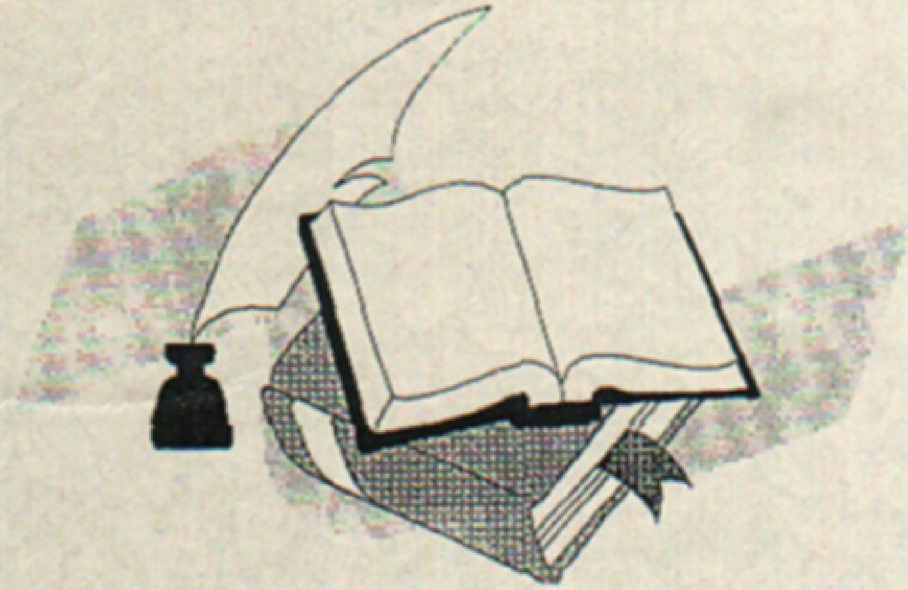
In India, the proximate analysis of fodder and feeds was started during the early twenties at Pusa. This work was continued in the Animal Nutrition Division, Indian Veterinary Research Institute (IVRI), Izatnagar (1939), National Dairy Research Institute (NDRI), Karnal (1956), Regional station at Bangalore, Anand, Mumbai, Palampur and University Departments of Animal Nutrition. The work upto 1948 on chemical composition was reviewed by Sen (1957) in the monogram entitled Animal Research in India and from 1929 to 1954 by Kehar (Anonymous, 1962) in the book entitled Research in Animal Husbandary.

A forage research scheme was started at Mahatma Phule Krishi Vidyapeeth, Rahuri in April, 1969. Under this scheme several new strains of fodder grasses are developed for higher yield. However their chemical composition and nutritive value at different cutting stages are not determined. Therefore, the present research work on four type of fodder grasses viz., Bajra x Napier hybrid (cv RBN-9), Guinea (cv. PGG-9), Chenchrus (cv. CAZRI-75) and Stylo (cv. Stylo hamata) at different cutting stages was undertaken. These fodder grasses grown at Forage Research Scheme, Mahatma Phule Krishi Vidyapeeth, Rahuri were selected for determining their chemical composition and nutritive value.

For the present research work the objectives were as follows:

1 To study the changes in nutritional composition of some fodder grasses during subsequent cutting stages.

2. To find out the appropriate cutting stage of the given grass species for maximum nutrient availability.



REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The quality of forages in ruminant ration is a major factor in determining the amount and type of supplementary feed. However, quality of forage has not been given adequate attention in regular practice as compared to quantity. Regulation of quality is rather difficult since it is influenced by plant species, stage of maturity and season. It is usually measured by chemical composition, palatability and digestibility. A number of experiments have been carried out to study the chemical composition and nutritive value at different stages of the various fodder grasses.

The results from these type of studies indicated that the chemical composition and nutritive value of fodder grasses changed according to the stage of growth. Further, it also differed as per crop species and season.

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

For assessment of feed and fodder quality externally, dry matter is one of the important factor. Higher dry matter is a positive aspect for higher fodder feed yield.

a. Bajra x Napier hybrid grass

Katoch *et al* (1987) evaluated fourteen genetically diverse Napier-Bajra hybrids obtained from Jhansi, Ludhiana and Coimbatore

These hybrids were evaluated along with NB-21 and checked for fodder yield and quality components from 1982 to 1985 grown in the forest prone rainfed Shivalik ranges of Himachal Pradesh IGFRI-7, IGFRI-10 and PBN-24 yielded 38, 16 and 38 per cent dry matter, respectively.

b. Guinea grass

Ranjan (1977) reported that Guinea grass contained 25.93 per cent dry matter. Patel *et al.* (1992) conducted field experiments at Forage Research Farm, Anand during 1987-88 to 1989-90 and showed that Guinea grass produced significantly higher green forage and dry matter yields than *Cenchrus ciliaris.*

c. Chenchrus grass

Singh *et al.* (1974) found the dry matter content of 'rabi' and 'kharif' forages as 11.40 to 23.60 and 13.05 to 28.80 per cent. Das and Bhatia (1978) examined the performance of two exotic and three indigenous strains of *Cenchrus ciliaris* (Linn) for different characters like fodder yield, leaf and stem weight and protein content, for four years. The significant forage yield was observed only after two successive years. On the basis of mean values of four years for dry matter yield/ha and protein content, the strain 357 was found to be the best.

d. Stylo grass

Gupta and Pradhan (1975) reported that the average dry matter content of legume and non-legume forages was 20.48 and 25.28 per cent respectively. Rai and Patil (1986) found that the forage yield increased with increasing intervals of cutting from 30 to 120 days.

Maximum green fodder yield (79.13 q/ha) was obtained at 120 days cutting interval followed by 90 days (78.21 q/ha).

2.1.2 Crude fibre

The crude fibre content is an important component in a forage grass from nutritional point of view. Nutritionally it is useful for normal functioning of digestive tract, food digestion and excretion. It also contributes to the total dry weight of fodder grasses.

a. Bajra x Napier hybrid grass

Panda *et al* (1967) studied the nutritive value of hybrid napier grass at pre flowering stage and reported that it contained 22.50 per cent crude fibre.

b. Guinea grass

Pathak and Kamara (1989) showed that crude fibre content of Guinea grass was 31.8 per cent during the first cut, 37.6 per cent at second cut, 37.7 per cent at third cut and 41.7 per cent a fourth cut. However, Sanjiv kumar and Garg (1995) reported 34.90 per cent crude fibre in Guinea grass. These scientists also reported that Guinea grass contained 29.80 per cent crude fibre.

c. Cenchrus grass

Narayanan and Dabadghao (1972) examined the chemical composition of Cenchrus grass. After analysing the samples on a dry weight basis, they contained 27.2 to 34.4 per cent crude fibre.

d. Stylo grass

Gupta *et al.* (1974) studied chemical composition and nutritive value of *Stylosanthes guganensus.* They found that Stylo grass contained 32.99 per cent crude fibre. Pathak and Kamara (1989) also showed that it contained 26.8 per cent crude fibre.

2.1.3 Crude protein

The crude protein content of fodder grasses is an important parameter to evaluate their nutritive value.

a. Bajra x Napier hybrid grass

Gupta (1969) crossed promising lines of *Pennisetum typhoides* with *Pennisetum purpureum* to develop high yielding hybrids with superior nutritional quality. Out of the twenty one hybrids, 19 were high yielding with over 10 per cent protein. Barevadia *et al.* (1976) analysed ten Napier-Bajra hybrids for their comparative performance and reported that the crude protein content of ten hybrid ranged from 9.3 to 10.1 per cent. Fernandes (1985) studied eleven hybrid Napier varieties in *kharif* season and found that the crude protein content was 9.77 per cent which was higher than summer and *rabi* seasons.

Katoch *et al.* (1987) examined taken fourteen genetically diverse improved Napier-Bajra hybrids from different sources for studying their fodder yield and nutrient production potential for four years and they reported that the crude protein content of these hybrids ranged from 3.70 to 12.18 per cent.

b. Guinea grass

Ranjan and Pathak (1979) evaluated several strains of Guinea grass and found crude protein with maximum 14.4 per cent, minimum 4.7 per cent and an average of 7.7 per cent. While Singh *et al.* (1992) found that Guinea grass contains 7.16 per cent crude protein. Sanjiv Kumar and Garg (1995) reported 7.56 per cent crude protein in same grass.

c. Cenchrus grass

Satya Paul *et al.* (1982) reported that crude protein content of Cenchrus grass changed according to stages of development. It contained crude protein 7.67 per cent during pre flowering, 4.69 per cent during flowering and 2.59 per cent during maturity for strain 358 and 7.47 per cent during flowering 6.87 per cent during maturity for palsana varieties of Cenchrus grass. Patel *et al.* (1992) also reported similar results for crude protein content in Cenchrus grass. Mishra *et al.* (1997) found that 3.70 per cent crude protein in Cenchrus grass.

d. Stylo grass

Gupta *et al.* (1974) and Chaudhari (1977) found 16.92 per cent crude protein in Stylo fodder grass. Pathak and Kamara (1989) analysed several cultivars of Stylo grass and they showed that stylo contained 18.1 per cent crude protein.

2.1.4 Carbohydrate

Bhatia *et al.* (1975) reported the quantitative studies on carbohydrate content of leaves, stems and grains of bajra, jowar and kangni. Sucrose, glucose and fructose were principle sugars at all stages. Water soluble carbohydrate were increased to maximum extent at flowering stage and decreased during maturation period. Cellulose contents were increased in early stage of growth of bajra and jowar.

Daniel *et al.* (1968) studied on economical appraisal of Guinea grass. They calculated carbohydrate content by difference method and found 44.35 per cent during pre flowering stage and 38.70 per cent during flowering stage.

2.2 Sugars

Lohan *et al.* (1983) reported sugar content of 10 strains of Lucerne. Total sugar content ranged from 3.14 to 4.30 per cent. Soluble sugars content was ranged from 1.49 to 2.48 per cent and reducing sugar from 0.89 to 2.15 per cent. Total soluble and reducing sugar pooled together were found to be significantly correlated with *in-vitro* dry matter digestibility of lucerne grass.

2.3 Ash

The total ash is an inorganic component of plant and constitutes major, minor and trace elements which are essential for the maintenance of normal health, production and reproduction of the animals.

a. Bajra x Napier hybrid grass

Panda *et al.* (1967) studied the nutritive value of hybrid napier grass at pre flowering stages and reported that it contained 14.11 per cent total ash. Amritkar (1982) studied 10 varieties of bajra forage and reported that ash content was 9.11 per cent,while Fernandes (1985) studied eleven hybrid napier varieties and found that total ash content was 11.66 per cent in *kharif* season.

b. Guinea grass

Daniel *et al.* (1968) reported 12.27 per cent ash during flowering stage and 7.81 per cent ash during post flowering stage.

Ranjan and Pathak (1979) reported ash with a maximum of 16.1 per cent, a minimum of 11.4 per cent and an average of 13.9 per cent in Guinea grass. Pathak and Kamara (1989) showed that Guinea grass contained 11.4 per cent ash during early stage 12.2 per cent during flowering stage and 15.5 per cent during maturity stage. Sanjiv Kumar and Garg (1998) reported 7.55 per cent ash in Guinea grass

c. **Cenchrus grass**

Narayanan and Dabadghao (1972) studied chemical composition of Cenchrus grass and indicated that it contained 13.3 to 18 1 per cent ash.

d. **Stylo grass**

Gupta *et al.* (1974) and Chaudhari (1977) reported 7.05 per cent total ash in Stylo feeds. Pathak and Kamara (1989) showed 12.5 per cent ash in stylo. Misra *et al.* (1997) studied nutritive value of Stylo grass and indicated that it contained 6.93 per cent total ash.

2.4 Minerals

In recent years, interest has been focused on the bio availability of minerals which is governed by factors like digestibility, chemical forms of minerals, dietary levels of other nutrients, presence of mineral chelates, particle size of food and food processing conditions (Reddy *et al.*, 1989).

a. **Bajra x Napier hybrid grass**

Panda *et al.* (1967) studied the nutritive value of hybrid napier grass at the pre flowering stage and reported that it contained calcium 0.41 per cent and phosphorus 0.19 per cent. Amritkar (1982) studied 10 varieties of bajra and reported that it contain 0.60

per cent calcium and 0.19 per cent phosphorus. Fernandes (1985) studied eleven hybrid napier varieties and found 0.58 per cent calcium, 0.22 per cent phosphorus and 0.30 per cent magnesium. Balaraman (1995) studied nutritive value of Hybrid Napier grass and showed that 1.00 per cent calcium and 0.20 per cent phosphorus.

b. Guinea grass

Pathak and Kamara (1989) analysed Guinea grass for mineral content and showed that 0.39 per cent calcium, 0.21 per cent phosphorus, 0.23 per cent magnesium, 0.17 per cent sodium and 0.65 per cent potassium for early stage while 0.51 per cent calcium, 0.39 per cent phosphorus, 0.23 per cent magnesium, 0.48 per cent sodium and 3.14 per cent potassium for pre flowering stage and 0.39 per cent calcium, 0.24 per cent phosphorus, 0.27 per cent magnesium, 0.32 per cent sodium and 1.20 per cent potassium for flowering stage.

c. Cenchrus grass

Satya Paul *et al.* (1982) analysed Cenchrus grass for two strains viz., strain-358 and Palsana at different growth stages. They showed calcium 0.70 per cent during pre flowering, 0.43 per cent during flowering and 0.40 per cent during maturity stage for strain 358, whereas 0.40 per cent during pre flowering, 0.43 per cent during flowering and 0.55 per cent during maturity for palsana variety. The potassium content was found to be 0.36, 0.20 and 0.23 per cent during pre flowering, flowering and maturity stage respectively for strain-358 and 0.58, 0.17 and 0.19 per cent respectively for three stages for palsana variety.

Iron content of 120, 260 and 140 ppm for strain 358 and 120, 147 and 140 ppm for palsana variety for three different stages of growth has also been reported.

d. Stylo grass

Pathak and Kamara (1989) reported 1.23 per cent calcium and 0.34 per cent phosphorus in Stylo grass. Gupta *et al.* (1974) studied chemical composition and nutritive value of Stylo grass and showed that it contained 1.09 per cent calcium and 0.26 per cent phosphorus.

2.5 Cell wall constituents

2.5.1 Cellulose

Cellulose is a major component of fibrous part of fodder crop and is a major source of energy for the ruminants.

Chaudhari *et al.* (1973) analysed some forage crops and stated that the cellulose content was in the range of 19.19 to 35.67 per cent. Ahuja *et al.* (1974) found 14.1 to 28.1 per cent cellulose in six different fodder crops, while Singh *et al.* (1974) found 20.50 to 32.40 per cent cellulose in some important grasses. Gupta and Pradhan (1975) observed that cellulose content of a legume and non-legume ranged from 9.37 to 28.92 and 29.06 to 32.79 per cent respectively. Cellulose was the most abundant component in the cell wall and was slightly higher in non-legume fodder crops. Lohan *et al.* (1983) reported that the quantity of cellulose changed according to cutting stages in lucerne grass. The amount of cellulose was 20.55, 19.46, 20.36, 20.98 per cent at first, second, third and fourth cut of Stylo grass respectively.

2.5.2 Hemicellulose

Hemicelllose is also one of the important components, which is less digestible.

Ahuja *et al.* (1974) reported 18.10 to 30.00 per cent hemicellulose content in six different fodder crops. There was a decrease in digestibility with a simultaneous increase in hemicellulose content of fodder crops. Singh *et al.* (1974) observed 5.63 to 13.00 per cent hemicellulose in some important grasses. Chaudhari *et al.* (1973) analysed some forage crops and stated that the hemicellulose content was 10.48 to 43.57 per cent. Lohan *et al.* (1983) analysed lucerne grass at four different cuttings and showed that the humicellulose content was 4.23, 5.40, 6.16, 6.22 per cent respectively.

2.5.3 Neutral detergent fibre (NDF)

Neutral detergent fibre is reported to be the best indicator of *in-vitro* dry matter digestibility. Ahuja *et al.* (1974) found that the NDF content of six different fodder crops ranged from 39.3 to 62.8 per cent. Singh *et al.* (1974) examined *rabi* forages for cell wall constituents. The values of NDF were 41.20 per cent for barseem and 59.80 per cent for oat. According to Gupta and Pradhan (1975), NDF content of leguminous crop was 47.93 per cent and that of non-leguminous fodder as 62.48 per cent.

Satya Paul *et al.* (1982) analysed strain 358 and palsana at different cuttings. The strain 358 shows NDF content 71.10, 72.60, 73.07 per cent and palsana, 61.13, 75.26 and 66.90 per cent for pre flowering, flowering and maturity stages respectively in both strains. Misra *et al.* (1997) analysed Stylo straw for different nutrient and reported 49.27 per cent NDF in Stylo grass.

2.5.4 Acid detergent fibre (ADF)

The level of acid detergent fibre (ADF) in feeds and fodder determines their nutritive value. It includes the cellulose, lignin and silica. These components affects digestibility of feeds and forages.

Ahuja *et al.* (1974) reported that the ADF content of six different fodder crops ranged from 24.1 to 41.6 per cent. Gupta and Pradhan (1975) observed that the ADF content of leguminous and non-leguminous feed was 39.10 and 39.33 per cent respectively. Rakkiyappan and Krishnamoorthy (1981) evaluated guinea grass for nutritional quality at different stages. They reported that ADF was increased with the advancement of crop growth. Satyapaul *et al.* (1982) analysed two strains of Cenchrus grass strain-358 and Palsana at three different growth stages. ADF content of these two strains was 36.33, 39.27, 40.80 per cent and 36.13, 43.93, 36.33 per cent at pre flowering, flowering and maturity stages respectively.

Lohan *et al.* (1983) showed that ADF content of Lucerne grass changed at different cuttings i.e. 32.53, 32.04, 30.14 and 30.12 per cent at first, second, third and fourth cutting respectively. Misra *et al.* (1997) evaluated Stylo grass and showed that it contained 46.48 per cent ADF.

2.5.5 Lignin

Lignin is the most complex components of feed and fodders which is in association of crude fibre. It is almost undigested by ruminants. Normally it affects the digestibility of feed and fodder.

Chaudhari *et al.* (1973) found that the lignin content of forage grasses was 2.23 to 7.80 per cent. Ahuja *et al.* (1974) stated that the lignin content of six different fodder crops was in the range of 2 4 to 8.8 per cent. There was negative correlation of digestibility with lignin content. According to Gupta and Pradhan (1975), the lignin content in leguminous and non-leguminous crops was 9 37 to 11.60 and 5.40 to 8.40 per cent, respectively. Lohan *et al.* (1983) showed that lignin content of lucerne grass changed according to different cutting stages as 9.39, 10.20, 8.19, 8.13, respectively at first, second, third and fourth cuttings.

2.5.6 Silica

Gupta and Pradhan (1975) reported that the silica content in legume and non-legume forages was 0.71 to 1.31 and 1.61 to 2.53 per cent, respectively. They also observed that the silica content in legume was comparatively lower than in the non-legume forages. Satya Paul *et al.* (1982) analysed two stains of Cenchrus grass-strain-358 and Palsana at different growth stages. Silica content of strain-358 was 1.71, 1.17 and 1.06 per cent while in palsana 4.47, 3.06 and 2.67 per cent at pre flowering, flowering and maturity stages. According to Lohan *et al.* (1983) silica content of Lucerne grass was 1 41, 1 51, 1.49 and 1.05 per cent at four different cuttings.

2.6 *In-vitro* dry matter digestibility (IVDMD)

Estimation of dry matter digestibility is an important tool to evaluate nutritional quality of forage grasses.

Chaudhari *et al.* (1973) observed that IVDMD of kharif forage crop ranged from 27.83 to 42.86 per cent. Singh *et al.* (1974)

recorded that IVDMD of grasses ranged from 39.80 to 55.90 per cent. Gupta and Pradhan (1975) found that the IVDMD of legumes and non-legumes forage crops was in range of 67.17 to 69.89 and 59.07 to 67.72 per cent respectively. They further stated that the cell wall constituents were negatively correlated with IVDMD in both legume and non-legume forages.

Natarajan *et al.* (1981) evaluated the digestibility of hybrid napier grass (NB-21) at different stages of maturity by adopting *in-vitro* fermentation technique. They observed that the dry matter digestibility gradually declined in the grass upto 45 days of age followed by marked decrease at maturity. Fernandes *et al.* (1985) observed that IVDMD of hybrid napier grass was the highest (63.51 %) in *kharif* and the lowest (60.80 %) in *rabi* season.

2.7 Total phenolics

Phenolic compounds are the allelochemicals as non-nutritional chemicals produced by plants of one species and which affects the growth and health behaviour of another species.

Parihar *et al.* (1996) showed that large number of allelochemicals such as non-protein amino acids, cyanogenes, glucosinolates, phenolic compounds and alkaloids reported from various species of fodder grasses and evolved in plant-animal and plant-plant interactions have been reviewed. Their ecological significance for the forage plants as protective agents against herbivorous animals and microbes was also discussed.

2.8 Oxalates

Oxalic acid has been found to interfere with the mineral metabolism, mainly with regard to calcium in different classes of livestock

Des Raj and Mudgal (1968) reported that oxalic acid showed a decreasing trend from 3.44 at pre-flowering to 1.63 per cent at flowering stage of hybrid napier. Sehgal and Goswami (1971) analysed 22 bajra varieties for oxalic acid content and the range of oxalic acid was from 1.72 to 3.42 per cent in straws with a calcium to oxalic acid ratio of 0.12 to 0.22. Patel *et al.* (1970) compared hybrid napier, Guinea grass and green jowar in their chemical composition as a green fodder supplement. The results indicated that the hybrid napier was superior over green jowar in respect of protein, phosphorus and carotene content but hybrid napier was higher in oxalate content (3.04%) and may interfere in the absorption of calcium in animals digestive system. Guinea grass also contained 1 85 per cent oxalate, while in jowar it was present in a negligible amount. Ahuja *et al.* (1998) studied effect of season on oxalate content in Hybrid Napier and showed that oxalic acid ranged from 2.21 to 3.92 per cent.

MATERIAL AND METHODS

3. MATERIAL AND METHODS

The present investigation entitled "Effect of subsequent cuttings on nutritional quality of some fodder grasses" was carried out at the Department of Biochemistry, Post Graduate Institute Mahatma Phule Krishi Vidyapeeth, Rahuri.

3.1 Material

3.1.1 Fodder grass sample

The promising fodder grass varieties developed at Grass Breeding Scheme at Mahatma Phule Krishi Vidyapeeth, Rahuri were analysed to determine their chemical composition and nutritive value. One dose of basic fertilizer (40 : 30 : 20, NPK/ha) was given at the time of sowing. Four different grasses and their cuttings were taken for the analysis (Table 1).

These grasses were cut at suitable cutting stage, brought to the laboratory, cut into small pieces, dried in hot air oven at 40-60 ^{0}C temperature, powdered using multiplex plant grinder and then analysed for chemical composition and nutritive value. Each sample was analyzed atleast three or four times to get accurate results.

3.1.2 Chemicals

Most of the chemicals used in this investigation were of analytical grade (Merck, s.d. Fines, Qualigens, S.R.L. or Himedia companies).

Table 1. Various cultivars of fodder grasses and their different cutting stages

Sr. No.	Cultivar	Variety	Cutting interval (days)
1.	Bajra x Napier hybrid grass	RBN-9	45, 90, 135, 180
2.	Guinea grass	PGG-9	45, 90, 135, 180
3.	Cenchrus grass	CAZRI-75	60, 150, 240
4.	Stylo grass	Stylo hamata	90, 180, 270

3.2 Methods

3.2.1 Dry matter

Dry matter, crude oil, crude fibre, crude protein, ash, iron and carbohydrate content of various fodder grasses were estimated by the standard procedure of A.O.A.C. (1990).

The total carbohydrate was estimated by using following formula.

Total carbohydrate % = [100 – (Moisture + Lipids + Proteins + Ash)]

3.2.6 Sugars

3.2.6.1 Reducing sugar

Reducing sugar was determined by Nelson-Somogyi method (Nelson, 1994).

1. Regent A

Twenty five grams of sodium carbonate (unhydrous), 25 g sodium potassium tartarate, 20 g sodium carbonate ($NaHCO_3$) and 200 g sodium sulphate (unhydrous) were dissolved in distilled water and volume made to one litre.

2. Regent B

Fifteen grams of copper sulphate were dissolved in 100 ml distilled water and 1 to 2 drops of concentrated sulphuric acid were added.

3. Alkaline copper tartarate reagent

It was prepared by mixing 25 parts of Reagent A and one part of Reagent B This reagent was prepared just before use.

4. Arsenomolybdate reagent

Twenty five g of ammonium molybdate were dissolved in 450 ml of distilled water To this, 21 ml concentrated sulphuric acid was added. Three g of sodium arsenate was dissolved separately in 25 ml distilled water and added to above solution. The contents were mixed and incubated at 37 °C for 24 to 48 hours.

5. Stock solution of D-glucose

Hundred milligrams of D-glucose dissolved in distilled water and final volume made to 100 ml

6. Working standard olution of D-glucose

From stock solution 10 ml was pipetted out and final volume made to 100 ml (100 μg/ml).

Procedure

A. Preparation of standard curve

Working a standard solution of D-glucose, 0, 0.1, 0.2, ...1ml was pipetted in series of test tube in triplicate and volume made to 1 ml with distilled water. Then 1 ml of alkaline copper tartarate reagent was added in each test tube and kept in boiling water bath for 20 min. The tubes were cooled and 1 ml of arsenomolybdate reagent was added. Final volume made 10 ml with distilled water. Absorbance was measured on Spectronic-20 spectrophotometer at 520 nm after proper mixing on vertex mixture and graph was plotted (Fig. 1).

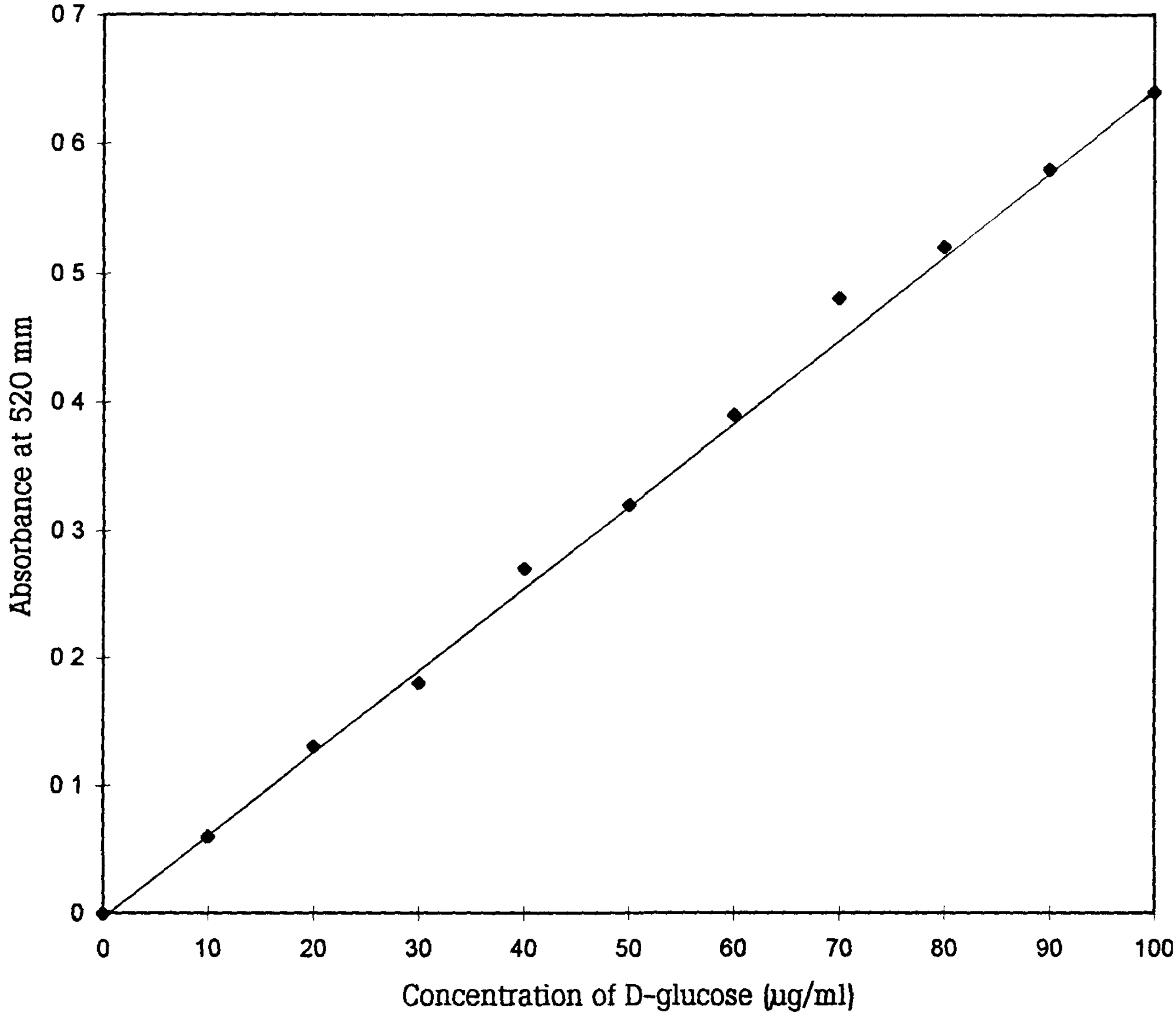


Fig. 1. Standard curve of D-glucose for estimation of sugars

B. Sample preparation

To 0.5 g finely ground defatted sample in centrifuge tube, 15 ml of 80 per cent ethanol (v/v) was added and kept in boiling water bath for 15 min. After cooling they were centrifuged at 8000 rpm for 10 min. The extraction was repeated two more times and supernatant was collected in beaker. The supernatant was evaporated in boiling water bath at 80 ^{0}C so as to reduce the volume to 5-10 ml.

The extract was diluted with distilled water and volume made to 50 ml. From this solution 1 ml extract was taken for colour development. Further procedure was the same as described for the calibration of a standard curve. Finally reducing sugars were calculated from standard curve of D-glucose.

3.2.6.2 Total sugar

In twenty five ml extract (prepared during reducing sugar), 5 ml diluted HCl (1:1, v/v) was added and kept for 24 hrs. for inversion. Then it was neutralized with 5 N sodium hydroxide and final volume made to 50 ml.

The hydrolysed sugars were estimated as total sugars as described above.

3.2.6.3 Non-reducing sugars

The non-reducing sugar content was calculated as difference between total and reducing sugar

3.2.8 Minerals

3.2.8.1 Calcium

The calcium content in the finely ground sample of fodder grasses was determined by the method as described by Black *et al.* (1965).

Reagents

1. Standard calcium solution (0.01 N) : Pure dried calcium carbonate 0.5 g was weighed and dissolved in 10 ml of 0.2 N HCl. The solution was boiled till CO_2 was completely driven off. Then it was cooled and volume was made to one litre accurately.
2. Standard ethylene diamine tetra acetic acid (EDTA solution) – Two grams of EDTA and 0.03 g of $MgCl_2$, $6H_2O$ was dissolved separately in distilled water, these solutions were mixed and volume was made to 1000 ml with distilled water
3. Sodium hydroxide (10 %, w/v) : Sodium hydroxide 10 g dissolved in distilled water and final volume was made to 100 ml.
4. Potassium ferrocyanide solution (4%, w/v) · Four grams of K_4FeCN_6 were dissolved in water and volume was made to 100 ml.
5. Erichrome Black T indicator (EBT) : EBT, 0.4 g was dissolved in 100 ml methanol.
6. Calcon indicator · Calcon powder, 40 mg dissolved in 100 ml of methanol.

7. Triethanolamine (TEA) : Commertially available triethanolamine in the market was used in this experiment.

Standardization of EDTA

Standard calcium solution (0.01 N) of 25 ml was piptted into a conical flask. Few drops of EBT indicator were added and it was titrated with EDTA solution and titre reading was recorded. The normality of EDTA was standardized by using the formula $N_1V_1 = N_2V_2$.

Procedure

A. Digestion of sample:

The ash sample was digested with 20 ml H_2O, 5 ml H_2SO_4 and 25 ml HNO_3 mixture. The digestion was carried out at low temperature initially and continue heating until all nitrate fumes were removed. The content was cooled and filtered through the Whatman No - 1 filter paper and volume made to 50 ml.

B. Calcium

To the 5 ml digested extract, 10 ml of distilled water was added followed by 5 ml of 10 per cent NaOH and 5 to 6 drops of each potassium ferrocyanide solution and triethanolamine (TEA). The flasks were allowed to stand for 10 min . After 10 min ten drops of colon indicator were added and it was titrated with standard EDTA solution until colour changes from wine-red to sky blue. From the volume of standard EDTA solution required for titration, calcium was estimated in mg/100 g of sample.

3.2.8.2 Potassium

The potassium content in the fodder grass sample was estimated by a flame photometer method as described by Chapman and Pratt (1961).

Reagents:

1. Stock solution of potassium chloride: Potassium chloride, 1.90 g was accurately weighed and dissolved in 1000 ml distilled water.
2. Working solution of potassium chloride: 10 ml of stock solution was diluted to 100 ml with distilled water. This solution contains 10 μg of potassium per ml.

Procedure

1. Potassium in sample

From the digested extract 0.1 ml sample was diluted to 10 ml with distilled water. The readings were recorded on a flame photometer (Aimil sales and Agencies Private Limited, Banglore).

2. Calibration standard curve of potassium

0, 0.5, 1, 1.5,......5 ml of working solution of KCL was pipetted in the 50 ml volumetric flask in duplicate and the volume was made with distilled water. The readings were recorded on flame photometer and standard graph was prepared by plotting flame photometer reading against concentration of potassium (Fig. 2).

The potassium content in the sample was determined using standard graph and results are expressed in percentage.

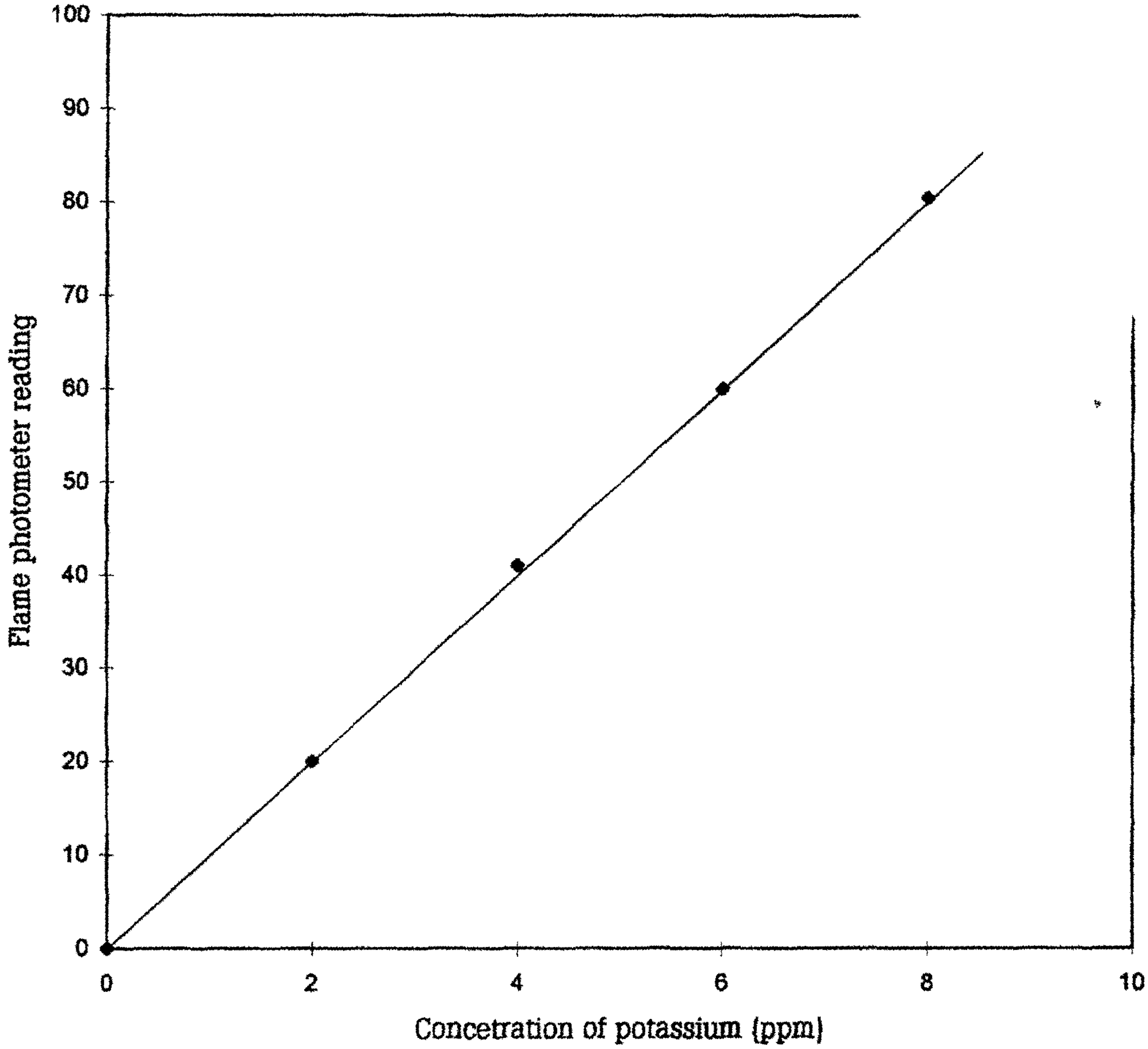


Fig. 2. Standard curve for estimation of potassium

3.2.8.3 Phosphorus

The phosphorus in the sample was determined by the colorimetric method as described by Chapman and Pratt (1961).

Reagents:

1. Ammonium molybdate- Vanadate solution

Ammonium molybdate (22.59 g in 400 ml distilled water), ammonium vanadate (1.25 g in 300 ml boiling water) and 250 ml concentrated nitric acid were mixed together and volume was made to 1000 ml with distilled water.

2. Standard phosphate solution

Dissolve 0.219 g of potassium dihydrogen phosphate in distilled water and diluted to 1000 ml (50 μg/ml phosphorus).

Procedure:

A. Phosphorus in the sample

Digested sample 5 ml was pipetted out into 50 ml volumetric flask. Then 10 ml of ammonium molybdate-vanadate reagent was added and the content was diluted to 50 ml with distilled water. Mixture of sample solution was kept for 30 min for colour development. Then absorbance was read at 470 nm on spectronic-20. Spectrophotometer Phosphorus content in the sample was calculated by using standard graph of phosphorus and results are expressed in percentage.

B. Standard curve of phosphorus

0, 0.5, 1, 1.5, 2, 2.5 ml of standard solution of potassium dihydrogen phosphate was taken into 50 ml volumetric flask and 10 ml of ammonium molybdate vanadate reagent was added. The contents were diluted to 50 ml with distilled water and mixed well. The absorbance was measured after 30 minutes at 470 nm on spectronic -20 spectrophotometer and graph was prepared (Figure 3).

3.2.9 Cell wall constituents

3.2.9.1 Cellulose

Cellulose was determined by the method of Van Soest (1963).

Reagent

1. 72 per cent H_2SO_4 by weight 61 g of H_2SO_4 dissolved in distilled water and final volume was made 100 ml.

Procedure:

Acid detergent fibre was used in estimation of cellulose. Sintered glass crucible was placed in tray and 72 per cent H_2SO_4 was added to this crucibles. It was stirred with glass rod to break the lumps. After draining the acid, crucibles again filled with acid and kept 20-23 °C for 3 hours. Crucibles were subjected to light suction. Then content was washed with hot water (95 to 100 °C) to make it free of acid. The sintered glass crucibles were dried for 8 hours, cooled in desiccater and weighed.

$$\text{Cellulose (\%)} = \frac{\text{Weight of crucible and ADF} - \text{Weight of crucible and residue}}{\text{Weight of sample}} \times 100$$

3.2.9.2 Hemicellulose

This was determined by working out the difference between neutral detergent fibre and acid detergent fibre as described by Van Soest (1963).

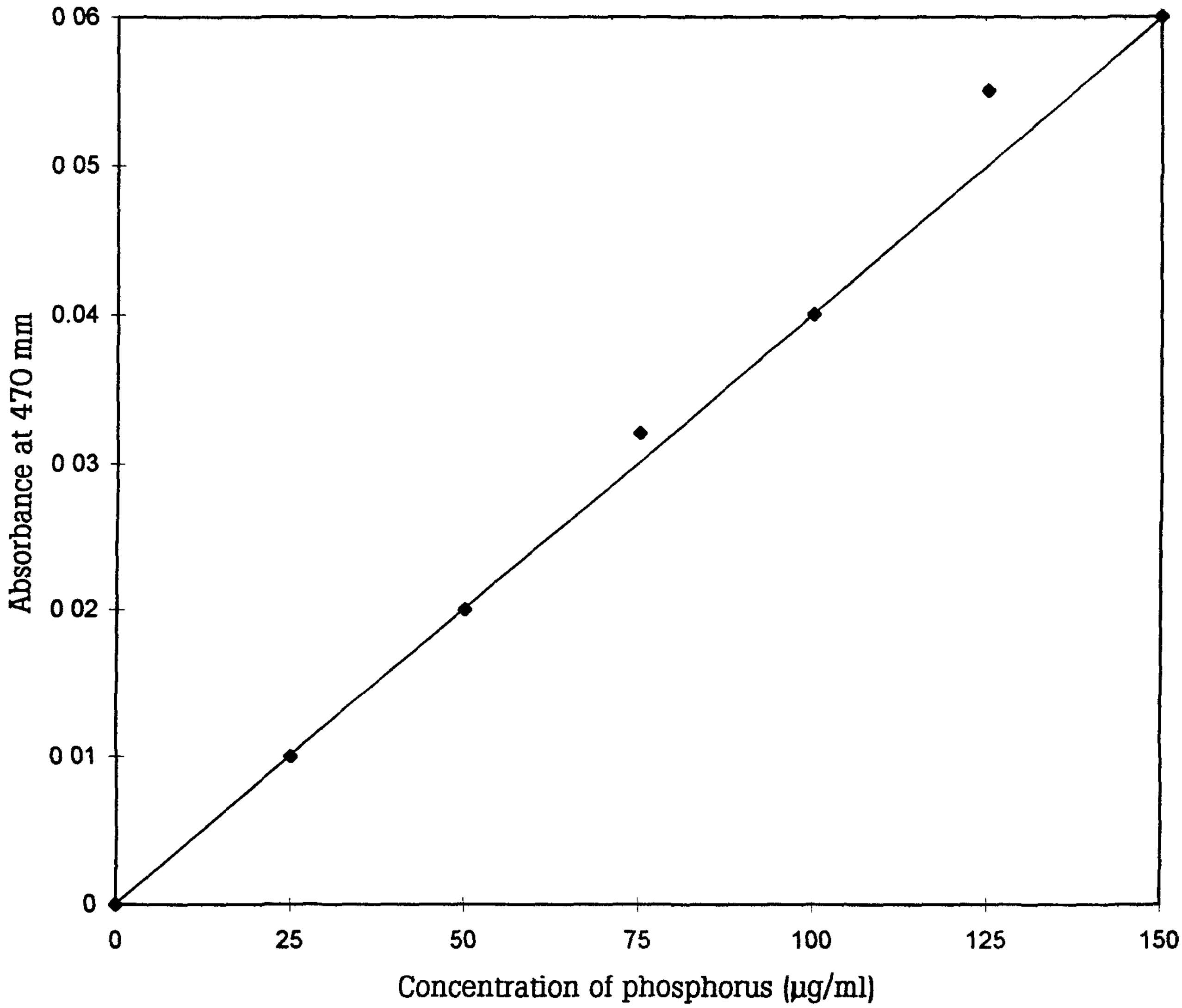


Fig. 3. Standard curve for estimation of phosphorus

Hemicellulose (%) = NDF (%) - ADF (%)

3.2.9.3 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 dihydrate crystal (EDTA)	18.61 g
iv.	Sodium borate decahydrate	6.81 g
v.	Disodium hydrogen phosphate (anhydrous, reagent grade)	4.56 g
v.	2-ethoxy ethanol (ethylene glycol monoethyl e ther)	10 ml

EDTA and sodium borate decahydrate were poured in 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. Disodium hydrogen phosphate (Na_2HPO_4) was taken in beaker with small quantity of distilled water and heated to dissolve it. Then added to the solution containing others in gradients and pH was adjusted to 7.0.

2. De cahydronapthalene (reagent grade)

3. Acetone

4. Sodium sulphate (anhydrous, reagent grade)

Procedure:

One g sample was taken into the beaker of refluxing apparatus. To this, 100 ml cold neutral detergent solution and 0.5 g sodium sulphate were added and heated for 10 minutes. Heat was reduced as the boiling began, to avoid foaming. This solution was transfered to previously weighed glass funnel. The glass funnel was attached to vaccum pump. Initially low vaccum was used and later increased. Sample in crucible was twice washed with hot water and acetone.

The crucibles were dried at 100 °C for 8 hours, cooled in desiccater and final weight was recorded.

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

3.2.9.4 Acid detergent fibre (ADF)

Acid detergent fibre content in sample was determined using the standard method of Van Soest (1963).

Reagents:

1. **Acid detergent solution:** Twenty grams of Cetyl trimethyl ammonium bromide (C.T.A.B.) was dissolved in 1000 ml of 1N H_2SO_4
2. **Decahydronapthalene:** Reagent grade
3. **Acetone**

Procedure:

One g of sample was weighed into the beaker of refluxing apparatus. To this 100 ml acid detergent solution was added and heated upto boiling for 10 min. Heat was reduced to avoid foaming, from the on set of boiling, it was refluxed for 60 minutes. Sample was filtered through previously weighed glass funnel by light suction. Two washings with hot water (90-100 ^{0}C) and acetone were given and then dried at 100 ^{0}C for 8 hours, cooled in desiccaters and weighed.

$$ADF = \frac{\text{Weight of crucible plus fibre} - \text{Weight of crucible}}{\text{Weight of sample}} \times 100$$

3.2.9.5 Lignin

Lignin was estimated by the method of Van Soest (1963).

Procedure:

The residue left in the crucible after estimation of cellulose from acid detergent fibre was ignited in muffle furnace at 500 ^{0}C for 3 hours. It was cooled first in desiccator and weighed.

$$\text{Lignin (\%)} = \frac{\text{Weight of crucible and cellulose} - \text{Weight of crucible and residue after ignition}}{\text{Weight of sample}} \times 100$$

3.2.9.6 Silica

It was determined by using standard method of Van Soest (1963).

Procedure

The residue left after ashing the cellulose is called as insoluble ash. This insoluble ash called as silica.

$$\text{Silica (\%)} = \frac{\text{Weight of crucible and ash - Weight of crucible}}{\text{Weight of sample}} \times 100$$

3.2.10 *In-vitro* dry matter digestability (IVDMD)

IVDMD was determined by the method of Van Soest *et al.* (1967).

The rumen liquor was collected from slaughter house of Ayub Mutton Shop, Rahuri for IVDMD study. The rumen liquor was strained trough four layers muslin cloth and filled in plastic bottle, kept in the ice container and brought to the laboratory. The composition of buffer solution (artificial saliva) used in present study was as below:

Chemical	g/lit
$NaHCO_3$	9.80
$NaHPO_4$	3.39
KCl	0.57
NaCl	0.47
$CaCl_2$	0.04
$MgSO_4$	0.12

All these ingredients, expect, $CaCl_2$ were weighed and dissolved in one litre water. $CaCl_2$ was added just before using the solution. The pH of buffer was adjusted to 6.7.

Procedure:

One gr ... sample was taken into 100 ml flask containing 40 ml artificial saliva (buffer solution) and 100 ml Strained Rumen Liquor (SRL) and immediately flushed with nitrogen gas for 30 seconds to ensure anaerobic condition. The flask was tightly closed with rubber cork, fitted with gas release valve and then incubated at 39 ^{0}C temperature for 48 hours in incubator.

At the end of incubation period, the microbial activity was stopped by addition of 1 ml 4 N H_2SO_4 to each flask. The content of flask was transfered to centrifuge tube and centrifuged at 1500 x 9 for 15 minutes. The supernatant liquid was discarded and insoluble residue was washed with water and the transferred previously weighed 100 ml beaker. The beaker containing undigested residue was dried in oven at 100 ^{0}C to a constant weight, control was also run simultaneously without rumen liquor but all other conditions were similar.

IVDMD (%) = (Wt. of control sample - Wt. of digested sample) x 100

3.2.11 Total phenolics

The total phenolics content of the fodder grass samples was determined by the method of Swain and Hillis (1959).

Reagent:

1. **Folin- Denis reagent**

Sodium tungstate (50 g), 10 g of phosphomolybdic acid and 25 ml conc., phosphoric acid were added to 375 ml of distilled water and the mixture was allowed to reflux for 2 hours and the final volume was made 500 ml.

2. **Saturated solution of sodium carbonate (Na_2CO_3):**

Sodium carbonate (350 g) in one litre of distilled water at 70-80 ^{0}C was dissolved to stand over night.

3. **Standard tannic acid solution:**

One hundred mg tannic acid dissolved in distilled water and final volume was made 100 ml.

4. **Working standard solution:**

One hundred ml of stock solution was diluted to 100 ml with distilled water. One millilitre solution containing 100 μg tannic acid.

Procedure:

A. **Extraction sample**

Accurately weighed 0.5 g of dry fodder grass sample was transfered to 250 ml conical flask and 75 ml of distilled water was added to it. The content was boiled gently for about 30 min., on water bath and centrifuged at 5000 rpm. for 20 min. The supernatant was collected in 100 ml vol. flask and final volume made with distilled water and aliquot was then used for colour development.

B. **Total phenolics in sample**

One ml of extract solution of phenolics was taken in test tube. To that sample, 0.5 ml Folin Denis reagent, 1 ml of saturated solution of sodium carbonate were added and final volume made to 10 ml by distilled water and mixed well.

After 30 min., standing at room temperature, absorbance was measured at 725 nm on Spectronic-20 Spectrophotometer. The quantity of total phenolics in sample was estimated using standard curve of tannic acid and expressed as percentage.

C. Standard curve

The 0, 0.1,0.2,0.3,..... 1ml of working standard solution of tannic acid was pipetted in test tube and volume made 1 ml with distilled water. To that 0.5 ml of Folin-Denis reagent and 1 ml of saturated solution of sodium carbonate was added and final volume made 10 ml with distilled water. After 30 min., standing at room temperature absorbance was measured at 725 nm on a Spectronic-20 Spectrophotometer and standard graph was prepared (Fig. 4).

3.2.12 Oxalates

Reagents:

1. 4 N H_2SO_4
2. 1 N NaOH
3 Diethyl ether
4. Calcium chloride – acetate buffer: Dissolve 25 g of anhydrous calcium chloride in 500 ml of 50 per cent acetic acid. Dissolve 330 g of sodium acetate trihydrate in water and make the volume to 550 ml, combine the two solutions and adjust the pH to 4.5
5 5 per cent acetic acid saturated calcium oxalate
6. Standard 0.02 N potassium permanganate solution method

Sample extraction

1. Oven dried sample to a contast weight in hot air oven at 80 ^{0}C.
2. Grinded the sample in fine powder in a grinding mill, dried the powder grain and from that 500 mg sample was taken for further analysis.

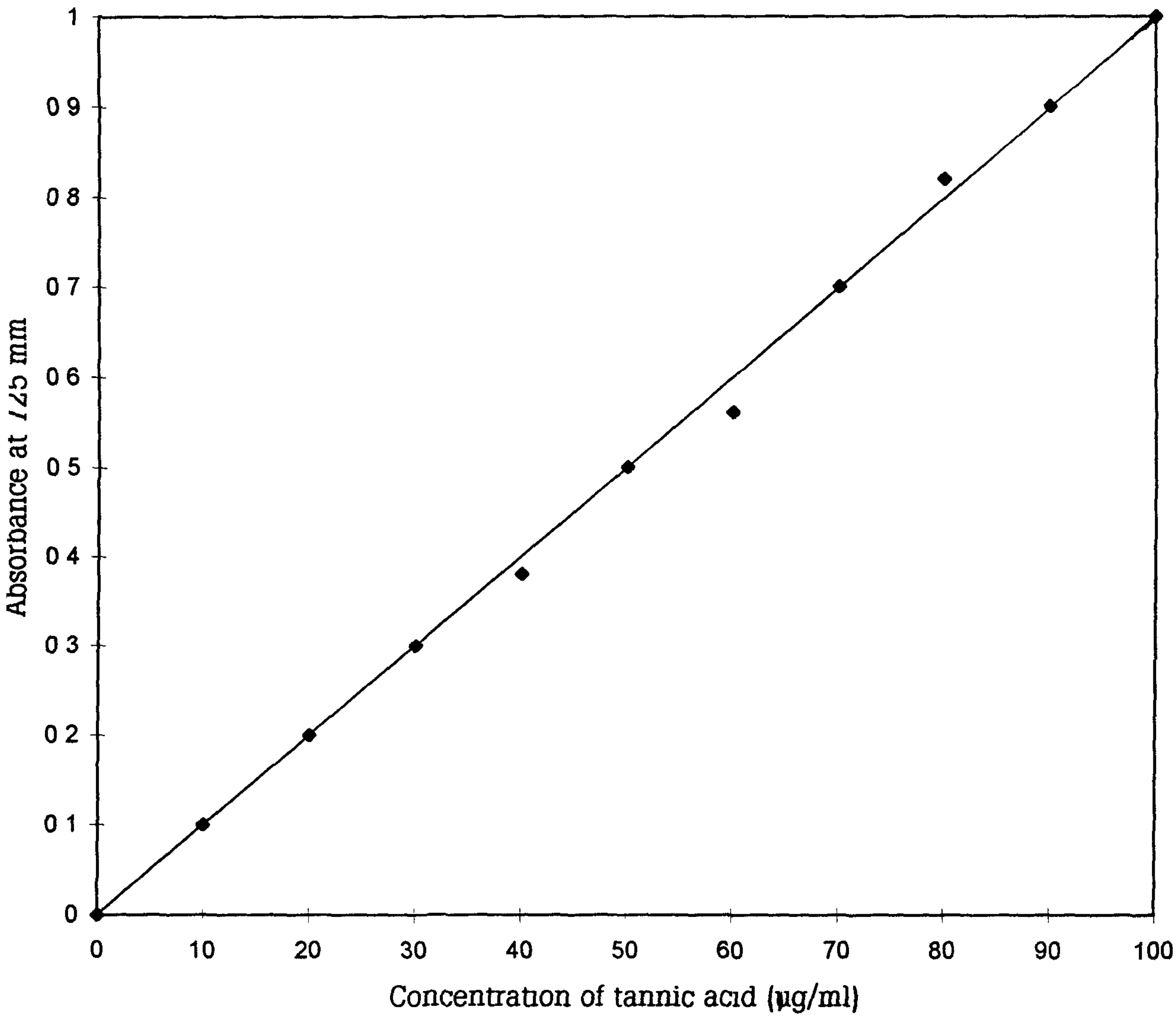


Fig. 4. Standard curve for estimation of total phenolic compounds

4. Filled the extraction thimble (prepared from whatman filter paper) to the depth of 2 cm with clear ground glass (20 mesh) place two circular pieces of cheese cloth of slightly greater diameter than thimble over the glass.
5. Transfered the sample mixed with asbestos and H_2SO_4 to the thimble quantitatively.
6. Placed the thimble with the contents in Soxhlet extraction apparatus and extracted with 500 ml of pure diethyl either for 48 hours.
7. Added 5 ml of 1N NaOH and 7 ml of water to the extract and shaked well.
8. Evaporate the ethyl layer in rotary evaporator.
9. Transfered the water phase to centrifuge tube and added 4 ml of calcium chloride acetate buffer and allow to stand over night.

Estimation

1. Centrifuged at 5000 rpm. for 10 min.
2. Discarded the supernatant and washed the pellet with 5 ml of 5 per cent acetic acid, saturated with calcium oxalate and centrifuged again
3. Dissolved the residue in 5 ml of 4 N H_2SO_4 and heated at 80-90 ^0C on water bath.
4. Filtered while hot and titrated against 0.02 N potassium paramagnet solution.
5. Calculated amount of oxalic acid (mg/100 g sample) present in the sample using the relationship.

1 ml of 0.02 N potassium permanganate 1.2653 mg of oxalic acid.

3.2.13 Statistical analysis

All experiments were planned using randomized block design (RBD) with three replications each and mean, range of chemical composition have been reported.

The data obtained in the present investigation were analysed for statistical significance according to the procedure given by Panse and Sukhatme (1967). The appropriate standard error (S.E.) and critical difference (C.D.) at 0.05 per cent probability were worked out and are presented at the appropriate places.

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

Experiments were conducted to investigate the "Effect of subsequent cuttings on nutritional quality of some fodder grasses". The results of these investigation are presented and discussed in this chapter.

4.1 Dry matter

The data on dry matter content of different varieties of fodder grasses at different cutting stages are represented in Table 2. The dry matter content ranged from 38.90 to 72.30 per cent for Bajra x Napier hybrid grass. The dry matter content at 45 days of cutting have the lowest, while the highest at 180 days cutting. The mean value for dry matter content was 56.07 per cent. The results indicated a significant difference in dry matter content as influenced by both the variety and the stage of cutting.

The dry matter content for Guinea grass ranged from 40.50 to 71.90 per cent. At 45 days of cutting it contained the lowest (40.50 %) while the highest (71.90 %) at 180 days of cutting. The mean value for dry matter content was 56.85 per cent.

For Cenchrus grass dry matter content ranged from 52.20 per cent to 71.84 per cent. At 60 days of cutting it contained 52.20 per cent while 71.84 per cent at 240 days of cutting. The mean value of dry matter was 61 44 per cent.

Similarly for Stylo grass the dry matter content ranged from 51.19 to 68.08 per cent. The mean value for dry matter content was 60.83 per cent. Out of these four fodder grasses Cenchrus grass

Table 2. Chemical composition of different cultivars of fodder grasses at different cutting stages

Sr. No.	Cultivar, cutting interval in days	Dry matter (%)	Crude oil (%)	Crude fiber (%)	Crude protein (%)	Carbohydrate (%)
A.	**Bajra x Napier hybrid grass (RBN-9)**					
1.	45 days	38.90	0.73	23.32	8.72	68.92
2.	90 days	52.00	0.91	29.00	6.64	69.77
3.	135 days	61.08	0.84	32.40	4.15	70.85
4.	180 days	72.30	0.96	33.40	3.08	71.06
	Mean	56.07	0.86	29.53	5.65	70.15
	Range	38.90-72.30	0.73-0.96	23.32-33.4	3.08-8.72	68.92-71.06
	S.E. ±	0.085	0.028	1.86	0.319	0.398
	CD at 5 %	0.293	0.097	0.44	1.105	1.378
B.	**Guinea grass (PGG-9)**					
1.	45 days	40.50	0.89	24.46	11.13	65.03
2.	90 days	51.00	0.96	33.60	9.96	65.15
3.	135 days	64.00	1.00	34.40	6.64	67.20
4.	180 days	71.90	0.97	36.30	3.32	67.40
	Mean	56.85	0.95	32.19	7.76	66.20
	Range	40.50-71.90	0.89-1.00	24.46-36.30	3.32-11.13	65.03-67.40
	S.E. ±	0.252	0.054	0.502	1.151	0.254
	CD at 5 %	0.871	1.13	0.736	3.985	0.999

Table 2. contd....

Sr. No.	Cultivar, cutting interval in days	Dry matter (%)	Crude oil (%)	Crude fiber (%)	Crude protein (%)	Carbohydrate (%)
C.	**Cenchrus grass (CAZRI-75)**					
1.	60 days	52.20	0.81	21.60	6.23	69.75
2.	150 days	60.28	1.05	30.20	4.98	69.80
3.	240 days	71.84	1.15	31.60	3.73	69.84
	Mean	61.44	1.03	27.80	4.98	69.80
	Range	52.20-71.84	0.81-1.15	21.60-31.60	3.73-6.23	69.75-69.84
	S.E. ±	0.294	0.163	3.073	0.726	0.158
	CD at 5 %	1.156	N.S.	N.S.	N.S.	0.621
D.	**Stylo grass (Stylo hamata)**					
1.	90 days	51.19	0.79	21.28	19.09	61.96
2.	180 days	63.24	0.81	25.88	17.84	62.57
3.	270 days	68.08	0.94	26.24	14.11	64.99
	Mean	60.83	0.85	24.47	17.01	63 17
	Range	51.19-75.08	0.79-0.94	21.28-26.24	14.11-19.09	61.96-64.99
	S.E. ±	0.298	0.029	2.35	0.316	0.140
	CD at 5 %	1.171	N.S.	N.S.	1.240	0.549

The results are the means of three or four determinations

ıve the highest dry matter (61.44% mean value) content. Higher ry matter production is more beneficial to the dairy industry to feed ıore animals. These differences in dry matter production may be ue to genetic variability of that particular cultivar.

The literature values for dry matter content in Bajra x Japıer grass ranged from 20.1 to 38 per cent. Ranjan (1977) eported that Guinea grass value for dry matter content was 25.93 ɔer cent, [illegible] Sanjiv Kumar and Garg (1995) observed that the dry matter varied according to variety. Ranjan (1977) also observed 33.23 per cent dry matter in Cenchrus grass during flowering stage. The present results are in accordance with the previous results.

4.2 Crude oil

The crude oil values of the four different grasses at their different cutting stages are summarized in Table 2. The lowest crude oil content at first cutting in Bajra x Napier hybrid grass was 0.73 per cent while highest at fourth cutting 0.96 per cent. The crude oil content in Guinea grass ranged from 0.89 to 1.00 per cent. There was lowest crude oil at first cutting (45 days) and highest at 135 days cutting in Guinea grass. The crude oil content in Cenchrus grass was found to have lowest value (0.81%) at 60 days cutting and highest value (1.15%) at 240 days cutting. The Stylo grass shows the lowest crude oil 0.79 per cent at 90 days of cutting and the highest (0.94 %) at 270 days cutting.

The mean values for crude oil content was found to be 0.86 per cent for Bajra x Napier hybrid grass, 0.95 per cent for Guinea grass, 1.03 per cent for Cenchrus grass and 0.85 per cent for Stylo grass.

The difference in crude oil content according to stages of cutting is non-significant except Bajra x Napier hybrid grass. The literature values for crude oil content for giant napier was 2.50 per cent (Panda *et al.*, 1967). Sanjiv Kumar and Garg (1998) evaluated Guinea grass and showed that it contained 2.75 per cent crude oil. Cenchrus grass contained 1.38 per cent crude oil. Reddy *et al.* (1996) and Misra *et al.* (1997) evaluated nutritive value of Stylo grass and showed that it contained 1.70 per cent crude oil.

4.3 Crude fibre

The data on crude fibre content for four different fodder grasses at different cutting stages are presented in Table 2.

The values for crude fibre content for the Bajra x Napier hybrid grass ranged from 23.32 to 33.40 per cent, the lowest being at 45 days of cutting and the highest at 180 days cutting stage. The mean value for crude fibre content for this grass was found to be 29.53 per cent In Guinea grass crude fibre values ranged from 24.46 to 36.30 per cent which are the lowest and the highest values for 45 days and 180 days cutting stages respectively. Here mean value for crude fibre content was found to be 32.19 per cent. For Cenchrus grass crude fibre content ranged from 21.60 to 31.60 per cent. The mean value found 27.80 per cent. In Stylo grass crude fibre content is relatively less. The values are ranged from 21.28 to 26.24 per cent. The crude fibre content values in all four type of fodder grasses goes on increasing with increasing days of cutting stages.

The literature on crude fibre content for Bajra x Napier hybrid grass at pre flowering stage was found 22.50 per cent (Panda *et al.,* 1967), which was approximately equal to first cutting stage. This value may be of 45 days cutting stage. For Guinea grass the literature values were reported to be 30.86 per cent during flowering stage and 28 per cent during post flowering stage (Daniel *et al.,* 1968). The previous results for crude fibre content ranged from 31.6 to 41 8 per cent with an average of 37.3 per cent for Guinea grass (Ranjan and Pathak, 1979). Sanjiv Kumar and Garg (1995,1998) reported 34.90 per cent and 29.80 per cent values of crude fibre for the same cultivar. The present results are found in accordance with the previously reported results. The literature values for crude fibre content in Cenchrus grass ranged from 27.2 to 34.4 per cent (Narayanan and Dabadghao, 1972) which are in agreement with the present results. The values of crude fibre in literature for Stylo grass were 32.99 per cent (Gupta *et al.,* 1974), (Chaudhari, 1977) and 43 10 per cent (Misra *et al.,* 1997). These are slightly higher than the present values which may be due to seasonal or varietal variations.

The cutting wise differences in crude fibre content were statistically significant in Bajra x Napier hybrid grass and Guinea grass and non-significant in Cenchrus and Stylo grasses.

4.4 Crude protein

Results of the present study on protein content of the fodder grasses along with their cutting stages are presented in Table 2. The values of crude protein content of Bajra x Napier hybrid grass ranged from 3.08 to 8.72 per cent. The lowest crude protein content was found at 180 days cutting and the highest at 45 days of cutting (first cut). The mean value of crude protein was found as 5.65 per cent. In Guinea grass the crude protein content ranged from 3.32 to 11.13 per cent at 185 and 45 days cutting stages respectively. The mean value for crude protein was found to be 7.76 per cent. The crude protein content for Cenchrus grass was relatively lower as compared to other three grasses. It ranged from 3.73 (240 days cut) to 6.23 per cent (60 days cut). The mean value for crude protein content was 4.98 per cent. For Stylo grass, the range was found to be 14.11 per cent which was the lowest found at 270 days cut (third cut) to 19.09 per cent at 90 days cut (first cut).

The literature values showed that the crude protein content in Bajra x Napier hybrid grass was found to be 7.94 per cent (Panda *et al.,* 1967), whereas 9.77 per cent (Fernandes, 1985) was found in kharif season. The literature values for crude protein content in Guinea grass ranged from 4.7 to 14.4 per cent with an average of 7.7 per cent (Ranjan and Pathak, 1979). Singh *et al.* (1992) and Sanjiv Kumar and Garg (1998) also reported the crude protein content in Guinea grass in between 7.16 – 7.94 per cent. For Cenchrus grass the literature values for crude protein content ranged from 6.2 to 11.4 per cent (Narayanan and Dabadghao, 1972). The crude protein for Stylo grass was reported to be 16.92 per cent (Gupta *et al.,* 1974 and Chaudhari, 1977) The crude protein content decreased with the increasing intervals of cutting. Crude protein content at 90 days cutting was 11.59 per cent, while 8.28 per cent at 150 days cutting in Stylo grass (Rai and Patil, 1986).

The present results are in agreement with those reported by earlier research workers. The cutting wise differences in crude protein content were statistically significant.

4.5 Carbohydrates

The results on carbohydrate content of the four fodder grasses along with their varieties at different cuttings are presented in Table 2. The carbohydrate content for Bajra x Napier hybrid grass ranged from 68.92 to 71.06 per cent. The lowest carbohydrate percentage of 68.92 was found at 45 days cut while the highest of 71 06 at 180 days cut. The mean value of carbohydrate content for this cultivar was found to be 70.15 per cent. For Guinea grass the carbohydrates ranged from 65.03 to 67.40 per cent. The mean value of carbohydrate content which of Guinea grass was 66.20 per cent Cenchrus grass had carbohydratescontent ranged from 69.75 to 69.84 per cent. The lowest carbohydrate content was found at 60 days cutting stage while the highest at 240 days cutting stage. The mean value of carbohydrate content in Cenchurs grass was 69.80 per cent. The carbohydrate content for Stylo grass was less than other cultivars and value ranged between 61.96 to 64 99 per cent. The mean value for carbohydrate content for Stylo grass was 63.17 per cent.

The literature values for carbohydrate content in above grasses are scanty. The average carbohydrate content for hybrid napier grass was 75.45 per cent (Panda *et al.,* 1967).

Carbohydrate content by difference method in Guinea grass was found as 44.35 per cent during pre flowering and 38.70 per cent during flowering stage. Present results are on the higher side than the previously reported values. The cutting wise differences in carbohydrate content were statistically significant.

4.6 Sugar

Results obtained in the present study on sugars (total sugars, reducing sugars and non-reducing sugars) of different fodder grasses at different cuttings are presented in Table 3. For Bajra x Napier hybrid grass the range was 54.65 to 67.44 mg/100 g for total sugars The mean value for total sugars is 61.02 mg/100 g. The reducing sugars ranged from 39.53 to 43.38 mg/100 g with a mean value of 40 85 mg/100 g and 14.82 to 27.91 mg/100 g with a mean value 20.17 mg/100 g for non-reducing sugars. At 135 days of cutting it showed the lowest total sugars while at 90 days cut it showed the highest total sugars content. For Guinea grass, the total sugars content ranged from 38.37 mg/100 g (45 days cut) to 60.46 mg/100 g (135 days cut) with mean value 51.16 mg/100 g sample. Reducing sugar ranged 17.44 mg/100 g (45 days cut) to 36.04 mg/100 g (135 days cutting) with mean value 29.36 mg/100 g. While non-reducing sugar contained ranges from 17.45 mg/100 g (180 days cutting) to 24.42 mg/100 g (90 days cutting) with mean value 21.81 mg/100 g. Cenchrus grass showed a ranged for total sugar content from 53.48 mg/100 g (60 days cutting) to 67.44 mg/100 g (150 days cutting) with mean value 60.07 mg/100 g, reducing sugar content from 37.20 mg/100 g (60 days cutting) to 43.02 mg/100 g (150 days cutting). Non-reducing sugar content from 16.28 mg/100 g (60 days cutting) to 24.42 mg/100 g (150 days cutting). For Stylo grass 180 days cutting had maximum total sugar

Table 3. Sugars contents of different cultivars of fodder grasses at different cutting stages

Sr. No.	Cultivar, cutting interval in days	Total sugar mg/100 g	Reducing sugar mg/100 g	Non reducing sugar mg/100 g
A.	**Bajra x Napier hybrid grass (RBN-9)**			
1.	45 days	60.40	43.38	17.02
2.	90 days	67.44	39.53	27.91
3.	135 days	54.65	39.83	14.82
4.	180 days	61.62	40.69	20.93
	Mean	61.02	40.85	20.17
	Range	54.65-67.44	39.53-43.38	14.82-27.91
	S.E. ±	0.326	1.268	0.139
	CD at 5 %	1.129	N.S.	0.480
B.	**Guinea grass (PGG-9)**			
1.	45 days	38.37	17.44	20.92
2.	90 days	55.81	31.39	24.42
3.	135 days	60.46	36.04	24.40
4.	180 days	50.00	32.55	17.45
	Mean	51.16	29.36	21.79
	Range	38.37-60.46	17.44-36.04	17.45-24.42
	S.E. ±	1.146	0.224	0.124
	CD at 5 %	3.967	0.777	0.428

Table 3 contd...

Sr. No.	Cultivar, cutting interval in days	Total sugar mg/100 g	Reducing sugar mg/100 g	Non reducing sugar mg/100 g
C.	**Cenchrus grass (CAZRI-75)**			
1.	60 days	53.48	37.20	16.28
2.	150 days	67.44	43.02	24.42
3.	240 days	59.30	41.16	18.14
	Mean	60.07	40.53	19.613
	Range	53.48-67.44	37.20-43.02	16.28-24.42
	S.E. ±	0.267	0.090	0.440
	CD at 5 %	1.050	0.354	0.174
D.	**Stylo grass (Stylo hamata)**			
1.	90 days	72.09	48.83	23.26
2.	180 days	75.58	54.65	20.93
3.	270 days	73.45	52.32	19.93
	Mean	73.70	51.93	21.37
	Range	72.09-75.58	48.83-54.62	19.93-23.26
	S.E. ±	0.635	0.209	0.233
	CD at 5 %	N.S.	0.820	0.916

The results are the means of three or four determinations

content with 75.58 mg/100 g and lowest at 90 days cutting 72.09 mg/100 g. For reducing sugar 48.83 mg/100 g (90 days cutting) to 54.65 mg/100 g (180 days cutting). Non-reducing sugar content ranged from 19.9 mg/100 g (270 days cutting) to 23.26 mg/100 g (90 days cutting) Out of these four major cultivars Stylo grass contained higher amount of total sugar followed by Cenchrus, Bajra x Napier hybrid grass and Guinea grass.

The literature values for sugar content in luserne, total sugar ranged from 3.14 to 4.30 per cent. Soluble sugar content was ranged from 1.49 to 2.48 per cent and reducing sugar from 0.89 to 2.15 per cent in luscrne (Lohan *et al.,* 1983).

4.7 Ash

The results on ash content of the four grasses and their different cuttings are presented in Table 4. The data revealed that the total ash content in Bajra x Napier hybrid grass ranged from 9.81 to 14.01 per cent. The lowest ash content of 9.81 per cent was observed at 45 days cutting and the highest of 14.01 per cent was observed at 180 days cutting. The total ash content in Guinea grass was 10.81 per cent at 45 days of cutting and 14.81 per cent at 180 days of cutting. The mean value of ash content was 12.32 per cent. The ash content in Cenchrus grass ranged from 12.79 per cent at 90 days of cutting and 16.62 per cent at 240 days of cutting. The average ash content was found as 14.76 per cent, whereas for Stylo grass ash content ranged from 4.37 to 7.12 per cent at 90 and 270 days of cuttings with a mean value of 6.14 per cent.

Table 4. Ash and major mineral content of different cultivars of fodder grasses at different cutting stages

Sr. No.	Cultivar, cutting interval in days	Ash (%)	Calcium (%)	Phosphorus (%)	Potassium (%)	Iron mg/100g
A.	**Bajra x Napier hybrid grass (RBN-9)**					
1.	45 days	9.81	0.58	0.26	3.16	84.30
2.	90 days	11.96	0.50	0.35	1.50	88.75
3.	135 days	12.25	0.66	0.22	2.50	85.62
4.	180 days	14.01	0.72	0.28	2.70	95.62
	Mean	12.01	0.61	0.28	2.48	88.57
	Range	9.81-14.01	0.50-0.72	0.22-0.35	1.50-3.16	84.30-95.62
	S.E. ±	0.031	0.009	0.011	0.029	1.338
	CD at 5 %	0.107	0.031	0.038	0.091	4.630
B.	**Guinea grass (PGG-9)**					
1.	45 days	10.81	0.36	0.22	1.80	93.13
2.	90 days	11.42	0.68	0.37	2.30	108.13
3.	135 days	12.16	0.54	0.24	3.80	105.00
4.	180 days	14.81	0.62	0.20	3.30	98.75
	Mean	12.32	0.55	0.26	2.80	101.25
	Range	10.81-14.81	0.36-0.58	0.20-0.37	1.80-3.80	93.13-108.13
	S.E. ±	0.164	0.015	0.007	0.075	2.276
	CD at 5 %	0.589	0.051	0.026	0.258	7.879

Table 4. contd....

Sr. No.	Cultivar, cutting interval in days	Ash (%)	Calcium (%)	Phosphorus (%)	Potassium (%)	Iron mg/100g
C.	**Cenchrus grass (CAZRI-75)**					
1.	60 days	12.79	0.42	0.32	2.50	106.88
2.	150 days	14.87	0.34	0.19	2.20	122.50
3.	240 days	16.62	0.48	0.23	2.80	80.63
	Mean	14.76	0.41	0.25	2.50	103.33
	Range	12.79-16.62	0.34-0.48	0.19-0.32	2.20-2.80	80.63-122.50
	S.E. ±	0.029	0.023	0.010	0.464	1.060
	CD at 5 %	0.112	0.089	0.040	N.S.	4.161
D.	**Stylo grass (Stylo hamata)**					
1.	90 days	4.37	0.58	0.34	1.30	63.75
2.	180 days	6.95	0.90	0.41	3.00	90.63
3.	270 days	7.12	1.00	0.31	2.30	61.25
	Mean	6.14	0.83	0.35	2.20	71.88
	Range	4.37-7.12	0.58-1.00	0.31-0.41	1.30-3.00	61.25-90.63
	S.E. ±	0.207	0.034	0.019	0.088	2.968
	CD at 5 %	0.813	0.132	0.076	0.346	11.656

The results are the means of three or four determinations

The literature values for ash content in Bajra x Napier hybrid grass were 14.11 per cent (Panda *et al.,* 1967) and 11 66 per cent in kharif season (Fernandes, 1985). For Guinea grass ash content was 12.77 per cent during flowering stage and 7.81 per cent during post-flowering stage (Danial *et al.,* 1968). Ranjan and Pathak (1979), Singh *et al.* (1992) and Sanjiv Kumar and Garg (1998) found that the ash content in Guinea grass ranged from 7.55 to 16.1 per cent. A range of 13.3 to 18.1 per cent total ash has been reported in Cenchrus grass by Narayanan and Dabadghao, (1972) and 7.05 per cent by Gupta *et al.* (1974) and 12.5 per cent by Pathak and Kamara, (1989) for Stylo grass. The present results are similar to previous literature values of ash content in the above fodder grasses. The cutting wise change in ash content were statistically significant. The variation in the ash content in various cultivar and their cutting stages may be due to variation in their metabolic synthesis and accumulation. Other reasons may be the source of plant nutrients during growing period and other climatic conditions.

4.8 Minerals

4.8.1 Calcium

The calcium content in the fodder grasses at different cutting stages are presented in Table 4. The calcium content of Bajra x Naiper hybrid grass was the highest (0.72 %) at 180 days of cutting and the lowest (0.50 %) at 90 days of cutting. For Guinea grass calcium content ranged from 0.36 per cent at 45 days of cutting to 0.68 per cent at 90 days of cutting stage with a mean of 0.55 per cent. In Cenchrus grass calcium content was found in the range of

0 34 to 0.48 per cent. The lowest of 0.34 per cent at 150 days cutting and the highest of 0.48 per cent was at 240 days cutting with a mean of 0.41 per cent. Calcium content in Stylo grass ranged from 0 58 per cent to 1.0 per cent, the mean value being 0.83 per cent.

The literature value for calcium content in Napier grass is 0.41 per cent (Panda *et al.,* 1967). Pathak and Kamara (1989) reported 0.39 per cent calcium in Guinea grass for early stage while 0.51 per cent and 0.39 per cent for prime and flowering stage, respectively The literature value showed 1.0 per cent calcium content (Ranjan, 1977) in Cenchrus grass, where as 1.23 per cent calcium content (Pathak and Kamara, 1989) has been reported in Stylo grass. The present results very well match with the previously reported results. The cutting wise differences, however, in calcium content were statistically significant.

4.8.2 Phosphorus

Phosphorus content of the four fodder grasses at different cutting stages is presented in Table 4. Phosphorus content ranged from 0.22 to 0.35 per cent in Bajra x Napier hybrid grass with a mean of 0.28 per cent, while phosphorus in Guinea grass ranged from 0.22 to 0.37 per cent with a mean value of 0.26 per cent. For Cenchrus grass, phosphorus varied from 0.19 per cent (150 days cutting) to 0.32 per cent (60 days cutting) having a mean value 0.25 per cent. In Stylo grass phosphorus content ranged from 0.31 per cent (270 days cutting) to 0.41 per cent (180 days cutting) with mean value of 0.35 per cent. Out of these four fodder grasses, Stylo grass contained relatively higher amount of phosphorus.

The reported value for phosphorus in hybrid napier is 0.19 per cent (Panda *et al*, 1967). The phosphorus content in Guinea grass was presented 0.21 per cent during early stage, 0.39 per cent during prime stage and 0.24 per cent during flowering stage (Pathak and Kamara, 1989). They also reported that Stylo grass contained 0.34 per cent phosphorus. These literature values are in accordance with the present results. The cutting wise differences in phosphorus content were statistically significant.

4.8.3 Potassium

The present results of potassium content in fodder grasses at different cutting stages are presented in Table 4. The potassium content in Bajra x Napier hybrid grass ranged from 1.50 per cent (90 days cutting) to 3.16 per cent (45 days cutting) with an average of 2.48 per cent. Guinea grass showed the range of 1.80 per cent (45 days cutting) to 3.80 per cent (135 days cutting). The mean potassium content was 2.80 per cent. The range was 2.20 to 2.80 per cent for Cenchrus grass with a mean value 2.50 per cent. The highest potassium content was found at 240 days cutting and the lowest being at 150 days of cutting. Stylo grass contained 1.30 to 3.00 per cent potassium content with a mean value of 2.20 per cent.

The literature values showed the potassium content of 0.85 per cent during early stage, 3.14 for prime stage and 1.20 for flowering stage in Guinea grass (Pathak and Kamara, 1989). Satya Paul *et al.* (1982) reported 0.36 per cent potassium during pre flowering, 0.20 per cent during flowering and 0.23 per cent during maturity stage for strain-358 of Cenchrus grass. These are similar values to the present results.

4.8.4 Iron

The four fodder grass samples with their different cuttings were analysed for iron content and the results are presented in Table 4. In Bajra x Napier hybrid grass iron content ranged from 84.30 mg/100 g at 45 days of cutting to 95.62 mg/100 g at 180 days of cutting with a mean value of 88.57 mg/100 g. Iron content for Guinea grass ranged from 93.13 mg/100 g at 45 days of cutting to 108.13 mg/100 g at 90 days of cutting with a mean value of 101.19 mg/100 g. The iron content in Cenchrus grass ranged from 80.63 mg/100 g at 240 days of cutting to 122.5 mg/100 g at 150 days of cutting with a mean value of 103.33 mg/100 g. Stylo grass contained 61.25 to 90.63 mg/100 g iron content at 270 and 180 days of cutting, respectively. The mean value of iron content was 71.88 mg/100 g per cent. Cenchrus grass had relatively high amount of iron than other three fodder grasses. The literature values for iron content in Cenchrus grass are 100 ppm, 260 ppm and 140 ppm for three cutting stages, pre flowering, flowering and maturity stage respectively (Satya Paul *et al.,* 1982). Ranjan (1977) reported that the iron content in fodder grasses ranged from 22.80 to 98.40 mg/100 g.

4.9 Cell wall constituents

4.9.1 Cellulose

The data on cellulose content of different fodder grasses at different cuttings are presented in Table 5. The cellulose content of Bajra x Napier hybrid grass ranged from 22.18 to 27.73 per cent with a mean value 24.89 per cent. Guinea grass showed their range for cellulose content from 21.25 per cent at 45 days of cutting to 37.39 per cent at 135 days of cutting with an average of 24.89 per cent. For Cenchrus grass cellulose content range varied from 24.85 per cent to 27.46 per cent. The mean value of cellulose content was 26.37 per cent. In Stylo, it ranged between 26.83 per cent to 27.89 per cent with an average of 27.48 per cent.

The literature values for cellulose content in the grass ranged from 19.19 to 35.67 per cent (Chaudhari *et al.,* 1973). Gupta and Pradhan (1975) observed cellulose content in non-legumes from 29.06 to 32.79 per cent while in legumes it ranged from 9.37 to 28.92 per cent. The cellulose content at different stages in Cenchrus grass was 28.59, 27.39 and 24.21 per cent at pre flowering, flowering and maturity stage, respectively.

The present results are in accordance with the literature value. The results indicated significant difference in cellulose content as influenced by different cutting stages in Guinea and Stylo grass.

4.9.2 Hemicellulose

The results on hemicellulose content of fodder grasses at different cutting stages are presented in Table 5.

The hemicellulose content in Bajra x Napier hybrid grass ranged from 36.85 to 37.52 per cent with a mean value of 37.18 per cent. The average hemicellulose content was 34.46 per cent for Guinea grass. In Cenchrus grass it varied from 35.58 to 36.43 per cent with a mean value of 35.95 per cent. For Stylo grass the values ranged from 36.42 to 40.45 per cent, with a mean of 38.61 per cent.

Table 5. Cell wall constituents and *In vitro* dry matter digestibility (IVDMD) of different cultivars of fodder grasses at different cutting stages

Sr. No.	Cultivar, cutting interval in days	Cellulose (%)	Hemicellulose (%)	Neutral detergent fiber (%)	Acid detergent fiber (%)	Lignin (%)	Silica (%)	IVDMD (%)
A.	**Bajra x Napier hybrid grass (RBN-9)**							
1.	45 days	22.18	37 07	66.99	29.92	4 87	1.59	44 40
2.	90 days	27.73	37.24	67 40	30 16	5 16	1 27	42 80
3.	135 days	25.39	37.52	68 08	30.56	7.29	1 05	42 20
4.	180 days	24.24	36.85	68.72	31.87	7.39	1 17	37 80
	Mean	24.89	37.18	67.80	30.62	6.18	1.27	41.80
	Range	22.18 - 27.73	36.85 - 37.52	66.99 - 68.72	29.92 - 31.87	4.87-7 39	1 05-1 59	37.80 - 44.40
	S.E. ±	0.309	0.173	0 021	0.183	0 032	0 018	1.683
	CD at 5 %	N.S.	N S.	0.072	0.633	0.111	0.010	N.S.
B.	**Guinea grass (PGG-9)**							
1.	45 days	21.25	28 65	59 52	30.87	5 11	2.44	64 00
2.	90 days	22 26	35 63	68 82	33.19	6 92	3 01	62 11
3.	135 days	37 39	37.28	73.04	35.76	6.29	2 08	61 02
4.	180 days	26.53	36.63	71.00	34.37	5 93	1.91	58 71
	Mean	26.86	34.46	68 01	33 55	6.31	2.61	61.46
	Range	21.25 - 37 39	28.65 - 37 28	59.52 - 73 04	30 87 - 35 76	5 11-6 92	1 91-3.01	58.71 -64 0
	S.E. ±	1.162	0.514	0 081	0.021	0 044	0 010	1 146
	CD at 5 %	4 022	1.78	0 279	0 072	0 152	0 033	N S

Table 5 contd… .

Sr. No.	Cultivar, cutting interval in days	Cellulose (%)	Hemicellulose (%)	Neutral detergent fiber (%)	Acid detergent fiber (%)	Lignin (%)	Silica (%)	IVDMD (%)
C.	**Cenchrus grass (CAZRI-75)**							
1.	60 days	24 85	36.43	68.20	31 77	5 93	1 59	32 40
2	150 days	27 46	35.58	72 01	36 43	6 22	1.33	37.43
3	240 days	26 79	35 78	73 20	37 42	7.95	1 76	29 80
	Mean	26.37	35 95	71 16	35.21	6 70	1.56	33.21
	Range	24.85 - 27.46	35.58 - 36 43	68 20 - 73 20	31.77 - 37.42	5.93- 7 95	1.33- 1 76	29 80 - 37 43
	S.E. ±	1 70	0 020	0.328	0.022	0.013	0 040	1 878
	CD at 5 %	N.S.	0.079	1.289	0 087	0.051	0 158	N.S
D.	**Stylo grass (Stylo hamata)**							
1.	90 days	26.83	36.42	73.01	36 59	7 37	1 49	58 70
2.	180 days	27.89	39 08	74.29	35 21	8 74	1 34	57.51
3.	270 days	27.72	40.45	77.37	36 92	7 85	1 35	54 92
	Mean	27 48	38 65	74 89	36.24	7 99	1.43	57.04
	Range	26 83 - 27.89	36 42 - 40 45	73 01 - 77 37	35.21 - 36 92	7.37- 8 74	1.34- 1.49	54 92 - 58 70
	S.E ±	0.050	0 035	0 135	0 031	0.014	0 008	2 761
	CD at 5 %	0.197	0 137	0 530	0.123	0 053	0 032	N.S.

The results are the means of three or four determinations

The literature values showed that the hemicellulose content in lucerne ranged from 10.48 to 43.57 per cent (Lohan *et al.*, 1983). The reported value for hemicellulose content in Anjan grass was 34 52 per cent (Ranjan, 1973). Ahuja *et al.* (1974) reported that hemicellulose content ranged from 18.10 to 30.00 per cent in Bajra x Napier hybrid grass. The present values of hemicellulose are similar, however cutting wise differences are statistically significant except Bajra x Napier hybrid grass.

4.9.3 Neutral detergent fibre (NDF)

The results obtained on NDF content for four grasses along with different cuttings are represented in Table 5. The NDF content ranged from 66.99 per cent (45 days cutting) to 68.72 per cent (180 days cutting). Guinea grass showed 59.52 per cent (45 days cutting) to 73.04 per cent (135 days cutting). In Cenchrus the range was between 68.20 per cent (60 days cutting) to 73.20 per cent (240 days cutting), while for Stylo, the value ranged from 73.01 per cent (90 days cutting) to 77.37 per cent (270 days cutting). The varietal differences in NDF contents are statistical significant.

The literature values for NDF content ranged from 68.80 to 70.70 per cent for Bajra x Napier hybrid grass (Barevadia *et al.*, 1976). For Guinea grass the NDF content ranged from 57.05 to 75.63 per cent (Ranjan, 1977). Reddy *et al.* (1996) showed NDF content 70.98 per cent for Cenchrus grass. For Stylo grass 49.27 per cent digestibility coefficient for NDF was reported by Misra *et al.* (1997).

4.9.4 Acid detergent fibre (ADF)

Acid detergent fibre (ADF) content of fodder grasses at different cutting stages are presented in Table 5. The lowest ADF content was found at first cutting (29.92 per cent at 45 days cutting) and the highest of 31.87 per cent at 180 days of cutting in Bajra x Napier hybrid grass. Guinea grass showed 30.87 per cent (45 days cutting) to 35.76 per cent (135 days cutting) ADF. ADF of Cenchrus grass ranged from 31.77 per cent (60 days cutting) to 37.42 per cent (240 days cutting). For Stylo grass the values for ADF ranged from 35.21 per cent to 36.92 per cent at 180 and 270 days of cutting, respectively.

The literature values for ADF content ranged from 24.1 to 41.6 per cent for different fodder crops (Ahuja *et al.,* 1974). ADF content of leguminous and non-leguminous feeds reported 39.10 and 39.0 per cent, respectively (Gupta and Pradhan, 1975). Satyapaul *et al.* (1982) reported ADF content for two strains (Strain-358 and Palsana) of Cenchrus grass 36.33, 39.27, 40.80 and 36.13, 43.93, 36.33 at pre flowering, flowering and maturity stage respectively. Misra (1997) observed that the Stylo grass contented 40.48 per cent ADF. The present results are in agreement with the literature values.

4.9.5 Lignin

The results for lignin content of different fodder grasses at different cuttings are presented in Table 5. The lignin content in Bajra x Napier hybrid grass ranged from 4.87 per cent at 45 days of cutting to 7.39 per cent at 180 days of cutting with a mean value of 6.18 per cent. In Guinea grass the lowest lignin percentage was found at 45 days of cutting (5.11%) and the highest at 90 days of cutting (6.92%). The lignin content in Cenchrus grass ranged from 5.93 to 7.95 per cent. In Stylo grass it ranged between 7.37 per cent to 8.74 per cent.

The literature values of lignin content of forage grasses ranged from 2.23 to 7.80 per cent (Chaudhari *et al.,* 1973). The lignin content of leguminous and non-leguminous crop was 9.37 to 11.60 per cent and 5.40 to 8.40 per cent (Gupta and Pradhan, 1975) respectively. The present results are in accordance with the literature value. The results indicated significant difference in lignin content was influenced by different cutting stages.

4.9.6 Silica

The results on silica content of different fodder grasses at different cuttings are presented in Table 5. The silica content of Bajra x Napier hybrid grass ranged from 1.05 per cent to 1.59 per cent at 135 and 45 days of cuttings respectively. In Guinea grass the lowest silica was found at 180 days of cutting (1.91%) and the highest (3.01%) at 90 days of cutting. In Cenchrus grass, it ranged from 1.33 per cent (150 days cutting) to 1.76 per cent (240 days cutting). The silica content in stylo ranged from 1.34 per cent (180 days cutting) to 1.49 per cent (90 days cutting).

The literature value showed that in legume and non-legume forages silica content ranged from 0.71 to 1.31 and 1.61 to 2 53 per cent, respectively (Gupta and Pradhan, 1975). The two strains of Cenchrus grass strain 358 and Palsana showed silica content of 1.71, 1.17, 1.06 and 4.47, 3.06, 2.67 at pre flowering,

flowering and maturity stage respectively (Satyapaul *et al.,* 1982). The present values of silica content of fodder grasses are in accordance with the literature values.

4.10 *In-vitro* dry matter digestibility (IVDMD)

The results on *in-vitro* dry matter digestibility (IVDMD) of different varieties of fodder grasses at different cutting stages are presented in Table 5. The IVDMD content of Bajra x Napier hybrid grass ranged from 37.80 to 44.40 per cent with a mean value of 41.80 per cent while in Guinea grass the lowest IVDMD was reported at 180 days cutting (58.71 %) and the highest at 45 days of cutting (64.00%) with a mean value of 61.46 per cent. In Cenchrus grass, the range was 29.80 per cent (240 days cutting) to 37.43 per cent (150 days cutting) with a mean value of 33.21 per cent. In Stylo it was from 54.92 per cent at 270 days cutting to 58.70 per cent at 90 days of cutting with mean value of 57.04 per cent.

The literature values for IVDMD of different forage crops ranged from 27.83 to 42.86 per cent for kharif season (Chaudhari *et al.,* 1973). Singh *et al.* (1974) also showed 39.80 to 55.90 per cent IVDMD for fodder grasses. Gupta and Pradhan (1975) reported that the IVDMD of legume and non-legume crops ranged from 67.17 to 69.89 per cent and 59.07 to 67.72 per cent respectively. Misra *et al.* (1997) reported 50.87 per cent dry matter digestibility coefficient for Stylo grass.

4.11 Total phenolics

The data regarding total phenolics of four fodder grasses along with different cutting stages are presented in Table 6. Bajra x

Table 6. Total phenolics and oxalate content of different cultivars of fodder grasses at different cuttings

Sr. No.	Cultivar, cutting interval in days	Phenolics mg/100 g	Oxalates (%)
A.	**Bajra x Napier hybrid grass (RBN-9)**		
1.	45 days	36.44	1.84
2.	90 days	35.66	1.63
3.	135 days	42.33	2.20
4.	180 days	34.70	1.91
	Mean	37.28	1.90
	Range	34.70-42.33	1.63-2.20
	S.E. ±	0.034	0.019
	CD at 5 %	0.142	0.065
B.	**Guinea grass (PGG-9)**		
1.	45 days	19.16	1.52
2.	90 days	16.38	2.02
3.	135 days	20.23	1.97
4.	180 days	19.01	2.50
	Mean	18.70	2.00
	Range	16.38-20.23	1.52-2.50
	S.E. ±	0.793	0.012
	CD at 5 %	N.S.	0.042

Table 6 contd...

Sr. No.	Cultivar, cutting interval in days	Phenolics mg/100 g	Oxalates (%)
C.	Cenchrus grass (CAZRI-75)		
1.	60 days	19.27	2.14
2.	150 days	15.94	2.70
3.	240 days	16.53	2.42
	Mean	17.25	2.43
	Range	15.54-19.27	2.14-2.70
	S.E. ±	1.114	0.023
	CD at 5 %	N.S.	0.089
D.	Stylo grass (Stylo hamata)		
1.	90 days	69.54	2.19
2.	180 days	54.66	1.74
3.	270 days	71.33	1.91
	Mean	65.18	1.95
	Range	54.66-71.33	1.74-2.19
	S.E. ±	1.253	0.011
	CD at 5 %	4.92	0.044

The results are the mean of three or four determinations

Napier hybrid grass contented total phenolics an the range of 34.70 mg/100 g to 42.33 mg/100 g with a mean value 37.28 mg/100 g, while in the Guinea grass it ranged from 16.38 mg/100 g to 20.23 mg/100 g with a mean value of 18.70 mg/100 g. In Cenchrus grass the lowest value of 15.94 mg/100 g at 150 days of cutting and the highest 19.27 mg/100 g at 60 days cutting was observed. For Stylo grass the value ranged from 54.66 mg/100 g to 71.33 mg/100 g with a mean value of 65.18 mg/100 g. The Guinea and Cenchrus grass showed the lowest amount of phenolics than the other two fodder grasses.

4.12 Oxalates

The results obtained in the present research work on oxalate content in four fodder grasses at different cutting stages are presented in Table 6. Bajra x Napier hybrid grass contained oxalate which ranged from 1.63 to 2.20 per cent with a mean value of 1.90 per cent. Guinea grass showed oxalate content which ranged from 1.52 to 2.50 per cent. In Cenchrus grass oxalate content ranged from 2 14 to 2.70 per cent with a mean value of 2.43 per cent. Stylo grass contained oxalate from 1.74 to 2.19 per cent at 180 and 90 days of cutting, respectively with a mean of 1.95 per cent.

The literature values of oxalate content in hybrid napier indicated a decreasing trend from 3.44 per cent at 60 cm height to 1 63 per cent at flowering stage (Des Raj and Mudgal, 1968). Sehgal and Goswami (1971) reported that bajra fodder contained 1.72 to 3.42 per cent oxalate. The oxalate content in hybrid napier bajra was observed from 2.21 to 3.92 per cent (Sidhu *et al.*, 1996). Higher amount of oxalate content in the fodder grasses is harmful for nutritional quality. Oxalates bind with different types of nutrients and make it unavailable for the good health of animal.

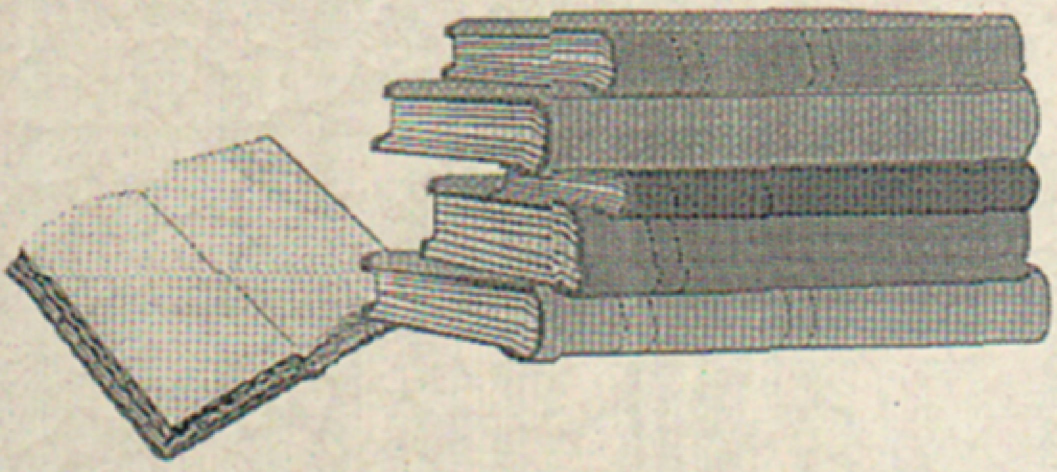
4.13 Correlation

Simple correlation coefficients were worked out between *in-vitro* dry matter digestibility (IVDMD), cell wall constituents, crude protein, total sugars and dry matter presented in Table 7.

The present results from correlation data revealed that the cell wall constituents *viz.*, NDF, ADF, cellulose, lignin, silica and crude protein were positively correlated with IVDMD, while hemicellulose and dry matter were negatively correlated. Crude protein, cellulose and silica had the highest correlation with IVDMD which indicated that crude protein, cellulose and silica were considered as precise predictor for IVDMD estimations in fodder grasses. Crude protein had positive ($r - 0{\cdot}599$) correlation with IVDMD which indicated that with the level of crude protein increase, the IVDMD also increased.

Table 7. Correlation coefficient (r) amongst different parameters means of fodder grasses

Parameter	IVDMD	NDF	ADF	Cellulose	Hemicelluloses	Lignin	Silica	Total Sugar	Crude protein	Dry matter
IVDMD	-	0.101	0.180	0 591	-0 049	0 291	0 606	-0.022	0 599	-0.753
NDF		-	0 852	0 694	0 670	0 976	-0.393	0 863	0.812	0 559
ADF			-	0 895	0 182	0 798	0.062	0 471	0 605	0.481
Cellulose				-	0.042	0.730	0.388	0 299	0 706	0 040
Hemicelluloses					-	0.704	-0.817	0.952	0 677	0.355
Lignin						-	-0.323	0.871	0 920	0.373
Silica							-	-0 732	-0.154	-0.646
Total sugar								-	0 774	0.495
Crude protein									-	-0 010
Dry matter										-



SUMMARY AND CONCLUSIONS

5. SUMMARY AND CONCLUSION

The present research work was undertaken to study the effect of subsequent cuttings on nutritional quality of some fodder grasses grown at Grass Breeding Scheme, Mahatma Phule Krishi Vidyapeeth, Rahuri.

Cultivar	Number of cuttings	Replication for analysis
Bajra x Napier hybrid grass (RBN-9)	4	3
Guinea grass (PGG-9)	4	3
Cenchrus grass (CAZRI-75)	3	4
Stylo grass (Stylo hamata)	3	4

The harvested samples at different cutting stages were dried in a hot air oven, powdered and analysed for chemical composition and nutritional evaluation. The present results of this investigation are summarized in this chapter.

1. The dry matter content of the four fodder grasses increased with increasing cutting days interval. Each variety showed the lowest dry matter content at first cutting, while the last cutting showed the highest dry matter content. On an average Cenchrus grass showed the highest dry matter content (61.44 %) than the other three fodder grasses.
2. The overall range of crude oil in all cutting was 0.73 to 1.15 per cent. On an average, Stylo grass had the lowest mean value of

crude oil (0.85%) whereas the Cenchrus grass had the highest (1.03 %) crude oil.

3 Crude fibre content increased with increasing cutting days interval If we consider all cutting stages at different interval, it ranged from 21.28 to 36.30 per cent. Each variety showed the lowest crude fibre content at first cutting (21.28 to 24.46 per cent) while the last cutting showed the highest ranging from 26.24 to 36.30 per cent.

4. Carbohydrate content ranged from 61.96 to 71.06 per cent in four grasses at different cutting stages. Carbohydrate and dry matter content in fodder grasses increased with increasing cutting interval.

5. There was decreasing trend in crude protein content in fodder grasses at their cutting stages from first cutting to the last cutting. It ranged from 3.08 to 19.09 per cent at all the cutting stages. The Cenchrus grass had the lowest mean value of crude protein (4.98%) while Stylo grass had higher mean value of protein content (17.01%) than the other three grasses because it is a leguminous crop. Decreasing trend of crude protein was observed with increasing dry matter content and crude fibre content

6. Over all mean of total sugars content of four fodder grasses ranged from 38.37 mg/100 g (45 days cutting of Guinea grass) to 75.58 mg/100 g (180 days cutting of Stylo grass). The reducing sugars ranged from 17.44 to 54.65 mg/100 g and the non-reducing sugars from 16.21 to 27.91 mg/100 g. Stylo

grass had higher sugar content followed by Bajra x Napier, Cenchrus and Guinea grass.

7. Ash content in all the four grasses ranged from 4.37 to 16.62 per cent. The ash content of fodder grasses generally increased with increasing dry matter content as well as cutting numbers. Cenchrus grass had relatively higher mean value of ash content while Stylo grass showed the lowest ash content at all the cutting stages.

8. Major minerals (calcium, phosphorus, potassium and iron) content in fodder grasses were significantly different at every cutting stage except the potassium in Cenchrus grass. Calcium content was ranged from 0.34 to 1.00 per cent. Stylo grass showed relatively higher amount of calcium content. The range of phosphorus in these grasses was 0.19 to 0.41 per cent. Stylo grass had the highest phosphorus content. Potassium content ranged from 1.30 to 3.80 per cent at all the cutting stages of four grasses. Cenchrus grass had the highest potassium content. Iron content ranged from 61.25 to 122.5 mg/100 g at the all cutting stages. Cenchrus grass had relatively higher amount of iron content, while Stylo showed the lower iron content.

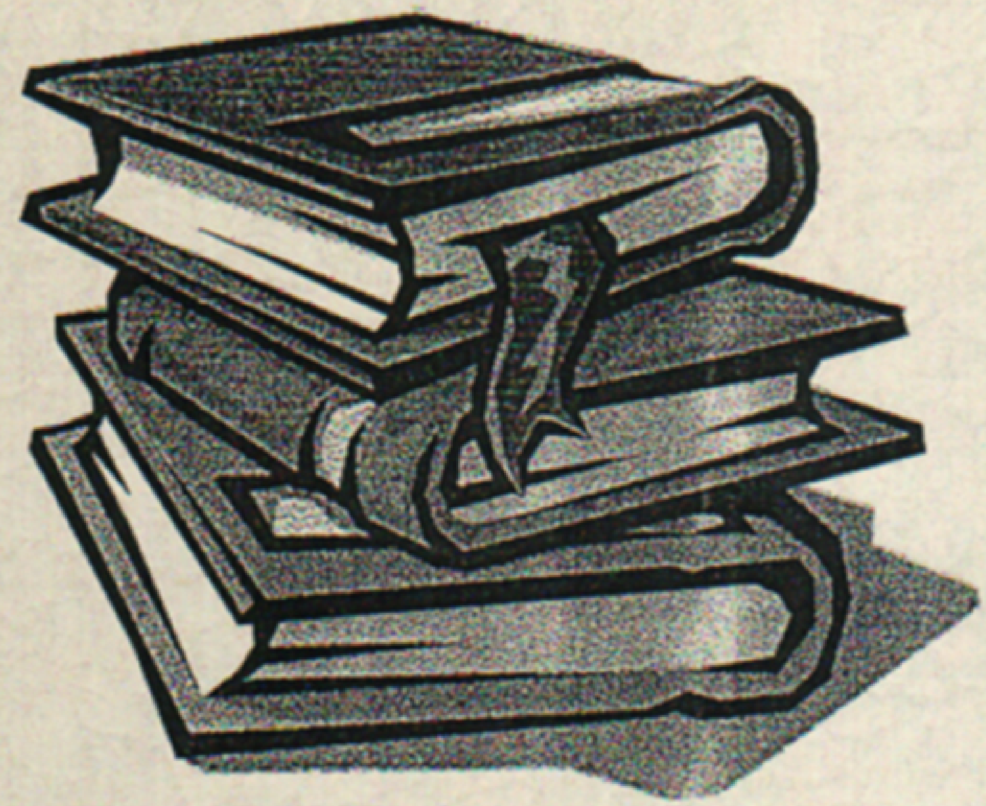
9. Cellulose content ranged from 21.25 to 37.39 per cent at all the stages. Stylo grass had comparatively higher amount of cellulose content.

10. Hemicellulose content varied from 28.65 to 40.45 per cent at all stages of the cutting. Stylo grass had relatively higher amount of hemicellulose (38.65%) while Cenchrus grass had the lowest hemicellulose content in four fodder grasses.

11. Neutral detergent fibre ranged from 59.52 to 77.37 per cent at considering all the cutting stages of fodder grasses. On an average Stylo grass had relatively higher amount of NDF content while Bajra x Napier hybrid grass had the lowest NDF content out in the four fodder grasses.
12. Acid-detergent fibre ranged from 29.92 to 37.42 per cent at all the cutting stages of fodder grasses. Stylo grass had relatively higher amount (36.24%) of ADF, while Bajra x Napier hybrid grass had the lowest amount (30.62%) of ADF in the four fodder grasses.
13. Lignin content in fodder grasses changed according to the stage of cutting. The value of lignin ranged from 4.87 to 8.74 per cent at all the cutting stages of fodder grasses. Stylo grass had relatively higher amount of lignin content (7.99 %), while Bajra x Napier had the lowest (6.18%).
14. Silica content in fodder grasses changed according to the stage of cutting. The silica content ranged from 1.05 to 3.01 per cent at all the cutting stages of fodder grasses. Guinea grass had the highest silica content of 2.61 per cent than the three other grasses.
15. *In-vitro* dry matter digestibility of fodder grasses ranged from 32.40 to 64.00 per cent at all the cutting stages of fodder grasses. In general IVDMD content of fodder grasses decreased with increasing number of cutting. On an average Guinea grass had relatively higher amount of IVDMD (61.46 %) while Cenchrus had the lowest (33.21%).

16. The allelochemicals *viz.,* phenolics and oxalate change according to stage of cutting. Phenolic content of fodder grasses ranged from 15.94 to 71.33 mg/100 g. Stylo grass had the highest phenolic content (65.18 mg/100 g). Oxalate content in fodder grasses ranged from 1.52to 2.70 per cent at all the stages of cutting. There were significant differences in oxalate content. Cenchrus grass had relatively higher amount of oxalate (2.43%) than the three other fodder grasses.

Considering overall cutting stages of all four fodder grasses, it clearly indicated that nutrient changes take place according to the cutting interval. Dry matter, crude fibre, carbohydrate and ash content of fodder grasses increased with cutting interval. But crude protein content decreased with increasing cutting interval due to increase in crude fibre content. Considering all nutritional and antinutritional components (dry matter, crude fibre, crude protein, minerals, IVDMD, lignin, silica, phenolics and oxalate) present in above studied fodder grasses the studies indicated that the first cutting of Bajra x Napier hybrid grass, third cutting of Guinea grass, second cutting of Cenchrus and Stylo grass appeared suitable for providing higher nutrients for animal feeding.



LITERATURE CITED

6. LITERATURE CITED

A.O.A.C. 1990. Official Methods of Analysis, (12th Edn) Association of Official Analytical Chemists, Washigton, D.C, U.S.A.

Ahuja, A.K., Gupta, B.K. and Multani, K.K. 1998. Seasonal variation in oxalate content of Hybrid Napier and its amelioration through ensiling. Indian J. Anim. Nutr. 15(2) : 147-148.

Ahuja, S.P., Chaudhary, K.C., Sharma, K.C. and Bhatia, I.S. 1974. Changes in chemical composition of forages and its relationship with *in-vitro* digestibility at different stages of maturity. Indian J. Anim. Sci. 44(10) : 725-736.

Amritkar, V.R. 1982. Chemical composition and *in vitro* dry matter digestibility of different Bajra (*Pennisetum typhoideum*) varieties as affected by growth stages. M.Sc. (Agri) Thesis submitted to M.P.K.V., Rahuri, Ahmednagar (M.S.).

Anonymous, 1962. Research in Animal Husbandary, ICAR, New Delhi, pp. 47-138.

Balaraman. N. (1995). Nutritive value of hybrid napier grass for goat. Indian J. Anim. Nutr. 12(4) : 245-246.

Barevadia, T.N., Patel, A.T., Patel, C.A. and Patel, A.S. 1976. Comparative performance of certain Napier-Bajra hybrids. Indian J. Dairy Sci. 29(1-4) : 314-316.

Bhatia, I.S., Singh, R., Dogra, K.K. and Dua, S. 1975 Changes in cell wall carbohydrate and lignin of some forage type millets as affected by growth stages. J. Sci. Food Agric. 26 (9) . 1391-1393.

*Black, C.A., Evans, D.D., Ensiminger, L.E., White, J.L. and Clark, F.E. 1965. Methods of soil analysis, Part III. Am . Soc. Agron. Inc. Publ. Medison, Wisconsin, U.S.A.

Chapman, H.D. and Pratt. P.F. 1961. Methods of Analysis for Soil, Plants and Water Division of Agric. Sci. University of California, Berkeley pp.169-176.

Chatterjee, A.K. (1986). National symposium on production and processing of meat and poultry products CFTRI, Mysore pp. 45-49.

Chaudhari, A.P. 1977. Introduction of Stylo in the pedicellatum pasture of salboni fodder farms of Midnapore district Indian Dairyman. 29 : 581-583.

Chaudhari, K.C., Dna, S., Hundal, L.S. and Bhatia I.S. 1973. The chemical composition and cell wall constituents of some kharif forage crops and *in-vitro* digestibility of dry matter and cellulose. Indian J. Dairy Sci. 26(4) : 249-252

Daniel, S.D. and Balasubramaniam 1968. Economic appraisal of Guinea grass. Indian Dairyman 20 : 311-313.

Das, R.B. and Bhatia, G.N. 1978. Studied on relative performance of promising strains of *Cenchrus ciliaris* (Linn.). under dry land conditions. Forage Res., 4 : 17-23.

Des Raj and Mudhal, V.D. 1968. Studies on chemical composition and nutritive value and mineral metabolism in cows fed on

Hybrid Napier. Indian J. Vet. Sci. and Animal Husbandary 38 (3) : 308-309.

Fernandes A.P., Deshmukh, A.P., Desale, J.S. and Deshmukh, V.D 1985. Effect of season and growth on chemical composition and *in-vitro* dry matter digestibility of hybrid napier grass. Dairy Guide. 7(7) : 26-29.

Fernandes, A.P. 1985. Chemical composition and *in vitro* dry matter digestibility of different hybrid napier grass varieties as affected by seasons of growth. M.Sc. (Agri) Thesis submitted to M.P.K.V., Rahuri, Ahmednagar (M.S.).

Gupta, B.N., Singh, R.B., Mathur, M.L. and Chaudhari, A.P. 1974. Chemical composition and nutritive value of Stylo H.B.K. A promising perennial legume. Indian J. Dairy Sci. 27 : 118-121.

Gupta, P.C. and Pradhan, K. 1975. Prediction of *in-vitro* dry matter digestibility of legume and non-legume forage from various chemical constituents. Indian J. Dairy Sci. 28(1) : 12-16.

Gupta, V.P. 1969. Breeding superior quality pennisetums for green fodder. Plant Sci. 1 : 20-23.

Katoch, D.C., Dogra, K.K., Bhandari, J.C. and Sud, R.G. 1987. Forage and nutrient production potential of Napier-Bajra hybrids in frost prone rainfed shivalik ranges of Himachal Pradesh. Forage Res. 13(1) : 39-43.

Krishna, G., Paliwal, V.K. and Yadav, K.R. 1981. The protein and non-protein nitrogen fractions in agro-industrial by products and wastes of Harayana State. Harayana Agric. Univ. J. Res. 11(3) : 458-462.

Lohan, O.P., Chahil, S.M. and Rathee, C.S. 1983. Effect of different cuttings on the cell wall constituents, sugar content and *in-vitro* nutrient digestibitlity by Lucerne. Indian J. Dairy Sci. 36(4) : 431-434.

Mishra, A.S., Santra, A., Chaturvedi, O.H., Prasad, R. and Karim, S.A. 1997. Comparative nutrient utilization in sheep and goats on Cenchrus (*Cenchrus ciliaris*) based diet. Indian J. Anim. Nutr. 14(4) :250-253.

Misra, A.K., Maity, S.B. and Radotra, S. 1997. Nutritive value of Stylo straw for sheep. Indian J. Animal Nutr. 14(1) : 59-60.

Narayanan, T.R. and Dabadghao, P.M. 1972. Forage crops of India. Indian Council of Agriculture research, New Delhi,pp. 167-168.

Natarajan, A., Krisnamoorthy, K.K and Gopal Krishanan, 1981. Evaluation of Hybrid Napier grass (NB-21) different stages of growth for their digestibility by using the *in-vitro* fermentation technique. Livestock Adviser. 6(3) : 33-38.

Nelson, N. 1944. A photometric adopton of the Somogyi method for determination of glucose. J. Biochem. 153 : 375-380.

Panda, P.B., Singh, G.S. and Singh, S.N. 1967. Nutritive value of Pusa Gaint grass when fed to Young Harayana bull calves. Indian J. Dairy Sci. 20 : 153-156.

*Panse, V.G. and Sukhatme, P.V. 1967. Statistical Methods For Agricultural Workers,ICAR, New Delhi, pp. 70-72.

Parihar, S.S., Shankar, V. and Kak, A. 1996. Toxic allelochemicals in forages and their ecological significance. Forage Res. 21(4) : 163-173.

Patel, C.A., Dhami, B.M. and Patel, M.B. 1970. Comparison of Hybrid Napier, Guinea grass and green Jowar as a green fodder supplement for milk production. Indian J. Dairy Sci. 23 : 119-120.

Patel, S.R., Sadhu, A.C., Patel, A.C. and Patel, B.G. 1992. Effect of biofertilizer and nitrogen levels on fodder production of grasses. Forage Res. 18(1) : 42-47.

Pathak, N.N. and Kamara, D.N. 1989. Appendix In-Text Book of Livestock Feeding in Tropics. A falcon book from cosmo publications, New Delhi. pp. 235-238 and 253-257.

Rai, P. and Patil, B.D. 1986. Forage yield and Quality of Stylo as influenced by defoliation intervals and intensity. Forage Res. 12(2) : 103-106.

Rakkiyappan, P. and Krishnamoorty, K.K. 1981. Effect of stage of harvest of forage quality of Guinea grass. Livestock Adviser. 6(4) : 37-42.

Ranjan, S.K. 1977. Appendix In: Animal Nutrition and Feeding Practices in India. Vikas Publishing House Pvt. Ltd., New Delhi 322-335.

Ranjan, S.K. and Pathak, N.N. 1979. Appendix I-II In: Management and Feeding of Buffaloes. Vikas Publishing House Pvt. Ltd, New Delhi pp. 242-252.

Reddy, N.R., Padhye, V.W. and Salunkhe, D.K. 1989. Black gram In: CRC Handbook of World Food legumes: Nutritional Chemistry, Processing Technology and Utilization Vol. I. CRC Press, Inc. Boca Rath on, Folrida, pp. 195-222.

Reddy, Y.R., Krishana, N. and Ramaprasad, J. 1996. Effect of urea treatment and Palm kernal cake supplementation on nutritive value of Anjan grass hay in Lambs. Indian J. Anim. Nutr. 13(1) : 23-26.

Sanjiv kumar and Garg, M.C. 1995. Nutritional evaluation of guinea grass (*Panicum maximum*) in buffalo calves. Indian J. Anim. Nutr. 12(1) : 59-60.

Sanjiv kumar and Garg, M.C. 1998. Comparative evaluation of signal (*Brachiaria decumbeuse*) and Guinea (*Panicum maximum*) grasses in buffalow heifers. Indian J. Anim. Nutr. 15(1) : 61-63.

Satya Paul, Joshi, D.C. and Gupta, A.K. 1982. Nutritional status of two *Cenchrus ciliaris* strains at different stages of growth. Forage Res. 8 : 27-30.

Schneider, B.H. and Lucas, H.L. 1950. The magnitude of certain sources of variability in digestibility data J. Anim. Sci. 9 : 504-506.

Seghal, K.L. and Goswami, A.K. 1971. Studies on chemical composition of the straw of seed type bajra entire with particular references with oxalic acid content. J. Res. P.A.U. 8(3) : 79-82.

Sen, K C 1957 The Nutritive values of Indian Cattle Feeds and the Feeding of Animals. ICAR Bulletin No. 22, New Delhi. pp. 46-48.

Singh, B., Narang, M.P. and Makkar, H.P.S. 1992. Rate and extent of in sacco degradation of dry matter and cell wall constituents of various grass species. Indian J. Anim. Nutr. 9(1) · 1-12.

Singh, R., Gupta, P.C., Vidya, S. and Pradhan, K. 1974. Cell wall constituents and *in-vitro* dry matter and cell wall digestibility of *rabi* and *kharif* forages. Indian. J. Dairy Sci 27(4) : 246-250.

Singhal, V. 1999. Indian Agriculture. Indian Economic Data Research Centre, New Delhi. pp. 481-500.

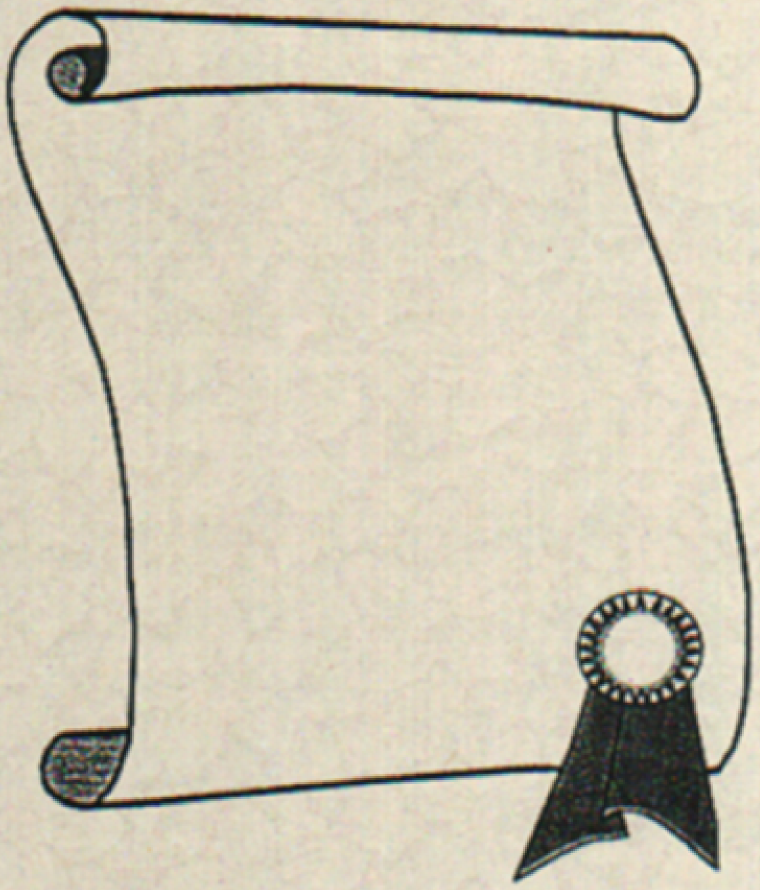
Swain, T. and Hillis, W E 1959. Phenolic constituent of *prunus domestica*. I.Quantitative analysis of phenolic constituents. J. Sci Food Agric. 10 : 83-84.

Van Soest, P.J. 1963. Use of detergents in analysis of fibrous feed II. A rapid method for determination of fibre and Lignin. J. Asso. Offi. Agril. Chem. 46(5) : 829-835.

Van Soest, P.J , Vane, R.N. and Moore, L.A. 1967. Estimation of true digestibility of forages by in-vitro digestion of cell wall Xth International cong. pp. 438.

---

* **Original not seen**



VITA

7. VITA

Samadhan Vasantrao Khatkale

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

2002

Title of thesis	:	Effects of subsequent cuttings on nutritional quality of some fodder grasses
Major Field	:	Biochemistry

Biographical Information :

*Personal	:	Born at Akola (Wasud), Tal. Sangola, Dist. Solapur on 10^{th} February, 1979. Son of Shri. Vasantrao Dattu Khatkale and Sau. Subhadra Vasantrao Khatkale.
*Educational	:	Passed Secondary School from Late S.S. Ligade Vidyalaya, Akola (Wasud) in 1994 in First Class with Distinction.
	·	Completed higher secondary school from Vidyamandir Prashala and Jr. College Sangola in 1996 with first class.
	:	Received B.Sc. (Agri.) degree in First class from College of Agriculture Kolhapur, M.P.K.V., Rahuri in 2000.
*Other activities	:	Participated in NSS at College level for 2 years and NSS camp.
	:	Participated in inter collegiate Kabbadi and Wrestling
	·	Receipt of rural area scholar student scholarship during 11^{th} and 12^{th} standard from Central Government.

	:	Recipient of merit scholarship given by Indian Council of Agricultural Research, New Delhi during 1996-2000 at Undergraduate level.
	:	Recipient of Merit-cum-college scholarship at Post Graduation, 2000-2002.
*Address	:	A/P – Akola (Wasud) Tal – Sangola Dist- Solapur Pin – 413 307.