GROWTH, YIELD AND QUALITY OF *RABI* SEASON FORAGE CROPS UNDER *TARAI* REGION OF UTTARAKHAND

Thesis

Submitted to the

G.B. Pant University of Agriculture & Technology
Pantnagar-263145 (U.S. Nagar), Uttarakhand, India

By

Brajkishor Prajapati
B.Sc. (Ag.) Honors

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Science in Agriculture
(AGRONOMY)

June, 2014

ACKNOWLEDGEMENT

"This manuscript is dedicated to the respectful memory of my late grandma and grandpa"

First and foremost, I blow my head and express gratitude with all reverence and devotion to the "Almighty" for His showers of blessings throughout my research work to complete the research successfully. He is the one who lead me into the light from the darkness, to the truth from the lies, to the eternal from the death and given me a chance to acknowledge whole heartedly all those who have provided me utmost support all through my thesis research.

I have the privilege with rejoice to express may deep admiration, profound sense of reverence and gratitude to ***Dr. Kewalanand****, Professor, Department of Agronomy and he Chairman of my Advisory Committee, his inspiring guidance, calm endurance and supportive attitude are unparalleled. His dynamic dissensions coupled with befitting counsel nurtured in me the zeal to wake and the will for improvement. He has been may mentor, philosopher and friend throughout the course of the investigation as well as preparation of this manuscript.*

I extend my deep sense of gratitude for supportive guidance showered by amiable members of my advisory committee, ***Dr. Y. P. Joshi,*** *Ex-Professor, Department of Agronomy,* ***Dr. Dheer Singh,*** *Professor, Department of Agronomy and* ***Dr. Amit Bhatnagar,*** *J.R.O, Department of Agronomy, without their full fledged co-operation, able guidance and valuable suggestions my effort would have remained incomplete.*

I express my gratefulness to Dean, College of Post Graduate Studies; Dean College of Agriculture; Director, Experiment Station; Joint Director, Instructional Dairy Farm and ***Dr. D.S.Pandey,*** *Head, Department of Agronomy, for providing the necessary facilities.*

I find no world to appreciate the field staff of Forage and Fodder, Agronomy project especially Sri Ramesh Chandra and Dr. Y.S. Panwar, Sri Ramnath and Sri Manu, for their brotherly behave and help rendered as and when needed.

A word of appreciation goes to all the faculty member of Department of Agronomy for their generous help and encouragement at various stages of research. Thanks are also to Dr. V.K. Singh, Professor and Incharge, Chemical Lab, Department of Agronomy and to Dr. Mandal Assosiate Professor and Incharge, Chemical Lab, Department and Animal Nutrition Laboratory, IDF, Nagla, specially Sri S.S. Pawar, Mr. Ali Mohammad and Sri Chandradev for their timely help and cooperation during the time of laboratory studies.

All the words in lexicon will be futile meaningless if, I fail to express my gratitude towards my respected father Mr. Salik Prajapati and mother Mrs. Bachi Devi Prajapati for their blessing, sacrifice, affection, moral support and an endless source of inspiration throughout my life.

With the personal touch of emotion I seize these opportunity to express my heart full and affectionate gratitude to bhaiya Tribhuwan Prajapati, bhabi Parmeena and cute niece (Chahat).

I am extremely grateful to my loving brothers Nareshwar, Rajesh, Rakesh, Rahul, Rishabh, Harsh and sisters Jaya, Ankita, Anubha, Poonam, Akansha and Pooja for their keen interest, inspiration, love, affection and moral support. Words would never be able to fathom the depth of my feelings towards my reverend other family members.

I am overwhelmed with love and, to evince my hearty appreciation to my amiable seniors cum friends especially N. Ramu sir, Netam sir, Pandyraj sir, Churachand sir, Arun E.K. sir, Mahesh sir, Tanumay sir, Amrender sir, Amin sir, Nazim sir, Dr. Shilpi m'am, Maya m'am, Seema m'am, Thoi Thoi Devi m'am, and Arunima m'am, who helped me whole heartedly in every iota of thick and thin.

It is neither possible nor probably within the scope of acknowledgement to record any feeling of affection, love and thanks towards my batch mates Jayant, Priyankar, Ankush, Prakash, Sankat, Siraz, Dilkhus, Suresh, Amit, Vinod, Anshu, Rakesh, Priyanka, Pooja, Sakshi, Neha and Jhimari (Pravamanjiri giri)

"A friend is one whom you can pour your heart out" I shall never forget the help, love, care and cooperation received from my friends Rakesh, Snehal, Anurag, Mahendra, Prashant, Mangal, Sneha, Soni and Sangeeta Sapkota who kept me floating over the world during my stay at pantnagar.

I extend my sincere thanks to ICAR for providing me Junior Research Fellowship (JRF) during the M.Sc. programme.

A word of heartfelt appreciation goes to Sri Mahesh Pandey, for his pains taken during my research work and careful typing of this manuscript.

Lastly thanks to all beloved and respected people around me who directly and indirectly helped me during my degree programme and whose names could not be mentioned here but could not find separate mention.

Pantnagar
June, 2014

(Brajkishor Prajapati)
Author

CERTIFICATE

This is to certify that the thesis entitled **GROWTH, YIELD AND QUALITY OF *RABI* SEASON FORAGE CROPS UNDER *TARAI* REGION OF UTTARAKHAND** submitted in partial fulfilment of the requirements for the degree of **Master of Science** in **Agriculture** with major in **Agronomy** of the college of Post-Graduate Studies, G. B. Pant University of Agriculture and Technology, Pantnagar, is a record of *bona-fide* research carried out by **Mr. Brajkishor Prajapati, Id. No. 44087**, under my supervision and no part of the thesis has been submitted for any degree or diploma.

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

(Kewalanand)
Chairman
Advisory Committee

Pantnagar
June, 2014 Advisory Committee

CERTIFICATE

We, the undersigned, members of the Advisory Committee of **Mr. Brajkishor Prajapati, Id. No. 44087**, a candidate for the degree of **Master of Science** in **Agriculture** with major in **Agronomy**, agree that the thesis entitled **GROWTH, YIELD AND QUALITY OF *RABI* SEASON FORAGE CROPS UNDER *TARAI* REGION OF UTTARAKHAND** may be submitted in partial fulfillment of the requirements for the degree.

(Kewalanand)
Chairman
Advisory Committee

(Y.P. Joshi)
Member

(Dheer Singh)
Member

(Amit Bhatnagar)
Member

CONTENTS

LIST OF TABLES

ABBREVIATION USED

%	Percentage
&	and
@	At the rate of
±	Plus or minus
ANOVA	Analysis of variance
e.t.c	Et cetra
et al	And other
Fig	Figure
g	Gram
Kg	Kilogram
q	Quintal
ha	Hectare
i.e.	That is
SEm	Mean standard error
C.D.	Critical difference
DAS	Days after sowing
ADF	Acid - detergent fibre
NDF	Neutral- detergent fibre
CP	Crude protein
DMD	Dry matter digestibility
GFY	Green forage yield
DMY	Dry matter yield
CPY	Crude protein yield
DDMY	Digestible dry matter yield
IGFRI	Indian Grassland and Fodder Research Institute
ICAR	Indian Council of Agriculture Research
CF	Crude fibre
EE	Ether extract

Introduction

Chapter 1 INTRODUCTION

Agriculture and animal husbandry in India are interwoven with the intricate fabric of the society in cultural, religious and economical ways as mixed farming and livestock rearing forms an integral part of rural living. Although the contribution of agricultural sector in the Indian economy is steadily declining (from 36.4% in 1982-83 to 18.5% in 2006-07), the agriculture and livestock sector still provides employment to 52% of the work force. India's livestock population is highest (529.7 million) in the world **(Anonymous 2011-2012)**. India supports nearly 20% of the world livestock and 16.8% human population on a land area of only 2.3%. It is leader in cattle (16%) and buffalo (55%) population and has world's second largest goat (20%) and fourth largest sheep (5%) population. At present, the country faces a net deficit of 62.7% green fodder, 21.9% dry crop residues and 64% feeds. During 2010 Supply of green forages and roughages was 395.2 and 451 million tonnes against the demand of 1061 and 589 million tonnes and deficit was 666 (62.76%) and 121 (21.93%) million tonnes respectively **(ICAR, 2012)**. The situation is further aggravated due to increasing population of human being and livestock. The available forages are poor in quality, being deficient in available energy, protein and minerals. To compensate for the low productivity of the livestock, farmers maintain a large herd of animals, which adds to the pressure on land and fodder resources.

There has been no change in the cultivated area under the forage production during the last two decades. Currently, area under fodder crops in India is around 8.3 million ha **(ICAR, 2012).** Sorghum amongst the *kharif* crops (2.6 million ha) and berseem (Egyptian clover) amongst the *rabi* crops (1.9 million ha) occupy about 54% of the total cultivated fodder cropped area. The area under permanent pastures has been declining over the years and the trend could well continue in the future. Due to overgrazing also, the productivity of the pastures has been declining. The area under fodder crops has almost remained static for the last 3-4 decades. In order to meet the fodder shortage for the growing animal population, the fodder growing area should ideally be around 12.0 million ha. However, diversion of area from food or commercial crops to forage crops would not be possible due to industrialization and increasing

population pressure. Under such circumstance the only way to bridge the gap between demand and supply of fodder is to ameliorate the forage resources.

The present investigation was done in a project "cool season varietal & dairy trails on forage crops" sponsored by **Royal Barenbur group P.O. Box 4, 6678 ZG Oosterhout Glg. The Netherland**.

Rabi season forage crops are Oat, Berseem, Lucerne, Rye grass, Red clover and forage Sarson etc. which are commonly grown in India. Some imported varieties of these crops like Genie Oat variety of Oat and Baralafa IN variety of Lucerne from Netherland, Makkhan grass variety of Rye grass from Advanta and Barduro variety of Red clover from Netherland have been tested in the present investigation with Mescavi variety of Berseem, UPO-212 variety of Oat and Local variety of Rye grass in *Rabi* season of 2012-2013.

Among *rabi* season cereals forage crops of Poaceae family Oat (*Avena sativa* L.) is an important winter feed and forage crop. It is native to Asia Minor. Oat ranks around fifth in world cereal production statistics, following wheat, maize, rice and barley. The total area under oat cultivation in the country is about 500 000 ha. Mainly growing in Punjab, Haryana, Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Rajasthan, Maharashtra and West Bengal. The crop can also be grown for pasture, hay or silage and animals concentrate apart from its use in green forage, which may be boon to achieve the goal of 'White Revolution'. It is highly nutritious and its forage contains 13-14 % crude protein, 2.1% ether extract, 32.9% crude fibre, 36.4% nitrogen free extract, 13.9% ash, 0.48% calcium, 0.33% phosphorus and 60-62% dry matter digestibility. Due to its excellent growth habit, better regeneration capacity and good quality forage, it has become promising forage crop.

Another crop in Poaceae family is Rye grass (*Lolium perenne* L.) which is an annual and perennial grass. It is native to Europe, Asia and Northern Africa, but is widely cultivated around the world. It contains approximately 10,000 species. Ryegrass is an important pastures and forage crop. It has high digestibility and crude protein (56-85% and 8.0-27.7%) which makes it ideal for dairy and sheep forage system and it is particularly suitable for animal with high nutrient requirement.

Ryegrasses are also used in soil erosion control programs. In cold areas, Perennial Ryegrass plays an important role in short term leys with high yields and quality. Perennial Ryegrass is compatible in mixtures with White Clover.

Among *rabi* season legume forage crops, Berseem (*Trifolium alexandrinem* L.), also known as Egyption clover, is widely adaptable and valuable forage crop since 1916 grown as winter forage crop and considered as **"King of fodder"**. It is grown in India, Pakistan, Turkey, Egypt and countries of Mediterranean region. In India, it is grown mainly in irrigated area of Northern India and Western part of country. The main state growing this crop are Punjab, Haryana, Delhi, Rajasthan, Utter Pradesh, Gujarat, and some parts of Bihar, Maharashtra, and Andhra Pradesh. It occupies 1.9 m ha area with the variable production of 100-120 t/ha green fodder yield from November to May with 5-6 cuttings per season **(ICAR, 2012)**. The crop is grown under irrigated condition and provides highly palatable, tender and nutritious green fodder. It contains 20-21 % crude protein, 1.89% ether extract, 25.9% crude fibre, 40.7% Nitrogen free extract, 14.16% ash, 1.92% calcium, 0.28% phosphorus, 70-72% dry matter digestibility and also rich in calcium.

Another important *rabi* season forage crop of leguminoceae family is Lucerne (*Medicago sativa* L.) which variety Baralfa IN is a high yielding perennial, forage legume commonly known as Alfalfa. Due to many benefits, it is the reputation as **"Queen of forages"** that grows in different climates all over the world **(Lancefield *et al.* 2009)**. Origin of lucerne is Asia Minor, Transcaucasia, Iran and the highlands of Turkmenistan. More than 33 million hectares of alfalfa are cultivated throughout the world. The major lucerne producing countries are USA, Europe, Asia, Argentina, Canada, Russia, China, Italy, Africa and Oceania. About 70 % of world's lucerne is grown in USA, Argentina and Russia whereas, 17% of worlds lucerne is grown in France, Canada, China, Italy. In India it is grown in U.P., Haryana, Maharashtra, T.N., Rajasthan, Punjab, Gujarat and Himachal Pradesh in about 1.0 million hectare area **(ICAR, 2012)**. Lucerne is a highly nutritious forage legume with 65-75% DMD of whole plant (leaves 75-80% and stems 45-70%) and crude protein15-25%. The forage contains 2.0% ether extract, 29.2% crude fibre, 36.4% nitrogen free extract, 8.3% ash, 2.0% calcium, 0.48% phosphorus.

The Barduro variety of Red clover (*Trifolium pratense* L.) from Netherland is an important forage legume grown in temperate regions throughout the world. It is believed to have originated in southeastern Europe near the Mediterranean Sea. Red clover variety Barduro is widely grown in America extending from the Northeast through the Midwest to eastern North and South Dakota, Kansas and New Zealand. It is a common component in cool season perennial forage grasses pastures. It is most often grown in association with cool season grasses (Tall fescue, timothy and smooth bromegrass) but can be grown alone or with certain warm season perennial grasses.

Quantity and Quality of *rabi* season forages is lacking in our country leading to decline in potential of dairy sector. The yielding potential of local *rabi* season forage crops is declining day by day due to abiotic and biotic stresses. In order to overcome this problem new *rabi* season forage crops/varieties need to be tested and introduced. Keeping this in view, the present study "GROWTH, YIELD AND QUALITY OF *RABI* SEASON FORAGE CROPS UNDER *TARAI* REGION OF UTTARAKHAND" was under taken with following objectives.

1. To study the growth and yield performance of *rabi* season forage crop's varieties.
2. To study the quality parameters of *rabi* season forage crop's varieties.
3. To study the cutting potential of *rabi* season forage crop's varieties.

Review of Literature

The research work pertaining to the "GROWTH, YIELD AND QUALITY OF *RABI* SEASON FORAGE CROPS UNDER *TARAI* REGION OF UTTARAKHAND" has been reviewed and summarized in this chapter.

Oat

Growth and yield

The genus *Avena* comprises of about seventy species, a few are cultivated. *A. sativa* and *A. byzantina* are the main oats grown for fodder and grain. It is important winter forage in many parts of the world and is grown as multipurpose crop for grain, pasture, forage or as a rotation crop. Oats are consumed as human food and fodder for cattle. Oat requires a long and cool season for its growth, therefore, it is successfully grown in the plains and hilly areas of the country.

As one of the important growth characters, the plant height of oat has been observed to be more (114 cm) with 5 leaves at second cutting compared to first cutting (157 cm tall plants with 5 leaves per plant). It indicated that cutting at early stage had deleterious effect on plant height even with heavy fertilizer application **Bokde (1968)**. He also observed one cutting at mid dough stage caused higher yields of green forage (377.10 q/ha) and dry matter (130.84 q/ha**)** than two cuttings which led to 344.50 q/ha green forage and 85.74 q/ha dry matter yield. **Mislevy (1973)** reported first harvest of oat taken at transition stage (vegetative apex changing to flowering apex) and subsequent harvests at a height of 13 to 18 cm of secondary tillers to be optimum schedule of harvest. Primary tillers at each harvest averaged at 30 cm tall. With this management criteria uniform forage distribution resulted four cuts throughout the cool season. Delay in the second harvest at the boot stage resulted death of tillers followed by death of whole plant. **Solanki *et al.* (1973)** found positive correlation of plant height with number of tillers and leaf breadth in oat varieties.

Deo (1974) from Pantnagar observed that cutting the crop at any stage of growth reduce the plant height at the maturity. **Gill and Niranjan (1974)** observed significant difference among the cutting management in respect of dry matter yield.

Single cut at 50% flowering caused significantly more dry matter yield (80 q/ha) than that of two cuts (67.70 q/ha) when first cut was taken at the boot stage and second at 50% flowering. **Smith (1974)** observed high growth rate at 27/21° C and least at high temperature (32/26°C). He also reported more shoot height when day temperature was 27°C and night temperature 15°C. **Verma *et al.* (1974)** found that crop harvested at dough stage gave higher dry matter yield than that at pre boot stage.

Palaniswamy (1975) from Coimbatore reported increases in mean number of leaves with age of the crop and attained its maximum value between flowering and grain development stage and then decreased. **Selman (1975)** observed dry matter yield in a ranged 7.42 to 11.79 t/ha. He also reported delayed cutting after flowering increased the dry matter yield. **Singh *et al.* (1975)** from HAU, Hissar reported that the higher green fodder (27.04 t/ha) and dry matter (5.39 t/ha) yield was obtained in two cuts (first cut taken at 55 days after sowing and second cut at earing stage) compared to one cut at earing stage. The higher yield in two cut treatment was due to better regeneration of oats.

Kumar and Rai (1976) observed increased yield of oat was due to the additive effect of the increase in plant height, number of shoots per plant and dry matter accumulation per unit area. **Rai *et al*. (1976)** from Pantnagar reported the fresh fodder and dry matter yield was higher when cut at 50% flowering stage (103 days after sowing). **Reddy (1976)** observed maximum number of green leaves between 50 to 90 days after sowing and the dry matter accumulation in leaves increased at a faster rate upto 70 days after sowing in eight varieties of oat and recorded maximum at 110 days in all the varieties. Later on dry weight of leaf in all the varieties declined. He also observed number of shoots per meter row length increased from 30 to 40 days after sowing in different varieties. The early maturing varieties had maximum number of shoots during early stage of growth (30 to 40 days after sowing). The other varieties reached at their maximum tillering between 40 to 60 days after sowing. The total dry weight increased with leaf area and plant height.

Sharma *et al*. (1977) from Canada reported that plant height and number of leaves increased almost linearly up to 6 weeks after emergence of wild Oat. They also observed tillering initiated in the second week and reached its maximum during the

fourth week. **Nair and Gupta (1978)** found that the number of tillers, leaf area and number of leaves had marked effect on the fresh weight of stem and leaves and thereby on dry matter yield. **Singh and Katoch (1978)** reported positive correlation between the total dry matter yield and number of days to 50 % flowering, plant height and leaf number which, however, was negatively correlated with leaf:stem ratio.

Rao *et al*. (1978) from Jhansi found positive correlation between dry matter accumulation from tillering to flowering with mean LAI and NAR in both erect and spreading type of oat and it was significantly correlated with specific leaf weight in drooping type oat. **Tseng *et al*. (1979)** observed that fresh fodder yield was 60.87 t/ha from crop harvested at 67 days after emergence. **Joshi (1980)** at Pantnagar observed higher forage yield of oat due to enhanced values of plant height, leaf dry weight, stem dry weight, and whole plant dry weight. In general, leaf:stem ratio was higher at early stage of the crop and declined with the crop age. The dry matter accumulation in leaves, stem and whole plant increased with age of crop except a short fall just after first cut. **Sangha *et al.* (1980)** from PAU, Ludhiana observed that the oat cut at full bloom stage gave the highest yields (340 q/ha green forage and 106 q/ha dry matter) than that of pre-bloom stage, however, maximum dry matter yield (115 q/ha) was noticed at hard dough stage. **Singh *et al.* (1980)** from Pantnagar reported the Plant height at flowering stage was significantly and positively correlated with green forage yield. They also observed a highly significant and positive association between number of tillers per plant and dry matter yield, green forage yield.

Increased yield due to more plant height, more number of tillers has been reported by **Tiwana and Puri (1980)**. They also reported that leaf:stem ratio had negative correlation with yield. **Tomar (1980)** reported that the value for yield attributing characters such as plant height, number of shoots, number of leaves, leaf: stem ratio and length of leaves were positively correlated with yield. **Tseng *et al.* (1979)** observed positive correlation between plant height and yield in oat and crop growth of oat was between 60 to 82 days after emergence. They also reported that fresh fodder was higher (559.5 q/ha) at 82 days stage which, however, decreased (549.2 q/ha) at 105 days stage. Regrowth declined with first cut taken from 40 to 50 days after emergence. **Vilela *et al*. (1980)** from Brazil observed linear correlation between LAI and dry matter yield of oat.

Verma (1984) from Pantnagar found that number of leaves increased with the age of crop upto 115 days after sowing except from 55 to 75 days after sowing when it declined due to first cut taken at 55 days after sowing, number of leaves again decline at final harvest (50% flowering). He also observed one cutting at 50% flowering was significantly superior to two cutting in respect to plant height at all stages of growth. Single cut at 50% flowering caused significantly higher number of leaves than double cut at all the stages.

Ghose (1985) observed decrease in the plant height and number of panicle per plant due to cuttings. This was mainly due to slow growth rate of the cut plants. Cutting at the stubble height of 5 cm at 45 days after sowing gave additional fodder yield of 1.4 t/ha. **Joshi (1985)** from Pantnagar reported that number of leaves increased with age of crop upto 55 days after sowing with the reduction from 55 to 70 days after sowing and the flowering stage. Also the number of shoots increased with age of crop upto 55 days after sowing and decreased thereafter.

Sharma and Dixit (1986) recorded average yields of 3.90 t/ha fresh fodder and 0.87 t/ha dry matter in one cut at 50% flowering. **Gill *et al*. (1988)** from Jhansi reported that green forage yield in one cut was low (26.0 t/ha) compared to two cut system (27.0 t/ha). Dry matter yield was also lower in one cut (7.76 t/ha) than two cut system (7.79 t/ha). **Prasad and Mukherji (1988)** observed increase in herbage yield with delay in harvesting**.**

Rana *et al.* (1990) reported that the two cut management of harvesting gave higher green fodder yield, while dry matter yield remained higher with single cut management. **Ray and Pradhan (1992)** reported that dry matter of oat was 3.39 t/ha when cut at 60 days after sowing. **Singh (1992)** reported that among cutting management, no cut showed superiority for number of shoots. The number of shoots decreased with cutting crop for forage at 60 or 70 days after sowing.

Joshi *et al*. (1993) reported that number of shoots and leaves were higher in case of two cuttings (first at 50 days after sowing and second at 50% flowering) compared to single cut (at 50% flowering). **Jain (1994) and Singh (1994)** from Pantnagar reported that in general, plant height increased with the advancement of crop age. **Singh (1994)** from Pantnagar reported superiority of UPO-212 over other oat genotypes. It might be due to more plant height, more number of tillers/plants, more

number of leaves causing more interception of light which ultimately increased forage yield of crop and increase in dry matter accumulation by leaves was upto 60 days after sowing and decreased with advancement of crop age. He also observed one cut at 40, 50, or 60 days after sowing led to significantly more number of shoots than that of no cut system at all stages because of more regeneration capacity of auxiliary buds, which resulted more number of tillers in cutting practices as compared to no cut system.

Dubey *et al.* (1995) observed that mean dry matter yield from cutting treatment was 3.0, 4.9 and 7.6 t/ha when oat cut at monthly intervals, boot and full flowering stages, respectively. **Joshi *et al.* (1997)** reported significantly taller plants when single cut was taken at 50 % flowering over double cut system. **Bali *et al.* (1998a)** reported that significantly more plant height obtained with single cut at 50 % flowering. **Chakraborty *et al.* (1999)** studied the effect of cutting (no-cut, single cut, two cut) on growth and forage yield and reported that growth and herbage yield increased with increasing cutting frequency.

Chandra (2000) from Pantnagar reported that in general, number of shoots per unit area increased up to first cut, Thereafter, it decreased. The yields of green forage and dry matter were influenced only upto 120 kg N/ha. He also observed superiority of UPO-212 over other varieties in term of green forage yield and dry matter yield. It was attributed to more plant height, LAI and dry matter accumulation in leaves and stem while the higher crude protein yield was due to higher crude protein % and dry matter yield.

Joshi *et al.* (2000) reported taller plants of UPO-212 than other varieties. **Sharma *et al.* (2001)** observed significantly more shoots per meter row length when first cut was taken at 65 days after sowing. He also observed significantly more leaf:stem ratio of forage oat when first cut was taken at 65 days after sowing. **Singh (2004)** observed that in general, leaf:stem ratio decreased with advancement of crop age. He also observed crop harvested once at 50% flowering stage gave maximum green forage and dry matter yield. **Aklilu (2005)** observed leaf:stem ratio increased upto 60 days after sowing and thereafter, decreased with advancement of crop age.

Roy (2005) reported that the capacity of plant to accumulate dry matter is determined by its genetic rate of CO_2 fixation, photosynthetic area, duration of crop,

tillers/plant and environmental factor besides management practices. He also observed that increase in number of leaves might be due to optimum temperature, light intensity and higher number of shoots per unit area during growth period. **Joshi *et al*. (2005)** reported that the values for taller plants, number of leaves per unit area, tillers/plant and LAI were higher in UPO-212 than other varieties.

Quality

They have a high fat, protein and mineral content. It has excellent growth habit, quick recovery after cutting and good quality herbage. It is a palatable, succulent and nutritious crop. The protein quality of oat is excellent.

The progressive lignifications of plant cell wall with maturity perhaps lower the digestibility of cell wall and total dry matter. The encrusting nature of lignin which form a physical barrier against the rumen micro-organisms seem to be possible cause for lowering the nutrient digestibility **(Sharma and Mudgal, 1966)**. **Bokde (1968)** concluded that increasing the nitrogen supply was more effective for increasing the total protein yield than green forage and dry matter yield. He also reported that with the higher nitrogen supply, more readily synthesized carbohydrates were converted to protein and smaller portion of protein left available for cell wall material because carbohydrates and nitrogen provide skeleton for photosynthesis. The higher protein percentage was, thus associated with early harvesting and higher doses of nitrogen application.

Burgess *et al*. (1972) observed that crude protein declined rapidly with increased maturity from flag leaf to hard seed stage. The total protein percent in the dry matter declined from 16.4 (flag leaf stage) to 5.0 per cent (hard seed stage). **Kilcher and Troelsen (1973)** reported higher whole plant protein (30 per cent) during early growth and least (8 per cent) at maturity. **Singh and Gupta (1973)** reported that NDF content increased from 55.4 per cent in first cut to 59.8 per cent in second cut. **Gupta and Pradhan (1974)** reported that crude protein content declined from pre flowering (14.0 per cent) to post flowering stage (5.34 per cent). This occurred because of leaf losses, decreased in leaf:stem ratio. They also reported that dry matter (11.80-32.20 per cent), NDF (43.0-72.52 per cent), cell content (27.48-57.00 per cent), ADF (25.64-39.98 per cent) and hemicellulose (11.11-34.17 per cent) increased from pre flowering to post flowering stage.

Bajpai *et al.* (1976) opined significant decreased in total nitrogen and true protein nitrogen with advancement of the age. **Gupta *et al.* (1976)** reported that oat varieties differed widely in chemical composition but differences were not significant. Crude protein content was significantly and positively correlated with per cent in vitro dry matter digestibility.

Mayland *et al.* (1976) observed that potassium and phosphorus levels in oat are quite high at the early stages but steadily decreased with advancing maturity. The ash content increased with application of nitrogen in dry fodder **(Sandhu *et al.*, 1976)**. **Driven and Deinum (1977)** found that digestibility of tropical grass decreased with the increased in temperature. **Kudryatsev *et al.* (1978)** reported that high crude protein content was because of high tillering and leafiness. **Mojumdar and Ahmed (1980)** reported that crude protein percentage at each cuttings exhibited decreasing trend with the advancing frequency of cuttings. The crude protein content significantly decreased with advancing plant maturity.

Sangha *et al.* (1980) observed that dry matter digestibility and mineral content of oat decreased with advancement of crop age. The crude protein, calcium, and phosphorus decreased. Similar result were also reported by **Cherney (1981); Kanwaljit and Gupta (1987) and Ostgard (1990)**. From NDRI, Karnal **Oberoi (1981)** reported that the value of dry matter, crude protein were significantly correlated with in vitro dry matter digestibility. **Cherney and Marten (1982)** observed decrease in crude protein content, *in vitro* digestible dry matter with increased time to cutting. Increased lignin concentration in stem accounted for reduced digestibility with increased maturity.

Joshi and Singh (1982) observed that the protein content of different oat varieties ranged from 8.1 to 16.1 per cent at second cutting stage with the negative correlation between dry matter and crude protein yields in oat. The digestibility content of different oat varieties ranged from 77.5 to 83.8 per cent at the first cut and 56.0 to 62.6 per cent at second cut with the average value of 80.5 and 62.5 per cent. **Hughes and Hoslemore (1983)** reported that decrease in digestibility with age was associated with the formation of stem tissue which had low digestibility (40%) and made up 70% of total crop weight at flowering.

Single cutting management was found to have no marked effect on crude protein content but more ADF, NDF and hemicelluloses however, two cutting management caused more crude protein content. **Verma (1984)**. **Verma and Singh (1987)** observed decrease in digestibility due to higher cellulose content, lower leaf:stem ratio and more lignifications of crop. They also reported higher dry matter % in single cut than two cutting taken at 55 DAS and 50% flowering stage. **Sadhu *et al*. (1990)** reported that crude protein content was higher at first cut and reduced during second and third cut.

Mohammad *et al*. (1994) observed negative correlation of crude protein content with NDF and ADF content with advancement in crop age. Among the cutting management, one cut at 60 days after sowing showed its significant superiority over rest of cutting practices in respect to dry matter %, this treatment closely followed by one cut at 50 days after sowing **(Singh, 1994)**. **Coronado *et al*. (1995)** from Mexico found that the CP content ranging from 15% in spring to highest value of 31% at the second cutting in late November and the digestibility of oat ranged from 65% in spring to 95% in late autumn. **Trivedi (1995)** observed that the crude protein percentage decreased as the crop age advanced. **Kim *et al.* (1999)** from Korea Republic found that the dry matter digestibility decreased with delay in harvesting.

Chandra (2000) reported that delay in cutting from 50 to 70 days after sowing increased dry matter content. **Singh *et al*. (2001)** studied the chemical composition of different strains of oat and observed that average digestible dry matter yield at first cut (60 days after sowing) was 8.62 q/ha and at second cut (50 per cent heading) was 32.11 q/ha. The average ash, neutral detergent fibre, acid detergent fibre, hemicelluloses and cellulose content at first cut (60 days after sowing) were 9.98, 41.87, 30.69, 11.15 and 25.36 per cent, respectively, whereas the corresponding values in second cut (50 per cent heading) were 7.98, 54.32, 34.94, 19.29 and 27.36 per cent. The ash content was higher in first cut, whereas, neutral detergent fibre, acid detergent fibre, hemicelluloses and cellulose were higher in second cut.

Deorari (2002) reported that digestible dry matter yield was higher under single cut than in the two cut system. **Roy (2005)** observed UPO-212 produced higher total crude protein yield as compared to other varieties. **Joshi *et al.* (2005)** reported that dry matter accumulation, total green forage yield, crude protein, digestible dry matter yield,

crude protein % were higher in UPO-212 than other varieties and the crude protein % and digestibility decreased with advancement of crop age. **(Anonymous, 2012)** reported minimum CP 7.52% in genie oat.

Local rye

Growth and yield

Ryegrasses are widely cultivated around the world. It contains approximately 10,000 species. Perennial ryegrass is best adapted to cool, moist climates. It can grow above 2400-2500 altitude. Maximum growth occurs between 68 and 77°F (20 to 25°C). In cold areas Perennial Ryegrass plays an important role in short term leys with high yields and quality. Perennial Ryegrass is compatible in mixtures with White Clover. It is suitable for cultivation in most types of soils except very wet land.

Ryegrasses is not tolerant of high temperatures **(Mitchell, 1956)**. There exists a close relationship between light interception, leaf area and pasture growth, i.e. when leaf area is sufficient to capture maximum light energy, maximum growth rate is achieved **(Korte and Sheath, 1978)**. Perennial ryegrass is sensitive to drought, which leads to a reduction in herbage production **(Garwood & Sinclair, 1979)**.

A new tiller will remain dependent on older rooted tillers for water and elements such as nitrogen, until it has developed sufficient roots itself. But it is not known at what moment rooted tillers become independent from older tillers for nitrogen **(Marshall, 1990)**. Sward structure is an important quality aspect of grass with respect to intake and digestibility. Sward structure includes herbage mass, sward surface height, bulk density, tiller density and morphological and botanical composition **(Laca *et al*., 1992; Laidlaw and Reed, 1993)**. The cultivar effects on digestibility of herbage intake and herbage utilization **(Munro *et al*., 1992)**.

Fulkerson and Slack (1995) reported that under too frequent defoliation, the plant may not have developed sufficient reserves for re-growth which compromises yield and plant. **Lantinga *et al*. (1996)** suggested that perennial-ryegrass varieties might differ in their cell-wall degradation rates. **Moser and Hoveland (1996)** determined that cool-season grasses grow well between 20 and 25° C and can grow at temperatures as low as 5°C and as high as 35° C. However, they are dormant during the winter months at lower altitudes. Dry matter production gets inhibited due to high

temperatures and dry conditions. They also observed that cool-season grasses are highly digestible during the vegetative stage of maturity. This high level of digestibility is due to the leaf tissues that break down rapidly during digestion. The nitrogen content is higher in young leaves at the upper part of the sward than in the older leaves of the sward **(Delagarde *et al.*, 2000; Smit and Elgersma, 2004)**.

The harvest interval or length of time between defoliation has a substantial effect on herbage growth **(Clark *et al.*, 2001 and Moot *et al.*, 2007)**. A grazing management approach must find a compromise between minimizing the accumulation of senescent material and the defoliation of immature leaves. Perennial ryegrass is used for forage and turf purposes throughout the temperate regions of the world **(Lamp *et al.*, 2001)** which exhibits poor tolerance to environmental extremes such as heat, and drought compared to other cool-season grasses **(McCarty, 2001)**.

Perennial ryegrass can produce stolons and this may account for tendency of ryegrass of dominate in heavily grazed pastures **(Waller and Sale, 2001)**. They also observed main limitation of perennial ryegrass pastures is reduced production and persistence at high soil and ambient temperatures and low soil moisture. **O'Donovan (2001)** found in a two-year grazing trial, where tetraploids had lower values for biomass and bulk density. **Gilliland *et al.* (2002)** found in a one-year cutting trial that tetraploids had higher values for biomass, tiller height and bulk density.

Perennial ryegrass is the most important sown pasture grass spices in temperate region of the world **(Cunliffe *et al.*, 2004)**. Perennial ryegrass is used for dryland pastures or as irrigated crop for grazing, hey and silage. It has excellent seedling vigorous which makes it easy to establish and it has a rapid recovery after grazing **(Lowien *et al.*, 2004)**. **Kemp *et al.* (2004)** reported that the extensive use of perennial ryegrass-based pastures is because it is easy to established can produce large amounts of highly digestible DM and tolerant to grazing. Perennial ryegrass tiller density declined during prolonged periods of hot dry conditions because decline in tiller density coincided with periods of extremely low rainfall and high temperatures **(Lowe *et al.*, 2008; Nie *et al.*, 2004** and **Thom *et al.*, 1998a)**

Report of Australian Govt. (2008) indicated Perennial ryegrass as a long-lived, densely tillared perennial and required temperate climate. **Report of Grassland Society of Southern Australia Inc (2008b)** indicated Perennial ryegrass plants as very

long lasting (30+ years) depending on management and environmental factors. It is tolerant to cold winter and can maintain growth down to 4°C. However, effective life of a pasture is 5-10 years. Defoliation by livestock is common practice, which occurs from late autumn and continues throughout winter until early stem extension in the spring **Chynoweth *et al*. (2010)**. **Minnee (2011)** observed that average tiller densities of ryegrass tall fescue and perennial ryegrass were 796, 683 and 641 tillers/m^2 respectively.

Quality

Ryegrass is an important pasture and forage plant. It has high digestibility and palatability making it ideal for dairy and sheep forage system and it is particularly suitable for animal. Perennial ryegrass forage is excellent, with high levels of protein and highly digestible for all classes of ruminant animals.

Reduction in the proportion of crude protein and increase in cellulose, hemicellulose and lignin was noticed with advancement in crop age **(Jarrige and Minson, 1964)**. Neutral detergent fibre (NDF) contains all the hemicellulose, cellulose, lignin and some ash and was negatively correlated with dry matter digestibility **(Van Soest, 1965)**. High temperatures increased the concentration of fibre in forage and reduced the dry matter digestibility **(Deinum, 1966)**. It was found that the lower dry matter digestibility of forages grown at high temperature was due to a higher rate of transpiration. In many temperate grasses, including ryegrass, digestibility remains high (> 65-70%) during spring and early summer, but falls rapidly and regularly to 50% following ear emergence **(Cooper, 1973**). As the plant matures, the crude protein content decreases due to the reduction in leaf proportion and protein content of the leaf itself **(Lyttleton, 1973)**.

Marten and Hovin (1980) reported that crude protein on dry weight basis for canary grass at second cutting was 15.8%, 12.4%, and 11.5%, at third cutting 20.2%, 15.8%, and 14.8%, and at fourth cutting was 23.8%, 19.1%, and 20.3% respectively for the first, second, and third years of establishment. Crude protein on dry weight basis for orchard grass at second cutting was 15%, 12%, 11.2%, at third cutting was 17.7%, 13.6%, and 13.2%, and at fourth cutting was 19.6%, 15.1%, and 14.9% respectively for the first, second, and third years of establishment. Crude protein on dry weight basis for

tall fescue at second cutting was 14.6%, 12.8%, and 11.2%, at third cutting was 16.8%, 12.8%, and 11.8%, and at fourth cutting was 18%, 14.1%, and 14.3% respectively for the first, second, and third years of establishment. The grasses did not differ greatly in the rate of cell wall concentration which ranged from 47% to 58% for every year and all cuttings.

The nutritive value of perennial ryegrass varies throughout the growing season **(Walsh** and **Birrell, 1987; Johnston, Singh and Clark, 1993)**. By increasing the period of regrowth of *L. multiflorum* from 2 to 10 weeks, the concentration of crude protein decreased from 188 to 699 kg^{-1} organic matter **(Minson, 1990b)**. At immature stage of growth, the dry matter digestibility of all plant parts was similar and higher, but at maturity, large differences in dry matter digestibility between the plant parts was noticed **(Minson, 1990c)**. **De Villiers *et al.* (1993)** reported that in rye grass, content of P and K ranged from 0.27–0.32 and 2.4 % respectively. Grazed Perennial ryegrass is one of the most important forage for dairy cows in temperate region because it has high forage yield and nutritive value **(Van Wijk *et al.*, 1993)**.

Warman and Sampson (1994) reported that rye grass content of P and K was 0.14 and 1.64 % respectively. Perennial ryegrass can withstand close continuous grazing and is ideally suited to intensive sheep and cattle grazing **(Jung *et al.*, 1996)**. **Report of National Research Council (1996), Morrison (1961), Thompson *et al.* (1990)** indicated that crude protein and phosphorus in ryegrass ranged from 8.6-19.0% and 0.32-0.40%. Perennial ryegrass is used for dairy and sheep grazing in temperate areas of Australia **(Blair, 1997; Lazenby, 1997** and **Callow *et al.*, 2003)**.

The neutral detergent fibre in tall fescue was 42% and in ryegrass was 42% **(Milne *et al.*, 1997)**.They also observed that well managed tall fescue and ryegrass pastures kept in a vegetative state, showed similar levels of fibre and digestibility. **Rollo *et al.* (1998)** found that the dry matter yield of irrigated ryegrass was 14.0 t /ha/yr. Perennial ryegrass can support good milk production as well as overcoming the drawbacks of using annually sown pasture **(Lowe *et al.*, 1999b)**. **Smith *et al.* (2005)** reported that ash content, neutral detergent fibre and acid detergent fibre in ryegrass was 7.8, 37.0-52.9 and 11-33 per cent respectively. **Charlton and Stewart (2006)** and **Kemp *et al.* (2000b)** found that the pastures are palatable to stock and the forage is highly digestible providing high levels of energy, protein and minerals. **Moore *et al.***

(2006) reported that dry matter digestibility and crude protein in ryegrass ranged from 56-85% and 8.0-27.7%.

Report of UADA (2006b) indicated that pasture is most palatable, most easily digested and most nutritive in the earlier season when leaves are young. Digestibility of ryegrass was 80 to 88% during different (vegetative, early bloom and heading) stages but dropped to 71% when the grass was mature and crude protein levels dropped from 13.2 to 9.1 % between heading and mature stage of growth. **Balocchi (2009)** reported that different cultivars of rye grass have 3 tillers per plant, 3 leaves per tiller and 20.9-22.9 cm plant height.

Clark *et al.* (2010) found that irrigated ryegrass dry matter yield was 16.8 t /ha/yr. **Crush *et al.* (2011)** reported that average N, P and K in rye grass was 2.91, 0.28 and 3.49 % respectively. The N and P were higher in winter and lowest in late spring/summer. **Minnee (2011)** observed that crude protein and neutral detergent fibre ranged from 14.3 -26.1%.and 37.9- 51.7% respectively. **Anonymous (2012)** indicated that average forage quality parameter of annual rye grass such as neutral detergent fibre (52.6%), crude protein (19.1%) and in-vitro dry matter digestibility (74.1%), respectively. Also indicated that average (3 cutting) forage quality values of makkhan rye grass were green forage yield (530 q/ha), dry matter yield (71.33 q/ha), crude protein 14%, in-vitro dry matter digestibility 59.4%, neutral detergent fibre 45% and acid detergent fibre 25%, respectively. **Report of IGFRI (2012)** indicated that green forage yield, dry matter yield and crude protein yield (q/ha) in Para grass were 692.1, 149.1 and 9.4 respectively.

Lucerne

Growth and yield

Lucerne or alfalfa is one of the oldest cultivated fodder crops. Roman writers described its value as feeds for horses and other animals as early as 490 BC. Alfalfa (*Medicago sativa* L.) is derived primarily from *M. coerulea*. The genus contains large number of species. In India other than *M. sativa,* the entire groups of Medics are treated as wild types. The existing *M. sativa* is largely a tetraploid species (2n=4x=32). Lucerne is commonly called as *rijka* in northern India. It is a perennial plant and can supply green fodder continuously for 3–4 years from the same crop stand. The root

system is deep and so can be easily grown in the areas where water is in short supply. Lucerne provides green fodder for a longer period (November-June) in northern parts and throughout the year in other parts of the country where winters are not severe.

The yielding ability of lucerne decline with age under irrigation and "optimum" management conditions **(Hayman and McBride, 1984)**. Lucerne produced over 20 t/ha of DM, 43% more DM annually than pasture under rainfed conditions on rich moisture retentive soils in the North and South Islands of New Zealand (**Douglas, 1986)**. Cutting lucerne at 10% bloom stage and then at 5-7 week intervals maximized dry matter (DM) production, provided forage of reasonable nutritive value and helped to maintain sward longevity in Minnesota **(Sheaffer *et al*., 1988)**.

Brink and Marten (1989) observed that the per year yield from three cuts was more than four cuts, although the forage was of lower nutritive value. **Sheaffer *et al*. (1991)** reported that in late summer and early fall, lucerne plants develope cold resistance and store energy reserves in their roots. This long-lived perennial is more drought-tolerant than most other temperate forage legumes including birdsfoot trefoil and red clover **(Peterson *et al*., 1992)**.

It is well documented that frequent harvesting of lucerne adversely affects shoot growth and stand persistence because of depletion of carbon and nitrogen reserves in roots required for regrowth **(Avice *et al.*, 1996** and **Dhont *et al.*, 2002)**. Lucerne becomes dormant in cold winters, and when summer approaches it re-grows by using the nutrients reserved in the roots **(Zanin, 1998)**. He also observed that 8-10 harvests are annually realized through irrigation. When lucerne is harvested by cutting, the plant regrows using the root nutrient reserves. Legumes are generally grown in combination with grasses to reduce the persistent high-viscosity foam (bloating hazard) that occurs with low fibre, high protein legume species **(Popp *et al*., 2000).**

In general, lucerne plants require at least 20-25 mm rainfall to produce substantial growth. A dry land lucerne pasture typically produces dry matter between 4-8 t/ha/year (15-20 t/ha under irrigation), Lucerne grows well in both tropical and temperate climates and it survives in frosty winters. The ideal temperatures for the growth of lucerne is 25^0 C and high production can occur between 10-30° C and yield significantly drop down when the temperature is below 10° C. Lucerne yield for commercial purposes in Australia range from 10 to 22 t/ha from six cuts between early

October and late April while under good management, yield of 25-27 t/ha, dry matter in the form of hay have been achieved **(McDonald *et al*., 2003)**.

The pattern of rate of dry matter accumulation of a crop canopy is typically characterized by a sigmoid curve. More or less three distinct phases can be distinguished (i) a period of exponential growth during early development followed by (ii) a period of more or less constant rate dry matter accumulation, and (iii) a period of declining crop growth rates during the final phase of development when green leaf area declines due to leaf senescence and leaf photosynthesis declines due to leaf aging **(Echarte, 2008)**.

Mills *et al*. (2008) reported consistently higher dry matter yield of lucerne (13.1-18.5 t/ha/yr) which out-yielded the other grass based pastures by > 6.6 t dry matter/ha/yr. It is a high yielding perennial nutritious forage legume. Lucerne, due to it many benefits, has earned the reputation as "**Queen of Forages**" **(Lancefield *et al.*, 2009)**.

Annicchiarico *et al*. (2010) reported that lucerne is a forage crop of huge importance because of its contribution to sustainable agriculture and its higher productivity of feed proteins per unit area compared to other forages or grain legumes. This is drought tolerant because lucerne has a deep root system with a straight taproot that can cover a depth of more than 15 m **(Jasjeet *et al.*, 2011; Kokate, 1990)**. Lucerne has a harvesting cycle of 40 days depending on weather and produces about 10-12 t/ha dry matter annually **(Limagrain, 2011)**.

Quality

Lucerne is a forage crop of huge importance because of its contribution to sustainable agriculture and its higher productivity of feed proteins per unit area compared to other forages or grain legumes. It is a drought resistant perennial forage legume that can yield high quality forage in times of little rainfall. Lucerne has high palatability for all kinds of livestock as it provides nutritious fodder and possesses about 16-25% crude protein and 20–30% fiber. Due to its high protein and vitamin A content, it is included as a feed component for poultry and piggery.

Reported of National Research Council (1971) indicated the average value of dry matter, crude protein and ash content to be (%) 90.1, 19.7 and 8.7 respectively. The

lower content of structural fibre and the higher protein content of legumes when compared to grasses results in an improved voluntary intake and digestion process as well as a more efficient absorption of nutrients **(Ulyatt *et al.,* 1977** and **Beever and Thorp, 1996)**. Lucerne accumulates only trace amounts of condensed tannins in forage **(Goplen *et al.,* 1980 and Ray *et al.,* 2003)**. **Report of National Research Council (1982)** indicated that dry matter, crude protein, neutral detergent fibre, acid detergent fibre and ash content was 23.0, 19.0, 40.0, 31.0 and 9.5 per cent respectively. Compared with grass, lucerne has higher intake characteristics and a higher animal production response per unit of dry matter ingested.

The potential reasons are high concentration of soluble protein (which assists in microbial synthesis in the rumen), the stimulation of cellulose digestion, a low concentration of cell wall in the dry matter, and an adequate supply of minerals and vitamins **(Conrad and Klopfenstein, 1988)**. **Ensminger *et al*. (1990)** reported that lucerne contains dry matter, crude protein, neutral detergent fibre, acid detergent fibre and ash content was 91.0, 17.9, 36.8, 29.0 and 8.4 per cent respectively. **Sheaffer (1990)** observed crude protein, neutral detergent fibre and acid detergent fibre ranged from 13-23, 38-56 and 28-42 per cent respectively.

Amrane and Michaeletdoreau (1993) observed that ruminal protein degradability declines with plant maturity. Cell-wall concentration is estimated by neutral detergent fiber (NDF), hemicellulose as NDF minus acid detergent fiber (ADF), and cellulose as ADF minus lignin-plus-ash. Acid detergent fiber contains cellulose and lignin while NDF also comprised of cellulose, lignin and hemicellulose. Stems contain a greater proportion of cell wall compared to leaves of the plant and are usually lower in digestibility. Stem digestibility declines more quickly than that of the leaves with increased plant maturity **(Collins and Moore, 1995)**. **Yahana (1996)** reported that dry matter, crude fibre and nitrogen free extract increased with the increase in frequency cuttings of lucerne whereas crude protein, ether extract and ash content showed reverse trend. He also observed that crude protein content of luceren decreased with advancement in crop age from January to March.

The high proportion of lignin is directly responsible for the low digestibility of dry matter in grass forages but legumes have higher rates of digestible neutral detergent fibre than grasses **(Buxton and Redfearn, 1997)**. Legume and grass forages with high

quality standards are good sources of proteins, energy, fibre and minerals to dairy cows and heifers **(Maiga *et al.*, 1997)**.

Arinze *et al.* (2003) reported that lucerne leaves have a higher nutrient content than stems on dry weight basis and on an average lucerne forage contains 18-22 % crude protein while lucerne leaves and stems separately containing 26-30 % and 10-12 % crude protein respectively. Leguminous forages have high nutrient contents with higher feeding values, dry matter intake and animal production than grasses, as well as fixing nitrogen in the soil **(Laidlaw and Teuber, 2001)**. Lucerne is a high nutritious forage legume with high animal feeding values and about 480 g/kg dry matter of the weight of the plant consists of leaves **(McDonald *et al*., 2003; Kokate, 1990)**.

The nutritive value of lucerne, in terms of digestibility and protein content decreases by 0.3-0.5% per day with advancing maturity from early flowering to near maturity stage **(McDonald *et al*., 2003)**. They also reported that dry matter digestibility and crude protein ranged from 61.20 to 72.90 and 15.0 to 23.0 per cent respectively. Lucerne cut at the early flowering stage is of high quality however, frequent harvesting at this stage compromises lucerne longevity. **Monsanto (2003)** reported that dry matter, crude protein, neutral detergent fibre, acid detergent fibre, and ash content ranged from 17.9 – 29.2, 15.3 – 25.8, 26.5 – 35.7, 23.1 -33.4 and 8.8 – 15.3 per cent respectively. Report of **Environment Directorate, Organization for Economic Co-operation and Development Paris (2005)** indicated that dry matter, crude protein, neutral detergent fibre, acid detergent fibre, ash content, K and P ranged from 17.9- 91.0, 15.3- 25.8, 26.5 – 40.0, 23.1 – 33.4, 8.4 – 15.3, 1.39-4.31 and 0.22-0.45 per cent respectively.

Brown *et al.* (2006) reported that dry matter yield ranged from 28 to 30 t /ha/yr under irrigation to summer drought condition. **Kaushal *et al.* (2006)** reported that crude protein, neutral detergent fibre, acid detergent fibre, hemi-cellulose, and ash content in lucerne was 8.6, 81, 62, 16.0 and 4.5 per cent respectively. **Katic *et al.* (2006)** stated that crude protein content in lucerne ranges between 18-25 %. Levels of starch, cell wall content, and other nutrients are similar for cool-season grasses but do vary somewhat depending on the species **(Report of National Research Council, 2007)**. The concentration of minerals in the form of macro and micro minerals and ash was observed higher in legumes than grass forages by **Paulson *et al.* (2008)**.

The animal feeding value of lucerne is mainly defined by the stage of growth at the time of its harvest. The nutrient content of plants'decreases with advancing maturity, resulting in the decreased leaf:stem ratio **(Tyrolova and Vyborna, 2008)**. They also reported lucerne forages when cut at fully flowered stage bears more stem proportion than forages cut at early stages of growth. Legume forages are capable of providing up to three quarters of the protein requirements for lactating dairy cows **(Bocher, 2010)**. The freshly cut lucerne from the field has a too low dry matter content, too high protein and calcium content, and too low sugar content to achieve a high degree of silage fermentation **(Dinic *et al.*, 2010b).** Lucerne crude protein content decreases with advances in maturity compared to crude fibre content which increases **(Stanacev *et al.*, 2010)**.

Red clover

Growth and yield

Red clover is a fast starting, highly productive, but short lived perennial clover. It is widely adapted throughout the humid, temperate regions of the world. It grows best where summer temperatures are moderately cool to warm and moisture is sufficient. Optimum temperature for growth is 68 to 77 F (20-25° C), with a growth range of 45 to 90 F (7-32 C). It is a tap-rooted plant, it does not possess the same deep tap root as lucerne.

Annual production of clover has been found to yield higher in the second year than in the establishment year **(Harris *et al.*, 1980)**. Also the total production of swards containing a mixture of perennial ryegrass and red clover had 40% higher annual pasture production with infrequent grazing intervals than with frequent grazing intervals. Annual red clover production was 25% higher under infrequent grazing than frequent grazing but was only significant over summer harvest. Each stem of red clover carries four to six green leaves during vegetative development **(Arnott and Ryle, 1982)** but this may be higher on flowering stems. **Hay and Ryan (1983)** have compiled three years yield for pure stands of Pawera red clover indicating dry matter production @ 10,200 kg dry matter/ha in Southland.

Campbell & Kunelius (1984) observed that grazing to 20 mm at three weekly intervals has resulted in greater survival and high numbers of red clover plants, and

greater plant size than less intensive or frequent grazing. Nitrogen fixation can contribute up to 80% of total nitrogen assimilation in red clover **(Heichel *et al*., 1985)**. **Buxton *et al*. (1985)** reported that digestibility of red clover and lucerne decreased as plant mature. **Lambert *et al*. (1986b)** observed that red clover persisted better under rotational cattle grazing than under sheep grazing. Branching is highly influenced by temperature, defoliation, mineral nutrition and inter-plant competition and growing point density which may vary greatly over time **(Laidlaw and Stewart, 1987)**. In mixed grass-clover sowings, red clover characteristically declines in the contribution to pasture yield after the first two years. Which is common because grazing preferentially removes reproductive growth and limits population maintenance by reseeding **(Harris & Kunelius, 1988)**. They also observed that dry matter yield is higher where red clover was spring drilled both as a monoculture and when sown with ryegrass.

Red clover has vigorous summer growth, which complements the seasonal growth pattern of the ryegrass, so this species is often used in dairying to promote summer milk production **(Ledgard *et al*., 1988)**. Also the red clover confers additional advantages in terms of N fixation during summer. Annual dry matter yields ranged from 6-22 t /ha in New Zealand as a monoculture **(Barry *et al*., 1998; Hay** and **Ryan, 1989; Litherland, 2001; Soetrisno *et al*., 1994 and Ussher, 1986)**.

Brock *et al*. (1989) report that optimum temperature for growth of white clover was more (24°C) and for ryegrass was comparatively less (18-21°C). **Hay** and **Ryan (1989)** reported that plant height of different cultivar ranged from 77-90 cm. With increasing maturity, the proportion of cell wall components (cellulose, hemicellulose, and lignin) of the forage increases whereas the proportion of cell contents decreases **(Bosch *et al*., 1992)**. The optimum temperature for red clover growth as noticed by **Taylor *et al.* (1996)** is 25-27°C. Pure stands usually persist only for three to four years **(Hyslop *et al*., 1998)**. The report of **Satell *et al.* (1998)** indicated that red clover sown in pure stand yielded 4 to 18 t DM/ha in Europe while in US this yielded 15-19t/ha. **Report of FAO (2013)** indicated that red clover yield is varied thus in the range of lucerne yield (20 t DM/ha) but it does not yield as early as lucerne. Temperature has very important effect on clover growth, particularly in the processes influencing the number and development of leaves and stolons **(Clark *et al*., 1996)**. These authors claim white clover has a lower rate of growth than ryegrass at temperatures below

10°C, but its growth rate continues to increase up to 24°C whereas ryegrass peaks at 15-20°C.

Interception of solar radiation by the leaf canopy of a sward is the main driver of photosynthesis needed for sward growth **(Hay and Porter, 2006)**. The rate of leaf appearance on stems of clover and grass plants depends mainly on temperature. The linear relationship between rate of leaf appearance from a stem and temperature between the base and optimum cardinal temperatures for plant development means that the process can be quantified by a single phyllochron in thermal time **(Hay and Porter, 2006)**. The work of **Hall (2007)** revealed that red clover can be primarily grown for hay or silage and should thus be cut at early-flowering stage for higher yield and feed value. **Adam *et al*. (2009)** reported that role of light and moisture; various management practices could be considered to enhance final red clover dry weight. Canopy of healthy green leaves is important to maximize the yield and persistence of a sward. The development of canopy depends on the leaf area expansion, senescence and canopy architecture (**Black *et al.*, 2009)**.

Quality

The nutritive value of forages varies according to many factors, including age of the plant, soil and fertilization, differences among species and varieties, season of the year, and cutting interval. Age of the plant is an important factor in affecting the chemical composition as well as the overall nutritive value of forages.

The digestibility of forage is highest in the vegetative stages due to variation in cell wall content and the stem:leaf ratio with increasing maturity **(Terry and Tilley, 1964)**. Mixture of red clover and ryegrass is highly palatable to dairy cows **(Charles, 1976)**. Red clover does not accumulate condensed tannins in forage **(Sarkar *et al*., 1976**). Red clover can provide high quality summer feed in temperate grazing systems **(Hay *et al*., 1978; Hay** and **Ryan, 1989; Ussher, 1986** and **Hyslop *et al*., 1998**). Digestibility of fresh red clover herbage has shown to be in the range of 78 to 83% **(John** and **Lancashire, 1981; John *et al*., 1988; Kelly, 1989; Semiadi *et al*., 1993** and **Waghorn *et al*., 1990)**.

Kenny and **Reed (1984)** and **Mosely** and **Jones (1979)** reported that red clover had a higher crude protein level, lower neutral detergent fibre level and higher rate of

flow of nutrients through reticule-rumen than perennial ryegrass, all of which contributed to its superior digestibility and overall superior nutritive value. Its high nutritive value allied to its high intake characteristics combine to give improved individual animal performance from different classes of animals compared with grass forage **(Thomas *et al.,* l985)**. Nutritive value of forages for ruminants depends highly on the ratio between cell content and cell wall and on the ability of the rumen microorganisms to degrade the plant cell walls **(Waldo, 1986)**.

The nutritive value of forages varies according to many factors, including age of the plant, soil and fertilization, differences among species and varieties, season of the year, and cutting interval. Age of the plant is an important factor in affecting the chemical composition as well as the overall nutritive value of forages. The decrease of some minerals with advancing age is due to the dilution effect of these elements in the dry matter, and also due to other factors such as a diminishing capacity of the plant to absorb nutrients from the soil and variation in the stem:leaf ratio **(Gabra *et al*., 1990** and **Underwood, 1977)**.

Clovers and lucerne collectively meet the legume pasture, hay and silage production requirements of temperate, humid and subhumid regions **(Rumbaugh, 1990)**. **Sheaffer *et al*. (1991)** reported that forage crops decline in nutritive value as they mature and continuous early harvests can reduce stand longevity. The rate of decline in digestibility increases with maturity **(Wilson *et al.,* 1991; Bargo *et al.,* 2003** and **Gallardo *et al.,* 2005)**. Increasing maturity of forage crops leads to increase in the proportion of cell wall components (cellulose, hemicellulose, and lignin) of the forage whereas the proportion of cell contents decreases **(Bosch *et al.,* 1992)**. Concentrations of NDF, ADF, and ADL increases across maturities. The digestibility of red clover's primary growth declines with advancing maturity in a linear fashion and is related to the declining leaf:stem ratio **(Hoffman *et al.,* 1993; Coblentz *et al.,* 1998; Belyea *et al.,* 1999; Elizalde *et al.,* 1999** and **Koukolova *et al.,* 2010)**. **Griffin *et al*. (1994)** observed reduction of leaf/stem ratio in summer. They also observed decrease of protein content from early to late crop age. Minerals content is high in red clover when grown on deep soils because of the deep-rooting characteristic. Mineral contents, particularly P, K, Ca, Mg, Cu and Zn, are increased by spring **(Narasimhalu and Kunelius, l994)**.

Taylor *et al*. (1996) observed stress caused by unfavorable environment as well as by seasonal changes may cause a significant decline in forage quality of red clover. The decline in digestibility is associated with increasing lignin content and a reduction in degradability of polysaccharides other than starch **(Taylor and Quesenberry, 1996).** Compared with grasses, red clover is usually higher in concentrations of pectin, lignin, nitrogen, calcium, magnesium, iron and cobalt **(Frame *et al*., 1998)**.

Superior levels of animal performance can be achieved from red clover, and other legumes and herbs compared with pure grass swards and mixed ryegrass/white clover swards. However, unlike white clover which does not change much in nutritive value with maturity, red clover does deteriorate in digestibility and other aspects of nutritive value (crude protein, sugar, fibre levels etc), mainly due to the development of thick, fibrous stems, in the similar manner to lucerne. Digestibility declines as the red clover matures **(Wiersma *et al*., 1998)**. They also observed low content of crude protein and high content of fibre in fodder when cut in spring.

Red clover also has higher concentrations of readily fermentable carbohydrate (soluble sugars and pectin) and lower concentrations of structural carbohydrate (cellulose and hemicellulose) than perennial ryegrass **(Barry *et al*., 1999** and **Cosgrove** and **Hodgson, 2003)**.When red clover and alfalfa are of similar fibre content, red clover may be more digestible than alfalfa, providing a more energy forage to the diets of lactating dairy cows **(Hoffman** and **Broderick, 2001**).

Red clover is also of a very good quality as to its nutritive value and ensiling **(Hoffman and Broderick, 2001)**. **Hakl *et al*. (2003)** reported inverse relationship of advancing forage maturity and declining of forage quality. Forage quality is affected by a combination of numerous factors such as stage of maturity, forage species, environmental conditions (locality of growth, temperatures, and precipitations), and agronomic treatments including storage conditions **(Dubbs, *et al*., 2003)**. **Tamm *et al*. (2003)** observed that the nutritive value of forage red clover influenced by growing year and environmental conditions.

Dragomir (2005) observed that mineral elements content decreased with maturity, the process in redclover showing similar traits with the one reported for alfalfa. **Hoffman *et al*. (2005)** observed that ash content of legume-grass forages were

initially increased later on decreased. The normal ash content of legume-grass forages is near 9.0 to 18% (DM basis).

Report of Environment Directorate, Organization for Economic Co-operation and Development Paris (2005) indicated that DM, CP, NDF, ADF, Ash content, P and K ranged from 87-89, 16.0 – 21.4, 34.9 – 48.0, 24.4, 1.62 – 3.24, 0.24 - 0.37 and 1.62-3.24 per cent respectively. **Dragomir (2006)** observed average mineral elements content of red clover showed 1.41- 1.93% calcium, 1.2-2.2% potassium and 0.29-1.41% phosphorous according to the phenological stages.

Drobna *et al.* (2006) reported that crude protein and ash content ranged from 16.9-20.7 per cent and 10.51-24.35 per cent of different varieties with 3 cuts. They also observed that environment significantly influences the nutritive value of forages. Red clover silage is highly palatable, more than grass silage, even if red clover had a lower digestibility than grass **(Steinshamn, 2010; Thomas *et al.*, 1985 and Steen *et al.*, 1982)**. **Homolka *et al.* (2012)** reported that DM, crude protein, neutral detergent fibre and acid detergent fibre in red clover ranged from 13.03-24.1, 17.74-21.88, 37.51-44.50 and 25.80-35.20 per cent respectively at different three growth stages.

Berseem

Growth and yield

Berseem or Egyptian clover is one of the most important winter forage legumes. It can be grown on all types of soils except very light sandy soils. Well-drained clay loam soils rich in calcium and phosphorous are ideally suited for its cultivation. The crop can be grown successfully on alkaline soils having good water retention capacity. The genus *Trifolium* commonaly called clovers comprised 237 annual and perennial species. The important perennial pasture clovers, *T. repens* (white clover), *T. hybridum* (alsike clover), *T. pratense* (red clover) and *T. ambiguum* (caucasian clover) are widely distributed in the temperate and sub-temperate regions of the world while the annual types such as *T. resupinatum* (Persian clover), *T. subterraneum* (sub-terranean clover) and *T. alexandrinum* (Egyptian clover or berseem) are commonly cultivated as winter annuals in the tropical and subtropical regions.

Jatasra (1981) reported that green fodder yield was positively associated with all the traits except leaf:stam ratio, stem girth and tillering. Dry matter showed positive

relation with green fodder yield, stem weight, leaf weight and plant height. Leaf and stem weight was positively associated with the forage yield and yield components. Five to six cuttings can be done under irrigation and one or two at the end of the cool season in dryland **(Gohl, 1982)**.

Taneja *et al.* (1987) reported that green fodder yield ranged from 568 to 704 q/ha during 1977-78 and 1978-79, when sown in October. They also observed dry fodder yield ranged from 50 to 79 (q/ha) during 1977-78 and 1978-79 when sown in October. **Nandanwar *et al.* (1992)** observed that dry fodder yield increased from 1.16 to 3.97 t/ha with the increase in number of cuts/year. **Mendhe *et al.* (1995)** reported that green forage yield ranged from 66.21 to 461.40 (q/ha) when cut at 60, 90, and 120 days after sowing. Berseem is an annual, cool season forage crop. Due to the extra ordinary regenerative power, berseem gives several cuttings during its growing season and supplies nutritious, palatable and succulent forage for animals **(Graves *et al.*, 1996)**. In Morocco, irrigated berseem yielded 8-10 t DM/ha **(Bounejmate, 1997)**.

Wiersma *et al.* (1998) reported that during growing season, under the effect of longer days and higher temperatures, the aging plants undergo morphological changes, leaf growth becomes slower, the stem increases in length and the proportion of dry matter increases. On the other hand, forage quality decreases drastically, especially digestibility and the contents of proteins and minerals.

Mandal *et al.* (1998) reported that average height of plant ranged from 29.8 to 50.1cm and average branches/plant ranged from 12.5 to 17.5. Berseem should be cut 50 to 60 days after sowing and then 30-40 days interval **(Suttie, 1999)**. Cutting is very important practice for increasing the forage as well as seed yield of berseem **(Mukharjee and Mandal, 2000)**. **Tiwana *et al.*, (2003)** reported that green forage yield, dry matter yield (q/ha)and CP % ranged from 376 to 803, 95.8 to 119.7 and 18.1 to 22.3 respectively during 1996-1997, 1997-1998 and 1998-1999. Highly branching and productive types such as Miscawi and Kahdrawi can yield higher upto 6 cuttings/season **(Hannaway *et al.*, 2004** and **Suttie, 1999)**.

Joshi *et al.* (2006) reported that number of leaves/meter ranged from 200-708 in berseem. **Hasina *et al.* (2013)** reported that plant height is a function of genetic makeup as well as the environmental conditions **ICAR (2012)**. Berseem prefers dry and cool climate for its proper growth. Best productive crop can be obtained between 15-25° C

temperatures. Its regenerative growth is retarded during severe cold or frosty period or at temperature above 40°C. **Alfred (2012)** reported that number of leaves increased with increase in temperature till March later on slightly decreasing trend was observed.

Quality

Berseem appeared to behave as a most potent milk multiplier in the lactating buffaloes, cows and cross breed cattle's as compared to other forage crops alone on in combination. The crop is grown under irrigated condition and provide highly palatable, tender and nutritious green fodder. The phenomenal success of berseem in India is also due to its high nitrogen fixing ability resulting in substantial improvement in soil fertility.

Alam and Sharif (1977) observed that in DM of berseem, P and K ranged from 0.26 to 0.38% and 3.11 to 3.59%, respectively. **Buttery (1977)** reported that leguminous fodders at vegetative stage contain more protein. **Deramus (1980) and Halmos (1982)** observed decreasing trend of crude protein with advancing age in case of different type of clovers. **Katta and katoch (1981)** reported that CP, CF, Ash, and Phosphorus in dry matter of berseem was 27.06, 12.79, 14.16 and 0.48 per cent respectively.

Harris *et al.* (1982) reported the chemical composition of berseem. At late vegetative, mid bloom and late bloom stages the values for DM were 12, 16 and 48%, NDF 42, 50 and 53 %, ADF 35, 39 and 42%. Fresh berseem has a good nutritional value very comparable to that of fresh alfalfa **(Brink *et al.*, 1988; Fraser *et al.*, 2004; Yoelao *et al.*, 1970)**. **Khalin and Durrani (1989**) reported comparatively higher CF and relatively lower DM, CP, and Ash content in berseem. Berseem crop provides a constant supply of nutrients to livestock from November to April against almost negligible nitrogen fertilizer requirement; rather it is fixing 3-4 q N/ha/yr in soil **(Williams *et al.*, 1990)**.

Ranjhan (1991) reported the chemical composition of berseem fodder as NDF, 42.2 to 53.3%, ADF, 35.1 to 41.7%, hemicelluloses 7.3 to 11.5%, cell content 46.6 to 57.55%, Phosphorus 0.14 to 0.40% and Potassium 1.11 to 4.22%. Forages are high in dietary fiber which is composed mostly of structural carbohydrates (SC) and lignin found in the plant cell wall, which increased with age of crop **(Longland *et al.*, 1995;**

MAFF, 1992). **Khan (1994)** reported that berseeem composition at weekly interval from January to April was on an average 21.09, 4.16, 20.68, 39.91 and 14.08% CP, EE, CF, NFE and Ash respectively on dry basis. He observed that NFE decreased by 10.71% from January to April, CP also decreased this period and extent was 14.63%, while CF increased by 18.21%. The ash contents of berseem increased was 11.79% from January to April. However EE showed very little change due to season.

Yahana (1996) reported crude protein content varied on dry matter basis from 16.33 to 20.70%. Crude fiber and total ash contents from 16.66 to 24.16 and 11.05 to 15.14% respectively and NDF, ADF, Hemi cellulose from 43.64 to 57.49, 37.28 to 47.11 and 10.94 to 13.64 per cent, respectively on dry matter basis**.** He also observed that P and K ranged from 0.19 to 0.39 and 2.27 to 3.39 per cent respectively. He also observed that ash content of berseem increased from January to April.

Berseem is very palatable and fairly digestible forage **(Das *et al.*, 1999)**. As forage matures, the cell contents of legumes tend to decline more quickly than in grasses **(Beever *et al.*, 2000)**. It is particularly valuable since it is a non-bloating forage legume **(Hannaway *et al.*, 2004). Kandi *et al*. (2005)** observed that crude fiber and ash content increased upto 3rd cutting and later on decreased till 5th cutting. **Vasiljevic *et al*. (2005)** found that there was no difference in the content of minerals at budding and early bloom stages, while the average ash content in the two stages was 8.9%. A somewhat lower value of this characteristic was found at the stage of full bloom (7.8%).

Kaushal *et al.* (2006) reported that CP, NDF, ADF, Hemi-cellulose, and Ash content in berseem was 8.5%, 68%, 51.5%, 16.5%, and 8.5% respectively. When grazed before the oldest foliage began to senesce, the metabolizable protein content of berseem can be particularly high compared to other fresh forages **(Fulkerson *et al.*, 2007)**.When there is an excess of photosynthetic activity during rapid growth and metabolism of the plant, carbohydrates are converted to fructose and distributed from the leaf to the stem **(NRC, 2007)**. **Vasiljevic *et al*. (2008)** observed that contents of both fractions of cellulose fiber (NDF and ADF) increased in summer due to high temperatures and accelerated aging (development) of plants. Report of **IGFRI (2011)** indicated that average dry matter digestibility in berseem was 65%. **Vasiljevic *et al*.**

(2011) reported highest content of minerals at the beginning of the growing seasons (first and second cutting) in 2004 and 2005.

Alfred (2012) observed dry matter content increased with increasing cutting frequency from 1st to 6th cuttings and it ranged from 12.9-19.4%. It was observed that crude protein yield increased from 1st to 4th cutting later on decreased due to lower production of green forage yield, dry matter yield and crude protein % and it ranged from 10.5-17.15 q/ha while dry matter accumulation through leaf and stem increased from 1st to 5th cutting but at later stages decreased.

ICAR (2012) indicated that average dry matter digestibility in berseem was 70%. **Reddy (2012)** reported that the pattern of rate of dry matter accumulation of a crop is typically characterized by a sigmoid curve. Three phases can be distinguished (i) Establishment and seedling growth, followed by (ii) period of repid growth, and (iii) Ripening and senescence. **Mezni *et al*. (2013)** reported that P and K contents decreased significantly with the increased friquency of defoliation. **Report of FAO (2013)** indicates dry matter, CP, NDF, ADF, Ash and P ranged in berseem from 8.4 to 25.7%, 14.4 to 26.7%, 30.6 to 51.2%, 20.6 to 38.4%, 11.3 to 20.2% and 1.5 to 3.8%, respectively. Berseem is a high-quality forage characterized by a high concentration of nutrients, primarily protein (15-25% DM), minerals (11-19%) and carotene **(FAO, 2013** and **Sharma *et al.*, 1974)**.

Materials and Methods

Chapter 3 MATERIALS AND METHODS

The edaphic and climatic conditions of the area under which the investigation was carried out and the materials and techniques employed during the course of the study are described in this chapter.

The present experiment was conducted under the project cool season varietal & dairy trails on forage crops sponsored by **Royal Barenburg Group P.O. Box 4, 6678 ZG Oosterhout Glg. The Netherland.**

3.1 Experimental site

The experiment was conducted at Forage Agronomy block of Instructional Dairy Farm (IDF), Nagla of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand, India during *rabi* season of 2012-13. The Instructional Dairy Farm is located in the *Tarai* belt of Shivalik range of Himalayas at latitude of 29°N and longitude of 79.3°E and situated at an altitude of 243.84 m above the mean sea level.

3.2 Climate of the Site

The climate experienced at Pantnagar is humid sub-tropical with extreme of weather conditions such as hot and dry summer and cold winter. Generally, south west monsoon commences in third week of June and few showers occur in winter and occasionally during summer also. The mean annual rainfall is 1369 mm of which 80 to 90 per cent is received from June to October. Temperature is generally maximum during May-June where mean maximum temperature may exceed even 38.9°C and lowest in December-January where mean minimum temperature may fall below 7.1°C. The mean relative humidity (0712 hours) and (1412 hours) varies 62-91 and 26-64 per cent from October to end of June, respectively.

The weekly weather parameters like maximum and minimum temperature, relative humidity and rainfall prevailed during experimentation recorded at the meteorological observatory of N.E. Borlaug Crop Research Centre, Pantnagar, have been graphically presented in Fig. 1 and data are given in Appendix-I.

The maximum temperature recorded during crop growth period was 41.8°C in the second week of May, 2013. The minimum temperature - 0.8°C was recorded in the second week of January 2013. The mean maximum and minimum temperature was 31.2°C and 16.1°C at sowing month (October) 2012, at 1st cutting December (21.3°C and 7.1°C), 2nd cutting January 2013(21.3°C and 7.1°C), 3rd cutting February (22.8°C and 9.9°C), 4th cutting March (29.1°C and 13.5°C), 5th cutting April (35.0°C and 17.6°C), 6th cutting May (38.9°C and 23.4°C), June (33.2°C and 25.7°C).

3.3 Soil Characteristics

The soil of *Tarai* region (Mollisols) has developed from calcareous medium to moderately coarse textured parent material under the predominance of forest vegetation and moderately to well drained conditions. These soils are originated from alluvial sediments. The composite soil sample taken from furrow slice (0-15 cm depth) in each replication was collected prior to sowing of crop and analyzed for different constituents.

Table 1: Physico-Chemical composition of the experimental soil

S. No	Particulars	Values	Methods
1	pH (1:2 soil : water ratio)	7.6	Glass electrode pH meter
2	Organic carbon (%)	0.848	Walkley and Black's method**(Jackson, 1973)**
3	Available nitrogen (kgN/ha)	284.48	Alkaline Permanganate method **(Subbiah and Asija, 1956)**
4	Available phosphorus (kgP/ha)	21.80	Olsen's method **(Olsen *et al*. 1954)**
5	Available potassium (kg K/ha)	232.80	Flame photometry method**(Jackson, 1973)**

The soil of experimental field was high in organic carbon, medium in available nitrogen, medium available phosphorus and potassium with neutral in reaction.

3.4 Experimental details

3.4.1 Treatment details (*Rabi* season forage crops)

The following crops varieties from different sources constituted the treatments.

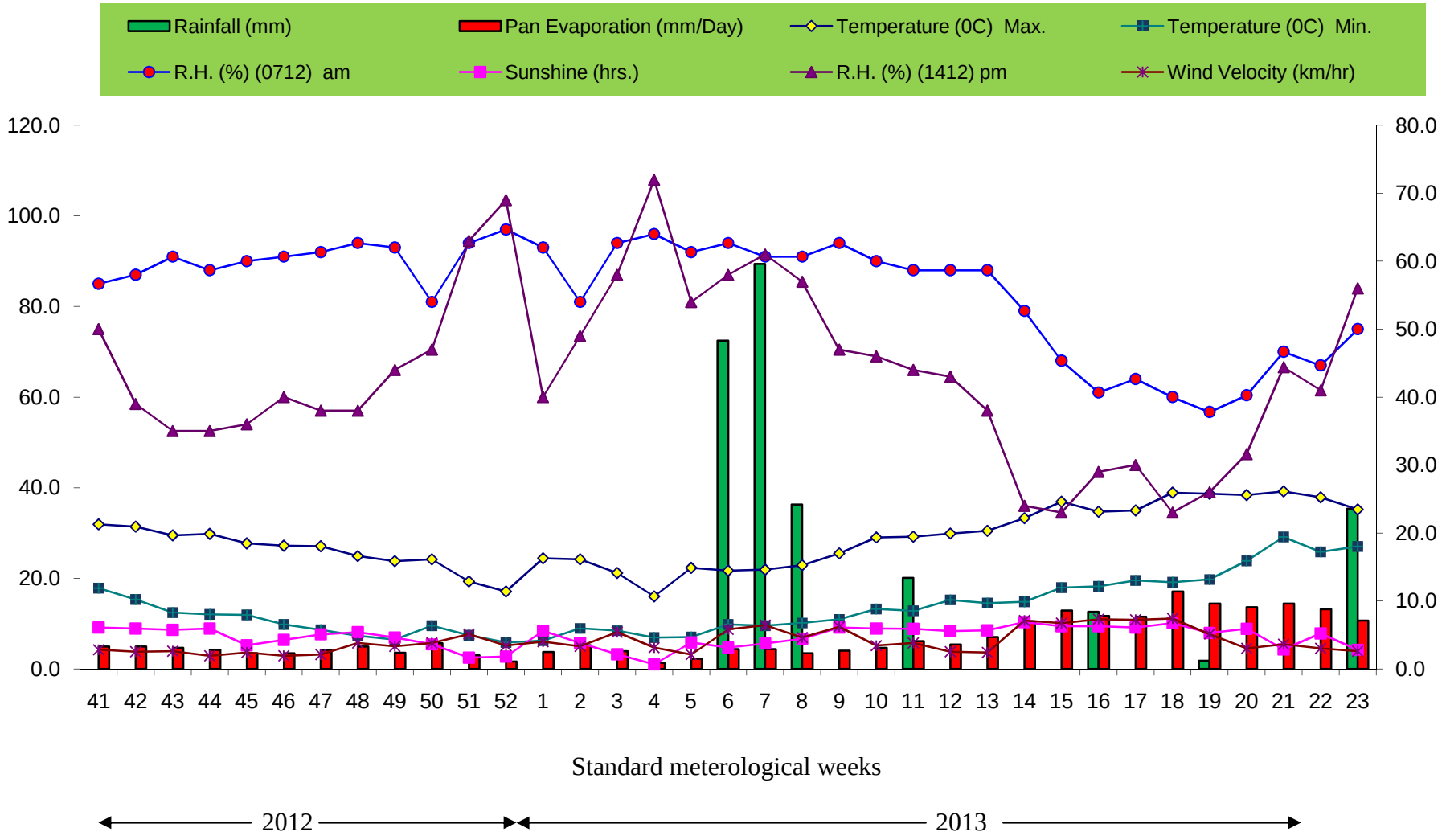


Fig. 1: Weekly weather conditions at Pantnagar during crop period (October 2012 to June 2013)

Varieties		Crops	Source
1)	UPO- 212 :	Oat (*Avena sativa* L.)	: GBPUA&T Pantnagar
2)	Genie Oat :	Oat (*Avena sativa* L.)	: Netherland
3)	Makkhan grass :	Rye grass (*Lolium perenne* L.)	: Advanta
4)	Local rye :	Rye grass (*Lolium perenne* L.)	: GBPUA&T Pantnagar
5)	Mescavi :	Berseem (*Trifolium alexandrinem* L.)	: GBPUA&T Pantnagar
6)	Baralfa IN :	Lucerne (*Medicago sativa* L.)	: Netherland
7)	Barduro :	Red clover (*Trifolium pratense* L.)	: Netherland

Table 2: Experimental details

Sl. No.	Items	Particulars
1.	Site of experiment	Instructional Dairy Farm, Nagla Pantnager (U.S. Nagar)
2.	Experimental design	Randomized Block Design
3.	Crop varieties	UPO- 212, Genie Oat, Makkhan grass, Local rye, Mescavi, Baralfa IN and Barduro
4.	Total number of treatments	7
5.	Number of replications	5
6.	Total number of plots	35
7.	Gross plot size	6 m x 3.2 m = 19.2 m^2
8.	Net plot size	Berseem and Lucerne- 5 m x 2.4m = 12.0 m^2 Rye grass and Makkhan grass- 5 m x 2.2m = 11.0 m^2 Oat and Red clover-5 m x 1.6m = 8.0 m^2
9.	Seed rate	Lucerne(25kg/ha), Berseem(30kg/ha), Redclover (10kg/ha),Oat(100kg/ha), Rye grass and Makkhan grass (25kg/ha)
10.	Row spacing	Lucerne and Berseem (20 cm), Red clover and Oat (25 cm), Rye grass and Makkhan grass (40 cm)
11.	Fertilizers	Nitrogen 120 kg / ha (grasses) Nitrogen 25 kg / ha (Legumenous forage crops) Phosphorus 60 kg / ha Potassium 40 kg /ha

3.4.2 Layout plan

The layout of the experiment and individual plot is given **Fig.2** and **3:**

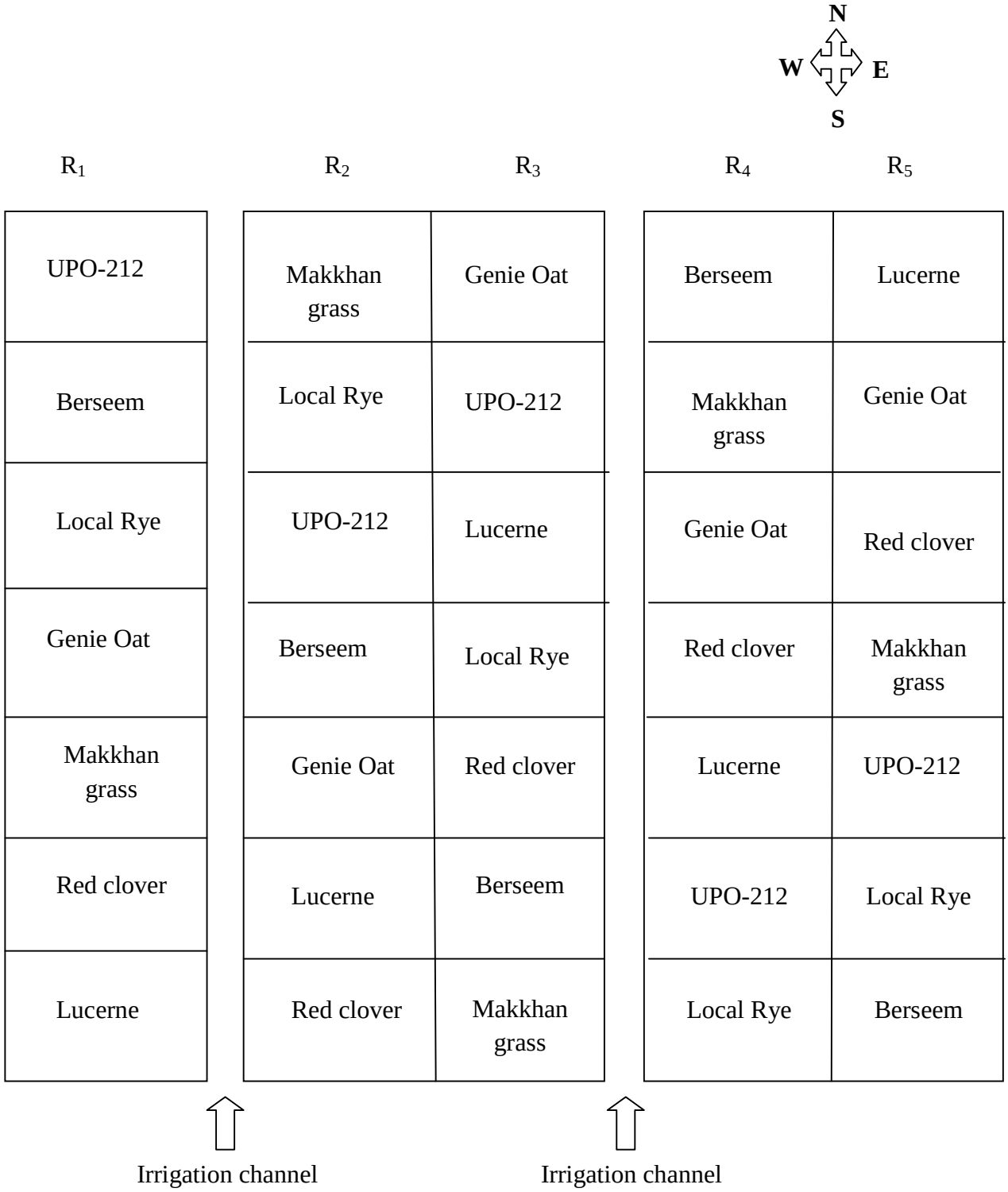
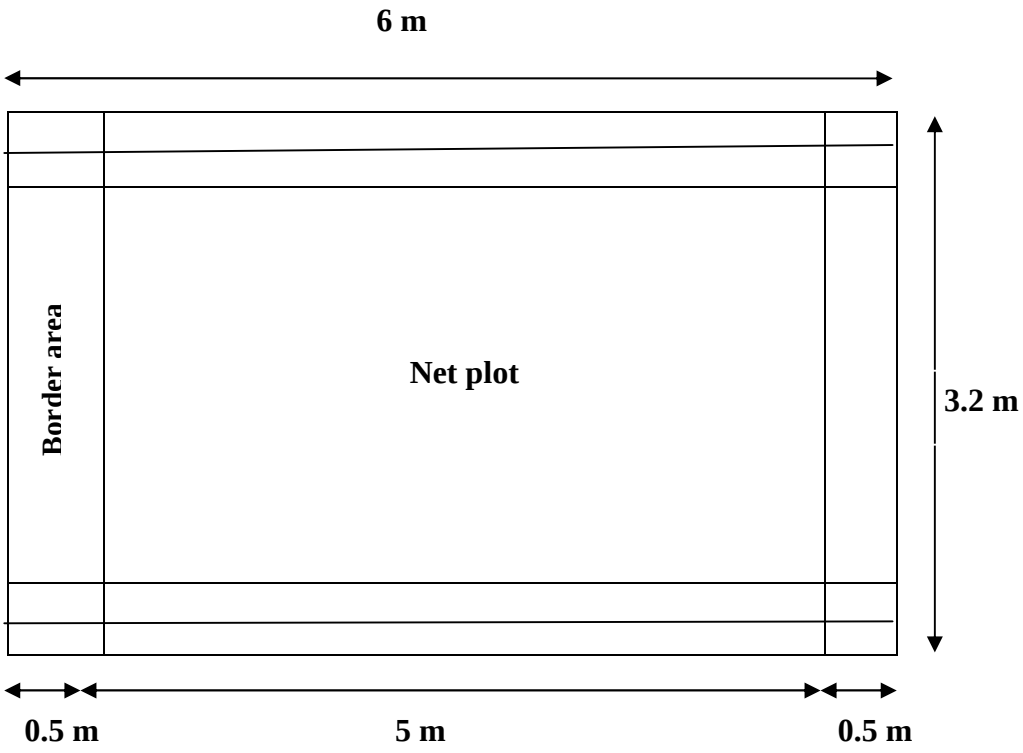


Fig 2: Layout plan of the experimental field



Berseem and Lucerne – 16 row, Red clover and Oat- 13 row, Makkhan grass and Rye grass- 8 row

Fig 3: Layout of individual plot

Two row of either side (E-W) and 0.5 m either side of the row (N-S) were kept as border area and remaining area as net plot area.

3.5 Cultural operations

A detail of the pre and post sowing activities and operational calendar during field experimentation is as given in Table 3.

Table 3: Details of Cultural operations in the experimental field

SN.	Particulars	Date	Implements/Method used
1	Ploughing	06.10.2012	Tractor drawn disc plough
2	Harrowing	07.10.2012	Tractor drawn disc plough
3	Layout and Levelling	08.10.2012	Manually
4	Fertilizer application Basal	10.10.2012	Half dose of nitrogen, full dose of Phosphorus and Potassium
5	Sowing	10.10.2012	Sowing depth of oat 4 cm and remain crops seed sown a depth of 2 cm in row
6	Top dressing	6.12.2012 10.1.2013 10.2.2013 13.3.2013 13.4.2013 12.5.2013	1/5 dose of nitrogen for grasses and oats applied till April.
	Irrigation	5.12.2012 09.1.2013 09.2.2013 11.3.2013 12.4.2013 10.5.2013	First irrigation after germination and subsequent irrigations after each cutting.
8	Weeding	5.12.2012 09.1.2013 09.2.2013 11.3.2013 12.4.2013 10.5.2013	Manually after each cutting
9	Harvesting	5.12.2012 08.1.2013 08.2.2013 10.3.2013 10.4.2013 09.5.2013 08.6.2013	Harvesting was done 55 DAS for first cut and subsequent cuttings at 30 days interval

Genie oat

UPO-212

Makkhan Grass

Local Rye

Fig. 4: Different *rabi* season forage crops

Baralfa IN

Barduro

Mescavi

3.5.1 Field preparation

The land was deep ploughed once with a tractor driven disc plough followed by two harrowings with disc harrow and then field was leveled with a tractor driven leveller in the first week of October. Experiment was laid out in the leveled field and soil samples were taken for analysis.

3.5.2 Fertilizer application

Each plot was supplied with uniform half quantity of the total dose of nitrogen through urea @ 120 kg N/ha (grasses), 25 kg N/ha (legumes); 60 kg P_20_5/ha through single super phosphate and 40 kg K_2O/ha through muriate of potassium as basal. The fertilizers were thoroughly mixed with the help of spade. The remaining half dose of nitrogen was top dressed equally in 5 splits for grasses and oats, first at 30 days after sowing and the remain nitrogen applied after each cutting.

3.5.3 Sowing

Crops were sown in E-W direction. Oat (100 kg/ha seed) was sown in 4 cm deep at 25 cm row to row spacing while Rye grass and Makkhan grass (25 kg/ha seed) at 40 cm row to row spacing, Berseem (30kg/ha seed) at 20 cm row to row spacing, Red clover (10 kg/ha seed) at 25 cm row to row spacing and Lucerne (25 kg/ha seed) at 20 cm row to row spacing were sown in 2 cm deep furrows opened with the help of hand hoe. The seeds were sown through drilling in furrow by hand and immediately covered with fine soil.

3.5.4 Irrigation

The first irrigation was given a week after sowing (after complete emergence of the plants) and subsequently plots were irrigated after each cutting.

3.5.5 Weeding

To keep the experimental plots weed free, hand weeding was done at 30 days interval.

3.5.6 Harvesting

The crop was harvested at 55 days after sowing (first cut) with the help of sickle leaving stubble height of 5-6 cm from ground for uniform and quick re-growth of the

crop. Subsequent cuttings were taken 30 days after each cutting till crops stop to re-growth.

3.6 Observations

3.6.1 Growth studies

Following growth parameters were taken at each cutting:

3.6.1.1 Plant height

The height of 5 plants selected randomly from the marked row length in the third or fourth row was measured from the ground to the tip of the longest leaf at all the stages. This was expressed in cm.

3.6.1.2 Number of tillers or branches / plant

Total number of tillers or branches of five randomly selected plants in each plot were counted and expressed as the average number of tillers or branches/plant.

3.6.1.3 Number of green leaves

From sampling area, samples from 50 cm row length were taken randomly at each sampling. The plants were cut with sickles close to the ground and separated into leaves and stem. Leaves were counted together from each plot in each sampling and converted into leaves/m row length.

3.6.1.4 Dry matter accumulation through leaves and stem

The separated leaves and stems as mentioned at 3.6.1.3 above were kept in oven for drying at 70 ± 2^{o} C for 48 hours. The dry weight was recorded with the help of weighing machine and converted into g/ meter row length.

3.6.1.5 Dry matter accumulation through plants/m row length

The dry weight of leaf and stem as obtained at 3.6.1.4 was added to get dry matter accumulation by plants and converted into g/meter row length.

3.6.1.6 Leaf to stem ratio

The leaf to stem ratio on dry weight basis was calculated as follow:

$$L : S = \frac{Dry\ weight\ of\ leaf\ (g)}{Dry\ weight\ of\ stem\ (g)}$$

3.6.2 Quality analysis

3.6.2.1 Dry matter content

Dry matter content was determined by drying 500 g. representative fresh samples from each net plot just after each harvest. The samples were dried at 70 ± 2^{o} C for 48 hours and weighed. Thereafter, dry matter content was calculated and expressed in per cent as given below:

$$Dry\ matter\ \% = \frac{Dry\ weight\ of\ sample}{Fresh\ weight\ of\ sample}\ X\ 100$$

All the oven dried samples were ground in Willey mill using 2 mm sieve for crude protein, ash and nylon bag method of dry matter digestibility and 1 mm sieve for NDF, ADF analysis.

3.6.2.2 Crude protein content

Crude protein content of dried samples as mentioned in 3.6.2.1 was calculated by multiplying nitrogen per cent with 6.25 **(A.O.A.C, 1965)**.

Crude Protein (%) = Nitrogen (%) x 6.25

3.6.2.3 Dry matter Digestibility (DMD)

The dry matter digestibility was determined by nylon bag technique of **Mehrez and Ørskov (1977)**. Nylon bags measuring 17 x 9 cm were made from 100 percent polyester cloth having pore size of 40-50 micron and by using nylon thread for stitching. Five gram oven dried and ground sample as mentioned in 3.6.2.1 was kept in a nylon bag and it was closed by draw string made from nylon thread tied by the same drawstring to an iron ring (5 cm diameter). The iron ring along with the sample bags was inserted in the rumen of fistulated animals for 72 hours tied by a 35 cm nylon string to the cannula lid. At the end of the incubation period the rings were removed from the rumen. The bags were washed thoroughly in the bucket under running tap water till the water coming out from the bags became colourless. The bags were dried in the hot air oven at 70°C for 48 hours to ensure that no moisture remained in the

material. The dry weight of incubated samples was recorded using weighing balance. The dry mater digestibility was calculated and expressed in per cent as follows:

$$Dry\ matter\ digestibilty\ (\%) = 100 - \frac{100\ x\ b}{a}$$

Where,

a = dry weight of sample before incubation

b = dry weight of sample after incubation

The fistulated cattle (male) used in this study was maintained on green sorghum and Maize diet fed *ad lib* and about 2 kg concentrate mixture was given to each animal daily. The cattle were allowed to drink fresh water *ad lib* twice a day once at 9 A.M. and again at 4 P.M.

3.6.2.4 Neutral- detergent fibre

One gram oven dried sample as mentioned in 3.6.2.1 was weighed and kept in a 500 ml capacity spoutless beaker, 100 ml neutral detergent solution, 0.5g sodium sulphite and 2 ml decahydronapthalene was added to it and the solution refluxed for 1 hour on the hot plate as per method of **Goering and Van-soest (1970)**. After 1 hour, contents of the beaker was filtered using vaccume filter machine and filtrate was collected in pre-weighed crucibles (Wo), washed first with hot water and then with acetone twice. Crucibles were then dried overnight in the hot air oven and weighed (W1). The NDF content was calculated and expressed in per cent as follows:

$$NDF\ (\%) = \frac{W1 - Wo}{wt.\ of\ oven\ dried\ sample\ taken}\ x\ 100$$

3.6.2.5 Acid - detergent fibre

One gram oven dried sample as mentioned in 3.6.2.1 was weighed and kept in to 500 ml capacity spoutless beaker, 100 ml acid detergent solution, 2 ml decahydronapthalene added to it and the solution refluxed for 1 hour on the hot plate as per method of **Goering and Van-soest (1970)**. After 1 hour, content of the beaker was filtered using vaccume filter machine and filtrate was collected in pre-weighed crucibles (Wo), washed first with hot water and twice with acetone and finally with

hexane. Crucibles were then dried overnight in the hot air oven and weighed (W1). The ADF content was calculated and expressed in per cent as follows:

$$ADF\ (\%) = \frac{W1 - Wo}{wt.\ of\ \ oven\ dried\ \ sample\ taken}\ x\ 100$$

3.6.2.6 Hemicellulose

The difference between the NDF and ADF was taken as hemicelluloses per cent.

3.6.2.7 Cell content

Cell content was also calculated as per formula given below:

Cell content (%) = 100 – NDF (%)

3.6.2.8 Total ash

Five gram oven dried sample as mentioned in 3.6.2.1 was de-smoked on a heater and ignite at 550°C in muffle furnace for 2 hours and cooled **(ISI, 1975)** The weight of residual ash in previously weighed crucible was taken as total ash. The ash content was calculated and expressed in per cent as follows:

$$Ash\ (\%) = \frac{Weight\ \ of\ \ ash}{Weight\ \ of\ \ sample\ \ taken\ \ for\ \ ashing}\ x\ 100$$

3.6.2.9 Nutrient concentration (NPK) in plant

Nitrogen, Phosphorus and Potassium content in plant were estimated from the samples obtained at 3.6.2.1 by using following method.

Nutrients	**Method used**
Nitrogen	Modified micro kjeldhal method
Phosphorus	Wet digestion molybdophosphoric acid method
Potassium	Flame emission spectophotometry method

3.6.2.10 Estimation of nitrogen by microkjeldhal method in Plant sample

Principle: The Kjeldahl method consists of three basic steps: 1) digestion of the sample in sulfuric acid with a catalyst which results in conversion of nitrogen to ammonia; 2)

distillation of the ammonia into a trapping solution; and 3) quantification of the ammonia by titration with a standard solution.

Apparatus:

1) Kjeldahl flasks (500 to 800 ml)
2) Kjeldahl digestion stand
3) Steam distillation apparatus (Gerhardt assembly)

Reagent:

1) Sulphuric acid, (concentrated 95-98%)
2) Sulphate mixture- Mix 20 parts of K_2SO_4 and 1 part of catalyst mixture (20 parts of $CuSO_4$ and 1 part of Selenium powder)
3) Boric acid (4%)
4) NaOH (40%)
5) Standard H_2SO_4 (0.005*N*)
6) Sodium thiosulphate powder

Procedure;

(A) Digestion:

1) Transfer 0.5 g powdered plant sample to a 100 ml Kjeldahl flasks.
2) Add 10 ml H_2SO_4 and swirl gently to bring the dry sample in contact with the regent. Allow it to stand overnight.
3) Next day add 5 g sodium thiosulphate and heat gently for about 5 minutes.
4) Cool the content and add 10g sulphate mixture. Digest on Kjeldahl apparatus at full heat (150^0 C for 45 minutes and then at 350^0 C for another 45 minutes).
5) Upon completion of digestion, cool the digest and dilute with some water.

(B) Distillation:

1) Transfer the digested sample into a kjeldahl distillation tube.

2) The distillation was done with the help of Gerhardt assembly in which about operation performs automatically.

(C) Titration

1) After completion of distillation, take out the conical flask containing the distillate from the unit and titrate the contents against standard H_2SO_4 (0.005 N) till the bluish green colour turn pink.
2) Run a blank distillation without the plant digest and note down the blank titration value.

(C) Observation and Calculation

Weight of sample- 0.5 g

Normality of H_2SO_4- 0.005*N*

Volume of digestion- 100 ml

Volume of aliquot taken-5 ml

Titration value (TV)- Sample titration (ml) – blank titration (ml)

N% in plant= TV× 0.00007×100×100/(0.5×5)

1 ml 0.005 *N* H_2SO_4 = 0.00007 g *N*

3.6.2.11 Estimation of Phosphorus in Plant sample

Principle: When vanadomolybdate and phosphate radical reacts in nitric acid medium a heteropoly compound is formed which is yellow in colour. The intensity of yellow colour is measured in a spectrophotometer at 420 nm. The amount of P in the plant sample is determined from the absorbance values.

Reagents

1. Ammonium molybdate – ammonium vanadate in HNO_3 (Barton's reagent)

a) Dissolve 22.5 g of ammonium molybdate in 400 ml of warm distilled water.
b) Also dissolve 1.25 g of ammonium metavanadate in 150 ml of boiling water.
c) Add the two solutions and cool to room temperature.
d) Add 250 ml of concentrated nitric acid (HNO_3) and dilute to 1 L.

2. Standard P solution: Dissolve 0.2195 g of analytical grade KH_2PO_4 and dilute to 1 L. This solution contains 50 µg P / ml.

3. Di-acid digestion: It is carried out using 9:4 of HNO_3 : $HClO_4$.

a) Weigh 1 g ground plant material in 100 ml conical flask.

b) To this add 10 ml of acid mixture and swirl the content of the flask gently.

c) Keep for overnight for pre digestion.

d) Place the flask on low heat hot plate in a digestion chamber then heat the contents at higher temperature until the production of red N_2O fumes ceases.

e) Evaporate the contents until 3 to 5 ml digest is obtained but not to dryness. The Completion of digestion is confirmed when the liquid become colourless.

f) After cooling the flask, add 20 ml of deionized or glass distilled water to the plant digest. Transfer the digest quantitatively into a 100 ml volumetric flask with the help of filter paper whatman No. 1.

g) Make up the volume with deionized water.

4. Procedure

Preparation of standard curve:

1) Transfer 0, 1, 2, 3, 4 and 5 ml of standard solution into 50 ml volumetric flasks and add 10 ml of vanadomolybdate reagent to each flask. Make up the volume with distilled water to obtain 0, 1, 2, 3, 4 and 5 ppm P standards respectively. Read the absorbance after 30 minutes.

2) Plot the absorbance (Y axis) against concentration of working standards (X axis). Linear calibration curve is established.

5. Sample preparation

1) Pipette out 5 ml of plant digest into a 50 ml of volumetric flask.

2) Add 10 ml of Barton's regent shake well and make up the volume.

3) Allow to stand for 30 minutes for yellow colour development.

4) Read the intensity of the colour at 420 nm in a spectrophotometer.

5) Plot the absorbance value in the standard graph to obtain the concentration of P in the coloured solution (X ppm).

6. Calculation

P % = *ppm* P (from calibration curve) × V_1/W_t × $100/V_2$×1/10000

Where:

V1 = Total volume of the plant digest (mL)

V2 = Volume of plant digest used for measurement (mL)

Wt= Weight of dry plant (g)

3.6.2.12 Estimation of Potassium in Plant sample

Principle: When liquid samples containing potassium is burnt in the flame, K emits photons characteristic of its wave length. The intensity of the emission is proportional to the K content. By measuring the intensity in flame photometer the K content is determined.

Preparation of working standards: Dissolve 1.907 g of AR grade KCl in 1 liter of distilled water. This gives 1000 ppm K. From this different working standards are prepared. Dilute 0, 1, 2, 3, 4 and 5 ml of the stock solution 100 ml to obtain 0, 10, 20, 30, 40 and 50 ppm K working standards.

Procedures:

1) Pipette out 5 ml of plant digest into a 25 ml volumetric flask and dilute to 25 ml with distilled water.

2) Aspirate the standards and then the sample to the flame and note the meter reading and calculate the K content by referring to the standard curve prepared.

3.6.3 Yield

3.6.3.1 Green forage yield

Crops from net area of each plot were harvested separately and weighed in kg with the help of spring balance and expressed as q/ha.

3.6.3.2 Dry matter yield (DMY)

Dry matter yield was calculated by using the following formula and expressed as q/ha.

$$Dry\ matter\ yield\ (q/ha) = \frac{Green\ \ forage\ \ yield\ \ (q/ha)}{100}\ \ X\ \ Dry\ \ matter\ \ \%$$

3.6.3.3 Crude protein yield (CPY)

Crude protein yield was calculated by using the following formula and expressed as q/ha.

$$CPY = \frac{CP(\%)\ X\ \ DMY\ \ (q/ha)}{100}$$

3.6.3.4 Digestible dry matter yield (DDMY)

Digestible dry matter yield of each plot was calculated by using fallowing formula:

$$DDMY(q/ha) = \frac{DMD\ (\%)\ X\ \ DMY\ \ (q/ha)}{100}$$

Where,

DMD: Dry matter Digestibility DMY: Dry matter yield

3.7 Statistical analysis

The data collected from the experiment at different growth stages have been subjected to statistical analysis, appropriate to Randomized Block Design **(Cochran and Cox, 1966)**. Whenever treatments exhibited significance at five percent level of probability the critical differences have been be calculated as follows:

$$SEm\pm = \sqrt{\frac{Error\ mean\ \ sum\ of\ \ square}{Number\ of\ \ replications}}$$

$$CD = SEm\pm \times \sqrt{2}\ \times t\ (0.05)\ \text{at error degree of freedom}$$

Results and Discussion

The results obtained during *Rabi* season of 2012-13 are interpreted on the basis of statistical analysis and documented graphically wherever found necessary. The results of the experimental study carried out are subsequently discussed in light of the available literature along with cause and effect relationships. Appropriate reasons for the current research findings are also incorporated in this chapter.

Table 4: Plant height (cm/plant) of different crops at different cuttings

Treatments	Plant height (cm/plant)						
	Cutting						
	1	2	3	4	5	6	7
Lucerne (Baralfa IN)	20.2	20.6	37.6	52.5	75.8	62.6	53.9
Red clover (Barduro)	10.6	10.7	18.1	32.0	38.3	36.7	34.8
Berseem (Mescavi)	27.8	32.0	61.7	69.0	78.8	76.3	-
Oat (Genie Oat)	51.4	52.1	61.9	54.6	52.0	47.4	-
Oat (UPO-212)	59.3	74.6	79.2	64.8	62.7	53.0	-
Rye grass (Makkhan grass)	38.2	38.5	50.7	56.0	63.7	61.4	-
Rye grass (Local rye)	38.6	45.4	62.7	63.0	65.2	63.2	-
SEm±	0.9	0.9	0.9	0.8	0.9	1.0	-
CD at 5%	2.6	2.5	2.5	2.2	2.5	3.1	-

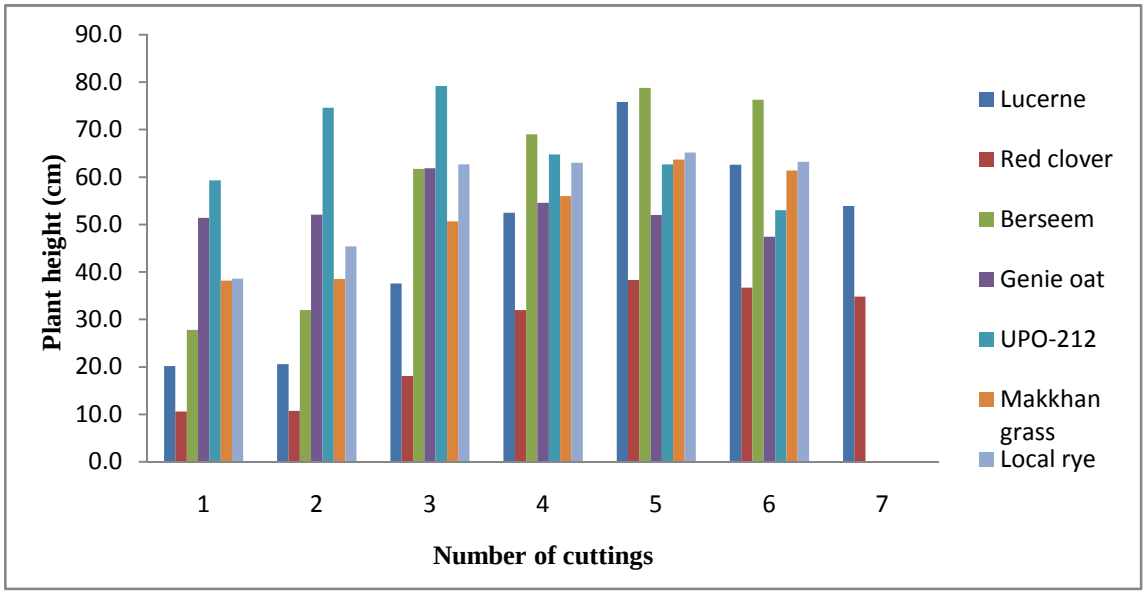


Fig 5: Plant height of different forage crops at different cuttings

Plant height

The data on plant height are presented in table- 4 and depicted in figure- 5. The analysis of variance is given in Appendix- II.

Plants of berseem (mescavi) were significantly taller compared to other crops at 4^{th}, 5^{th} and 6^{th} cuttings, while at 1^{st} , 2^{nd} and 3^{rd} cuttings, these plants were significantly taller than other leguminous cool season forage crops (lucerne and red clover). The taller berseem (Mescavi) plants might be due to genetic makeup as well as the environmental conditions **(Hasina *et al*. 2013; Mandal *et al.*, 1998)**. At all cuttings, the plants of red clover (Barduro) were significantly shorter than other crops under study (Table- 4). This might be due to environmental conditions especially temperature which influences the height of red clover. In the present study, with increased in temperature from 10^{o}C to optimum 24-27^{o} C the height of plants also increased but in late April onward decreased. Which is contradicting with the finding of **(Ledgard *et al*., 1988** and **Brock *et al*. 1989)** who worked under conditions where summer temperatures remain 24^{0} C. Among oat varieties, plants of UPO-212 were significantly taller compared to genie oat at all cuttings. The plants of oat variety UPO-212 are genetically taller compared to other varieties (UPO-270 and JHO-822) as has been observed by **Joshi *et al*. (2000); Jain (1994)** and **Singh (1994)**. Among rye grass At 1^{st}, 5^{th} and 6^{th} cuttings, both the varieties had statistically similar plant height, while at 2^{nd}, 3^{rd} and 4^{th} cuttings, the plant height of local rye was significantly more compared to makkhan grass. The local rye grass plants attained more height during early stages (2^{nd}, 3^{rd} and 4^{th} cuttings) but later in subsequent cuttings the height decreased due to short growth duration and increased temperature (Appendix- I) while Makkhan grass is perennial in nature which is mostly grown in temperate countries where the conditions are favourable for growth and it can sustain below 5^{0}C temperature **(Moser and Hoveland, 1996)**.

Table 5: Number of tillers/plant of different crops at different cuttings

Treatments	Number of tillers/plant					
	Cutting					
	1 Calculator.lnk	2	3	4	5	6
Lucerne (Baralfa IN)	3.5	4.4	6.5	7.3	10.0	9.0
Red clover (Barduro)	3.5	4.3	6.7	7.8	13.0	12.0
Berseem (Mescavi)	4.0	5.0	8.3	9.2	10.0	9.0
Oat (Genie Oat)	3.9	8.0	6.8	5.9	5.0	5.0
Oat (UPO-212)	3.9	4.0	7.0	7.0	6.3	5.0
Rye grass (Makkhan grass)	5.0	6.0	11.3	10.9	9.0	8.0
Rye grass (Local rye)	5.1	7.0	8.9	9.7	9.0	7.0
SEm±	0.2	0.5	0.6	0.7	0.7	0.6
CD at 5%	0.5	1.6	1.8	2.0	2.0	1.8

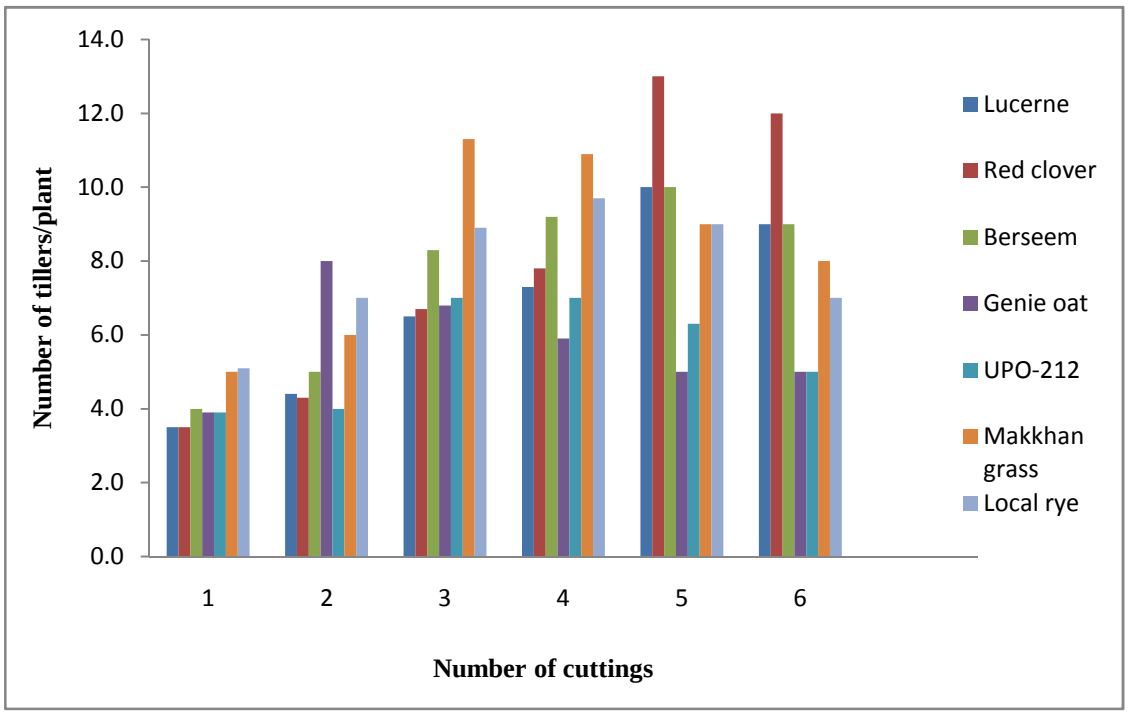


Fig 6: Number of tillers/plant of different forage crops at different cuttings

Number of tillers/plant

The data on number of tillers are presented in table- 5 and depicted in figure- 6. The analysis of variance is given in Appendix- III.

Among leguminous *rabi* season forage crops, numbers of tillers were higher in berseem (Mescavi) but it was statistically similar to lucerne (Baralfa In) and red clover (Barduro) at 1st, 2nd and 3rd cuttings (Table-5). Tillers were higher in berseem (Mescavi) at early stage due to favourable environmental **(Hannaway *et al*., 2004; Suttie, 1999)** while in the case of lucerne (Baralfa IN), low branching in winter (< 10^0 C) was observed which might be due to dormant and late summer due to storing energy reserves in their roots for next season as it is perennial in nature as well as unavailability of optimum temperature (25^0 C) for growth and development **(Zanin, 1998; McDonald *et al*., 2003** and **Sheaffer *et al*., 1991)**. At 5th and 6th cuttings, number of tillers were significantly more in red clover compared with remaining leguminous *rabi* season forage crops which might be due to increase in favourable environmental conditions especially temperature (> 24^0C) but late April onward decrease in tillers par plant was observed which is contradicting with vigorous growth obtained in summer as reported by **Ledgard *et al*. (1988)** and **Laidlaw and Stewart (1987)** as the branching is highly influenced by temperature, defoliation, mineral nutrition and inter-plant competition. The location effect might be a reason for this contradicting result numbers of tillers were similar in berseem and lucerne at 5th and 6th cuttings. Among oat varieties, numbers of tillers were significantly more in genie oat compared with UPO-212 at 2nd cutting, while it was statistically similar with UPO-212 at all other cuttings. Both oat varieties had mostly similar number of tillers except at 2nd cutting but slightly higher tillers in UPO-212 might be due to genetic makeup and slight increase in temperature (33.3^0C/14.8^0C) till April (Appendix- I). These results are in agreement with earlier work of **Joshi *et al*. (2005)** who reported that taller plants, tillers/plant and LAI were higher in UPO-212 than other varieties and **Smith (1974)** observed high growth rate at $27/21^0$ C and lowest at high temperature $32/26^0$C. Among rye grass varieties, at 1st, 2nd, 4th, 5th and 6th cuttings, the tillers were statistically similar in both varieties but at 3rd cutting, tillers were significantly more in makkhan grass compared to local rye. Both rye grass varieties having statistically similar numbers of tillers might be due to genetic character of plant but local rye had slightly lower tillers at later stage due to increase in

temperature and degeneration of roots as rye grass requires temperate climate **(Report of Australian Govt., 2008)** and also due to fact that ryegrasses are not much tolerant to high temperatures **(Mitchell, 1956)** while the makkhan grass grown as perennial can grow at 35^0C **(Moser and Hoveland, 1996)**. The tiller density of rye grass decreases with periods of extremely low rainfall and high temperatures might also be a reason for relatively low tillering in rye grass **(Lowe *et al.*, 2008; Nie *et al.*, 2004** and **Thom *et al.*, 1998a)**

Table 6: Number of leaves/ m row length of different crops at different cuttings

Treatments	Number of leaves/ m raw length						
	Cutting						
	1	2	3	4	5	6	7
Lucerne (Baralfa IN)	216	260	548	800	968	872	760
Red clover (Barduro)	232	336	408	708	944	848	732
Berseem (Mescavi)	132	180	600	796	660	616	-
Oat (Genie Oat)	352	624	424	444	440	340	-
Oat (UPO-212)	348	520	468	372	280	256	-
Rye grass (Makkhan grass)	580	800	672	532	616	576	-
Rye grass (Local rye)	604	864	712	584	620	592	-
SEm±	9	21	54	35	11	4	-
CD at 5%	28	60	160	104	32	16	-

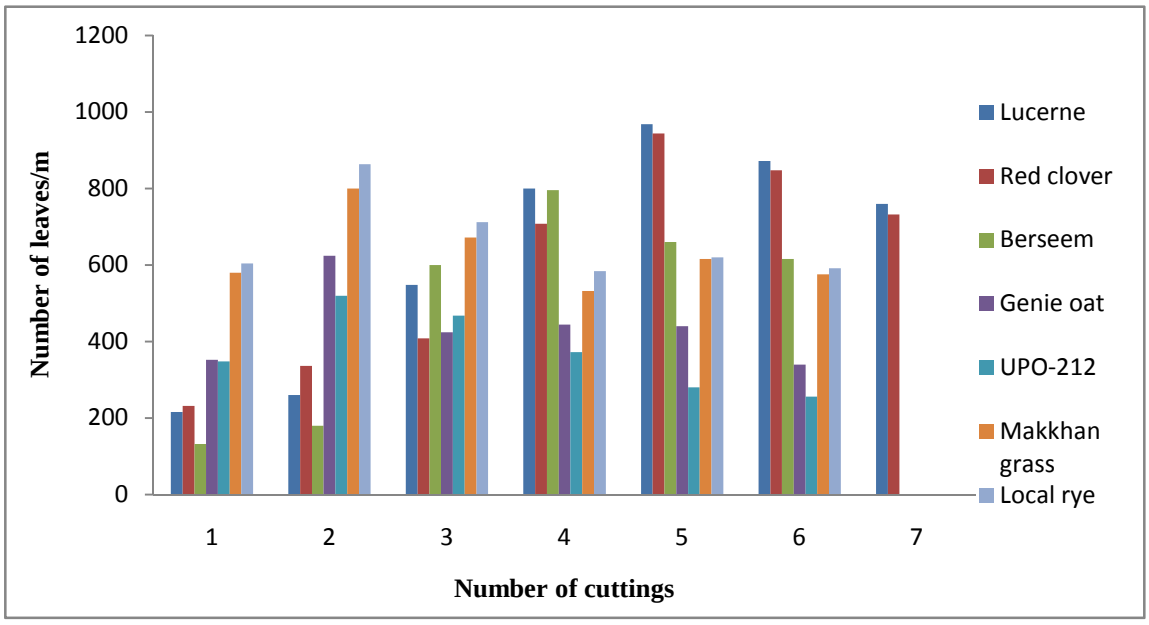


Fig 7: Number of leaves/ m row length of different forage crops at different cuttings

Number of leaves/ m row length

The data pertaining to number of leaves are given in table- 6 and depicted in figure- 7. Their analysis of variance is given in Appendix- IV.

All the leguminous *rabi* season forage crops had similar numbers of leaves at 4^{th} cutting. Leaves of red clover (Barduro) were significantly higher compared to berseem and lucerne variety at 2^{nd} cutting while it was statistically similar in case of lucerne (Baralfa IN) at 1^{st} cutting. Leaves of berseem (Mescavi) at 3^{rd} cutting were higher but it was at par with lucerne variety while it was significantly less at 1^{st} and 2^{nd} cutting compared to lucerne (Baralfa IN) and red clover (Barduro). Leaves of berseem (Mescavi) were less at early stage due to lower temperature (5^0C to 9.5^0C) or at later stage where higher temperature prevailed (Appendix- I). Reduction in less number of leaves at early and later stage might be due to sever cold and high temperature respectively **(Alfred, 2012** and **Joshi *et al.*, 2006)**. Leaves of lucerne (Baralfa IN) increased in subsequent cuttings from 1^{st} to 5^{th} due to optimum temperature **(Sheaffer *et al.*, 1991** and **Zanin, 1998)** and were significantly higher compared to berseem (Mescavi) and red clover (Barduro) at 6^{th} cutting while it was statistically at par with red clover at 5^{th} cutting. Leaves of red clover (Barduro) were less at early stage and more at later stage because of temperature but again decreased after April which is contradicting with the earlier observations that vigorous growth of red clover is obtained in summer due to linear relationship between rate of leaf appearance from a stem and temperature between the base and optimum cardinal temperatures for plant development means that the process can be quantified by a single phyllochron in thermal time (**Ledgard *et al.*, 1988; Hay and Porter, 2006)** which might be due to variation in location. Among oat varieties, leaves of both varieties were statistically similar at 1^{st}, 3^{rd} and 4^{th} cuttings while at 2^{nd}, 5^{th} and 6^{th} cuttings leaves of genie oat were significantly higher compared to UPO-212. At early stages (1^{st}, 3^{rd} and 4^{th} cuttings) similar leaves in both oat varieties might be due to environmental conditions especially optimum temperature and light intensity. At later stage UPO-212 had early senescence of leaves due to increased temperature which might have caused more degeneration of roots of UPO-212 compared to that of genie oat resulting in reduced leaves (Table-6). The results are in accordance with the findings of **Roy (2005)** and **Smith (1974)** who observed high growth rate at ($27/21^0$C) and lowest at high temperature ($32/26^0$C).

Among rye grass, though leaves were higher in local rye grass at all the cuttings but it had significantly higher leaves at 2nd cutting compared to makkhan grass. Higher leaves in local rye grass compared to makkhan grass might be because of its erect and busy growth habit. At later stages, leaves decreased in both rye grass varieties due to unfavourable environmental conditions. The results are in conformity with the finding of **Lyttleton (1973)** and **Smith *et al.*, (2005)** who observed that cultivars of rye grass did not differ in the proportion of leaf.

Table 7: Dry matter accumulation through leaves

Treatments	Dry matter accumulation through leaves (g/m row)						
	Cutting						
	1	2	3	4	5	6	Total
Lucerne (Baralfa IN)	18.0	16.4	5.2	30.8	58.0	58.0	186.4
Red clover (Barduro)	20.4	10.0	14.8	26.8	57.2	33.2	162.4
Berseem (Mescavi)	15.2	11.2	20.8	30.4	46.8	25.6	150.0
Oat (Genie Oat)	22.8	34.4	36.0	40.0	45.2	28.8	207.2
Oat (UPO-212)	20.8	14.0	30.8	30.8	33.2	30.0	159.6
Rye grass(Makkhan grass)	23.6	16.4	13.2	30.8	38.0	20.8	142.8
Rye grass (Local rye)	19.2	10.8	27.2	16.4	26.8	16.0	116.4
SEm±	2.4	2.8	18.4	3.2	6.0	2.4	2.8
CD at 5%	NS	8.0	5.6	8.8	NS	7.2	6.3

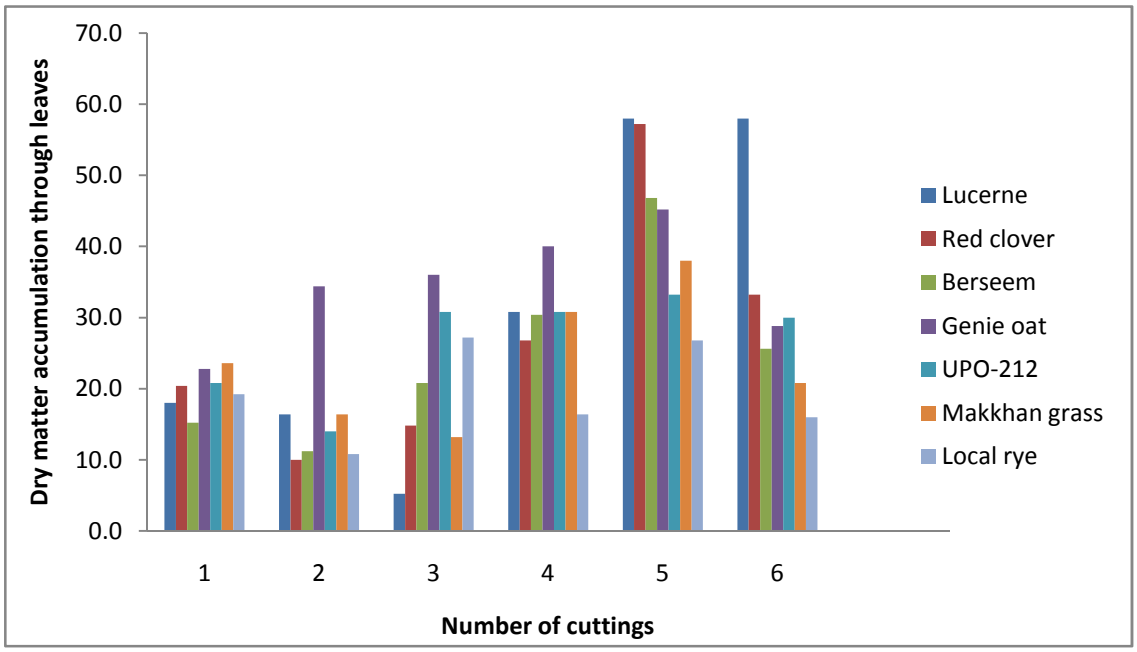


Fig. 8: Dry matter accumulation through leaves

Dry matter accumulation through leaves

The data on dry matter accumulation through leaves are presented in table -7 and depicted in figure-8. The analysis of variance is given in Appendix- V.

Total dry matter accumulation through leaves was significantly more in genie oat compared to remaining crops/varieties. Lucerne (BaralfaIN) among leguminous, genie oat among oat and makkhan grass among rye grass had significantly more dry matter accumulation through leaves.

At different cuttings dry matter accumulation through leaves was not significant at 1st and 5th cuttings for all crops. Among leguminous *rabi* season forage crops, dry matter accumulations through leaves was statistically similar at 2nd and 4th cuttings, while at 3rd cutting, it was significantly higher in berseem (Mescavi) compared to lucerne and red clover variety. It might be due to more number of leaves under favourable environment condition which provide higher surface area for photosynthesis but at later stage leaf senescence is common leading to lower dry matter accumulation in leaves. Increase in dry matter accumulation through leaves from 1st to 5th cuttings has been observed by **Griffin *et al*. (1994)** and **Alfred (2012)**. At 6th cuttings dry matter accumulations through leaves were significantly higher in lucerne (Baralfa IN) compared to berseem (Mescavi) and red clover (Barduro) and other crops under study. It might be due to the perennial growth nature and drought tolerance of lucerne producing leaves in summer also which helps in photosynthesis ultimately increased dry matter accumulation. The results are in conformity with the finding of **Jasjeet *et al.* (2011), Kokate** (**1990)** and **Echarte (2008**). Among oat varieties, dry matter accumulations through leaves was significantly higher in genie oat compared to UPO-212 at 2nd and 4th cutting, while it was statistically similar at 3rd and 6th cuttings. More dry matter accumulation through leaves in genie oat might be due to higher rate of CO_2 fixation, duration of crop, photosynthetic area, number of leaves (Table-6) and higher photosynthesis efficiency and environmental factors but in both the oat varieties dry matter increased till 5th cutting and at later stages it decreased due to leaves senescence (**Roy, 2005)**. Among rye grasses, dry matter accumulation through leaves was statistically similar at 2nd and 6th cutting, and at 3rd cuttings; dry

matter accumulations through leaves was significantly higher in local rye compared to makkhan grass. At 4th cutting dry matter accumulations through leaves was significantly higher in makkhan grass compared to local rye. Higher dry matter accumulations through leaves in local rye at 3rd cutting might be due to more number of leaves (Table-6) which provide more surface area for CO_2 fixation, while at 4th cuttings, dry matter accumulations through leaves was higher in makkhan grass due to environmental factor but in both ryegrass varieties, dry matter accumulations through leaves increased till April and later decreased due less number of leaves (Table-6). Pattern of rate of dry matter accumulation of a crop canopy is typically characterized by a sigmoid curve. Three more or less distinct phases can be distinguished (i) a period of exponential growth during early development, followed by (ii) a period of more or less constant rate dry matter accumulation, and (iii) a period of declining crop growth rates during the final phase of development when green leaf area declines due to leaf senescence and leaf photosynthesis declines due to leaf aging **(Echarte L., 2008)**. These factors might have been the reason for observation of present investigation.

Table 8: Dry matter accumulation through stem

Treatments	**Dry matter accumulation through stem (g/m row)**						
	Cutting						
	1	**2**	**3**	**4**	**5**	**6**	Total
Lucerne (Baralfa IN)	6.8	8.0	4.8	24.4	64.4	73.2	181.6
Red clover (Barduro)	8.8	4.8	9.2	19.2	66.0	44.0	152.0
Berseem (Mescavi)	8.8	9.2	24.4	42.8	69.2	47.6	202.0
Oat (Genie Oat)	7.2	19.6	30.8	31.2	54.4	38.4	181.0
Oat (UPO-212)	6.8	14.4	23.2	32.8	41.6	44.0	162.8
Rye grass(Makkhan grass)	7.2	10.0	8.8	26.8	55.6	34.8	143.2
Rye grass (Local rye)	10.0	8.4	14.0	21.2	55.6	40.0	149.2
SEm±	0.8	2.0	3.6	4.4	6.8	3.2	2.5
CD at 5%	NS	6.0	10.4	12.8	NS	9.6	7.1

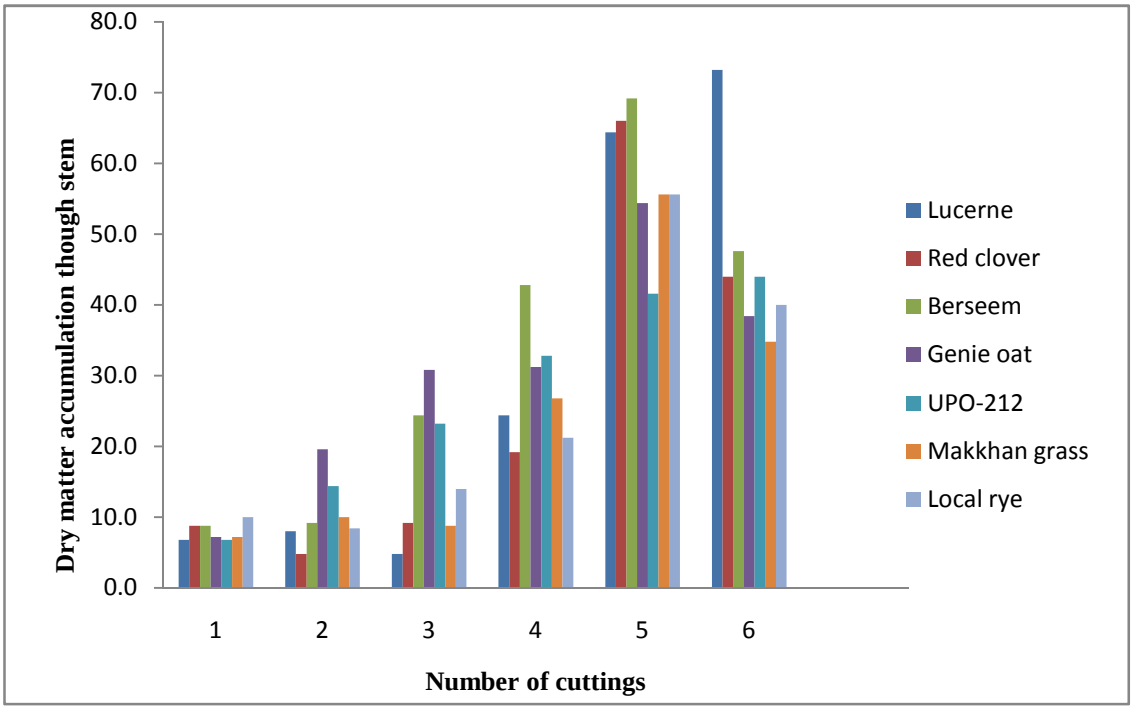


Fig 9: Dry matter accumulation through stem

Dry matter accumulation through stem

The data on dry matter accumulation through stem are presented in table-8 and depicted in figure-9. The analysis of variance is given in Appendix- VI.

Total dry matter accumulation through stem was significantly more in berseem (Mescavi) compared to remaining crops/varieties. Berseem among leguminous and genie oat among oat had significantly more dry matter accumulation through leaves while both rye grass varieties was statistically at par with each other.

Dry matter accumulation through stem was not significant at 1st and 5th cuttings for all crops. Among leguminous *rabi* season forage crops, dry matter accumulation through stem was significantly higher in berseem (Mescavi) compared with lucerne and red clover variety at 3rd and 4th cuttings while at 2nd cutting it was statistically at par with remaining leguminous *rabi* season forage crops. Higher dry matter accumulations through stem in berseem might be due to higher rate of CO_2 fixation, photosynthetic area, duration of crop, and environmental factor besides management practices. **Alfred (2012)** also found higher dry matter accumulation through stem of berseem. At 6th cuttings, dry matter accumulation through stem was significantly higher in lucerne

(Baralfa IN) compared to berseem and red clover variety. Continuous increase in dry matter accumulations through stem in lucerne might be due to its perennial nature and drought tolerance capacity producing more number of leaves till May (Table-6) but at later stages dry matter decreased in stem. At later stage (after May) green leaf area declines due to leaf senescence and leaf photosynthesis declines due to leaf aging resulting in decreased dry matter. The results are conformity with the finding of **Kokate** (**1990) and Echarte (2008**). Among oat varieties, dry matter accumulation through stem of both varieties was statistically similar at 2^{nd}, 3^{rd}, 4^{th} and 6^{th} cuttings. Similar was the trend among rye grass varieties. Continuous increase in dry matter accumulations through stems in oat and ryegrass varieties till 5^{th} cutting might be due to better environmental factor for regeneration and growth of plants after each cutting but at later stages decrease in dry matter was due to leaves senescence and less number of leaves (Table-6). The results are conformity with the finding of **Echarte (2008**) and **Reddy (2012)**.

Table 9: Dry matter accumulation through plants/m row length

Treatments	**Dry matter accumulation through plants/m row length**						
	Cutting						
	1	**2**	**3**	**4**	**5**	**6**	Total
Lucerne (Baralfa IN)	24.8	24.4	10.0	55.2	122.4	131.2	368.0
Red clover (Barduro)	26.4	14.8	24.0	46.0	123.2	73.2	307.0
Berseem (Meacavi)	24.0	20.4	45.6	73.2	116.0	73.6	352.8
Oat (Genie Oat)	30.0	54.0	66.4	71.2	99.6	67.2	388.4
Oat (UPO-212)	27.6	28.4	54.0	63.6	74.8	73.6	322.0
Rye grass (Makkhan grass)	30.8	26.4	22.0	57.6	93.6	55.6	286.0
Rye grass (Local rye)	29.2	19.2	41.2	37.6	82.4	56.0	265.6
SEm±	3.2	4.8	4.8	6.8	12.4	5.6	4.6
CD at 5%	NS	13.6	14.0	20.4	NS	16.8	13.4

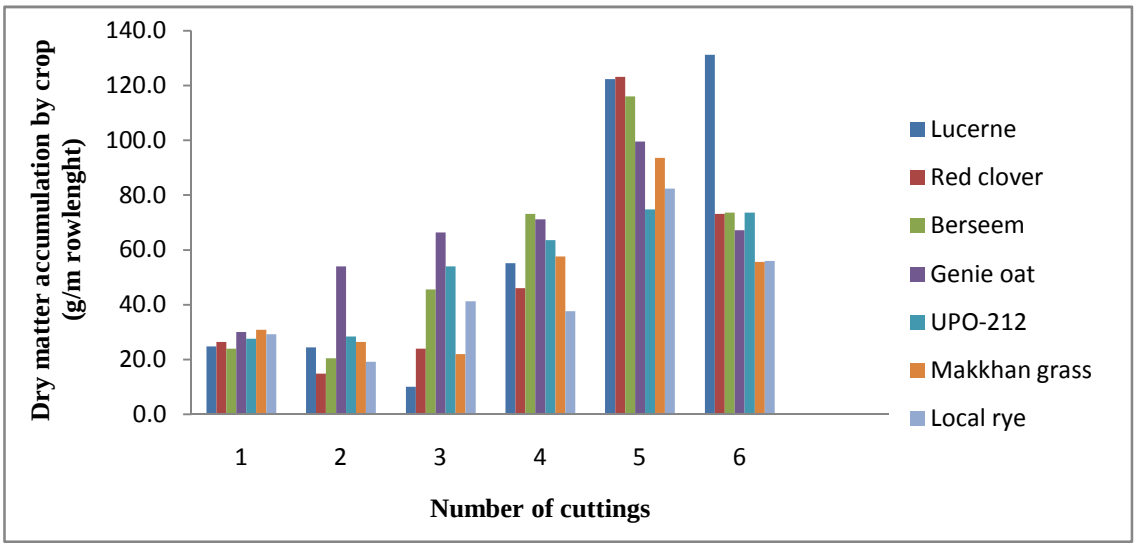


Fig 10: Dry matter accumulation through plants/m row length

Dry matter accumulation through plants (g/m row length)

The data on dry matter accumulation by crop are presented in table-9 and depicted in figure - 10. The analysis of variance is given in Appendix-VII.

Total dry matter accumulation through plants was significantly more in genie oat compared to remaining crops/varieties. Lucerne (Baralfa IN) among leguminous, genie oat among oat and makkhan grass among rye grass had significantly more dry matter accumulation through plants.

Dry matter accumulation by crop plants was not significant at 1st and 5th cuttings for all crops. Among leguminous *rabi* season forage crops, dry matter accumulation by plants was statistically similar at 2nd cutting but it was significantly higher in berseem (Mescavi) compared with lucerne and red clover variety at 3rd cutting while it was statistically similar with lucerne (Baralfa IN) at 4th cutting. Dry matter accumulations increased in berseen (Mescavi) with advancement of crop age but declined at 6th cutting which might be due to degeneration of root at higher temperature causing to leaf senescence. On the other hand lucerne accumulated higher dry matter which was significantly higher compared with remaining leguminous *rabi* season forage crops at 6th cuttings. Dry matter accumulations through plants of lucerne (Baralfa IN) and red clover (Barduro) increased with advancement of crop but decreased at 2nd and 3rd cuttings might be due to lower temperature (Appendix- I) causing reduction in photosynthesis, while at 6th cutting drought tolerance capacity of

lucerne might have helped in leaf production but in red clover declined trend was observed. The capacity of plant to accumulate dry matter is determined by its genetic rate of CO_2 fixation, photosynthetic area, duration of crop, tillers/plant and environmental factor besides management practices **(Jasjeet *et al.*, 2011** and **Roy, 2005)**. Among oat varieties, dry matter accumulations by plants was significantly higher in genie oat compared with UPO-212 at 2nd cutting while at 3rd, 4th and 6th cuttings it was statistically similar in both the varieties and decreased dry matter accumulations with advancement in crop duration which might be due to reduce plant height (Table-4), number of leaves (Table-6), there by reduced CO_2 fixation at later stages and enhanced values of these growth parameter at early stages **(Echarte, 2008)**. Among rye grasses, dry matter accumulations by crop plants was significantly higher in local rye compared with makkhan grass at 3rd cutting, while it was statistically similar with makkhan grass at 2nd, 4th and 6th cuttings. Dry matter accumulation by makkhan grass decreased till 3rd cutting, further increased upto 5th cutting and decreased thereafter. It might be due to temperature variation which caused variation in dry matter accumulation. In the case of local rye grass, dry matter accumulation decreased till 2nd cutting and further increased at 3rd cutting and decreased at 4th cutting however it again increased at 5th cutting and further decreased. Variation in dry matter accumulation in plants might be due temperature variation. Since nutritive value of perennial ryegrass varies throughout the growing season **(Walsh *et al*., 1987; Johnston *et al*., 1993)**.This might have caused variation in dry matter accumulation at different cuttings.

Table 10: Leaf:Stem (dry weight basis) of different crops at different cuttings

Treatments	Leaf:Stem (dry weight basis) of different crops at different cuttings					
	Cutting					
	1	2	3	4	5	6
Lucerne (Baralfa IN)	2.64	2.04	1.08	1.26	0.90	0.80
Red clover (Barduro)	2.32	2.08	1.61	1.39	0.86	0.76
Berseem (Mescavi)	1.72	1.21	0.85	0.70	0.67	0.53
Oat (Genie Oat)	3.15	1.76	1.16	1.28	0.83	0.75
Oat (UPO-212)	3.05	0.98	1.33	0.93	0.79	0.69
Rye grass (Makkhan grass)	3.27	1.64	1.51	1.15	0.67	0.60
Rye grass (Local rye)	1.92	1.28	1.94	0.77	0.48	0.40
SEm±	0.25	0.14	0.20	0.03	0.04	0.01
CD at 5%	0.73	0.40	0.57	0.09	0.13	0.03

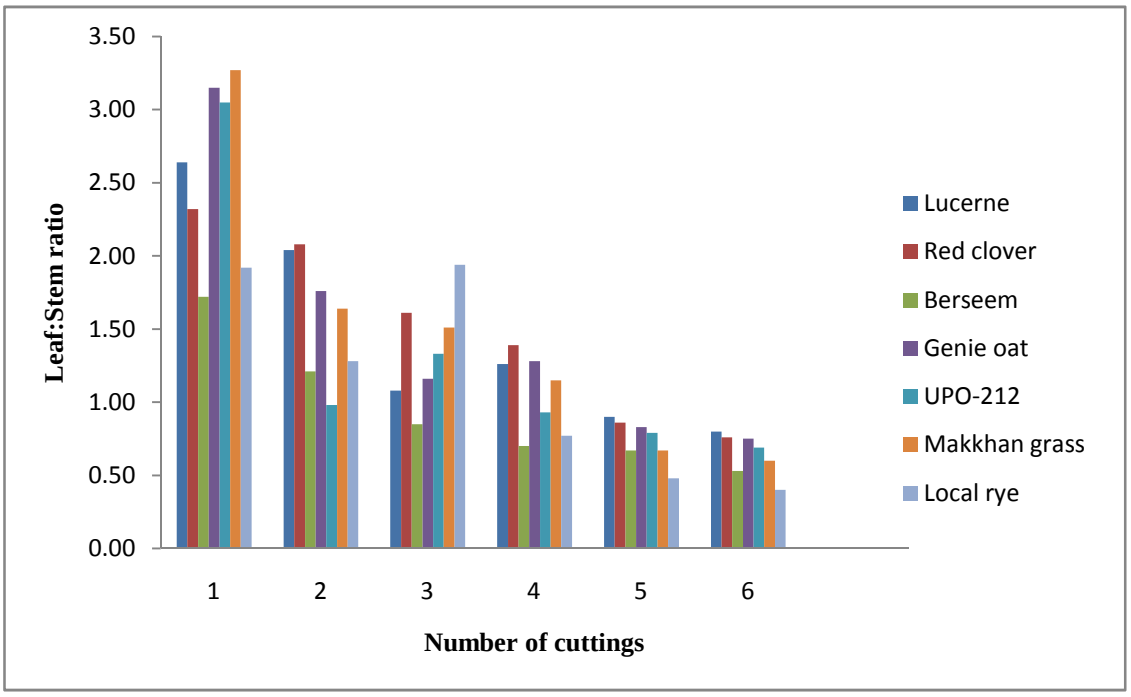


Fig 11: Leaf:Stem (dry weight basis) of different forage crops at different cuttings

Leaf : Stem ratio

In general leaf:stem ratio decreased with advancement in cutting frequencies in all the crops (Table-10). All the crops different significant with respect to leaf:stem ratio at all cuttings (Appendix- VIII).

Leaf:Stem ratio of lucerne (Baralfa IN) and red clover (Barduro) was statistically similar at 1st, 2nd, 3rd, and 5th cuttings, while that of red clover (Barduro) was significantly higher compared to berseem and lucerne variety at 4th cutting. Leaf:Stem ratio of lucerne (Baralfa IN) was significantly higher compared to remaining leguminous *rabi* season forage crops at 6th cutting. Decreased in leaf:stem ratio of leguminous *rabi* season forage crops with advancement of crop age might be due to more dry matter accumulation in stem (Table-8) but slight decline in leaf:stem ratio of lucerne at 3rd cutting than 4th cutting might be due to change in temperature and more dry matter accumulation in stem than leaves, while at 6th cutting higher leaf:stem ratio can be attributed to its perennial nature and drought tolerance capacity which caused production of leaves and storing energy in roots **(Jasjeet *et al.*, 2011** and **Kokate, 1990)**. Leaf:Stem ratio of red clover (Barduro) declined continuously with advancement in growth duration of crop while

at 4th cutting leaf:stem ratio was higher than berseem and lucerne variety which might be due to less accumulation of photosynthetic material in stem. The results are in conformity with the finding of **Griffin *et al.* (1994)**. Among oat varieties, leaf:stem ratio of both the varieties was statistically similar at 1st, 3rd, and 5th cuttings while that of genie oat was significantly higher compared to UPO-212 at 2nd, 4th and 6th cuttings. Decreased leaf:stem ratio of genie oat and UPO-212 with advancement of crop age might be due to reduction in number of leaves (Table-6) and more dry matter accumulation in stem (Table-8) but at 3rd cutting leaf : stem of genie oat slightly declined than 4th cutting might be due to change in temperature and more dry matter accumulation in stem (Table-8) than leaves. At 3rd cutting, leaf:stem ratio of UPO-212 increased slightly compared to 4th cutting which might be due to more number of leaves (Table-6). It has been reported earlier that the leaf:stem ratio of oat varieties remains higher at early stage of the crop and declined with the crop age **(Joshi, 1980)**. Among rye grass, leaf:stem ratio of both the varieties was statistically similar at 2nd and 3rd cuttings while at remains cuttings leaf : stem ratio of makkhan grass significantly higher compared to local rye. Better adoption of makkhan grass with change in temperature might have enhanced leaf : stem ratio **(Moser and Hoveland, 1996)**.

Table 11: Green forage yield (q/ha) of different crops at different cuttings

Treatments	Green forage yield (q/ha)							
	Cutting							
	1	**2**	**3**	**4**	**5**	**6**	**7**	Total
Lucerne (Baralfa IN)	36.1	41.5	165.8	249.4	251.0	228.1	164.6	1134.3
Red clover (Barduro)	2.9	9.6	60.1	132.1	134.0	122.2	37.7	498.8
Berseem (Mescavi)	55.6	62.2	226.8	286.8	300.0	45.3	-	976.9
Oat (Genie Oat)	53.4	100.9	129.6	92.0	87.6	9.2	-	472.5
Oat (UPO-212)	67.8	127.8	131.3	92.9	85.1	8.6	-	513.4
Rye grass (Makkhan grass)	42.4	117.5	222.3	129.4	79.6	19.0	-	609.9
Rye grass (Local rye)	41.2	65.6	211.9	112.7	63.6	16.9	-	511.9
SEm±	2.6	4.5	1.4	1.3	2.1	0.9	-	7.9
CD at 5%	7.5	13.2	4.1	3.7	6.1	2.6	-	23.1

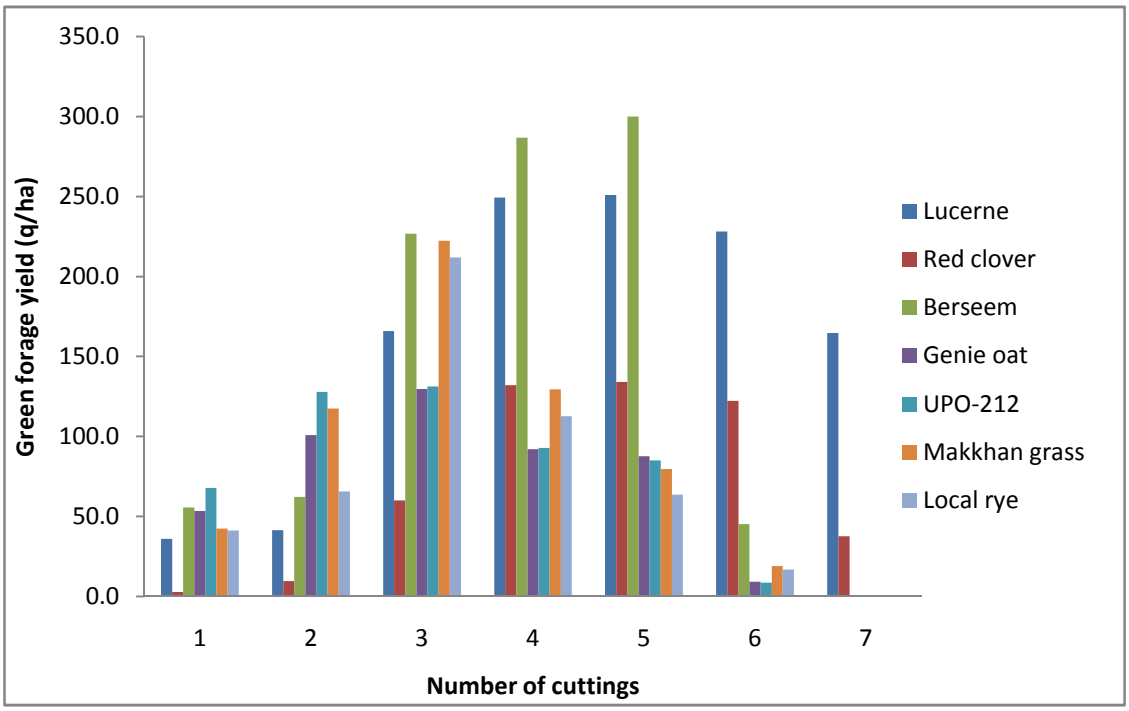


Fig 12: Green forage yield (q/ha) of different forage crops at different cuttings

Green forage yield

The data on green forage yield (q/ha) are presented in table -11 and depicted in figure-12. The analysis of variance is given in Appendix- IX.

The total green forage yield was significantly more in the case of lucerne (Baralfa IN) compared to remaining crops which was mainly due to more cuttings (7 cutting) followed by berseem (Mescavi). Red clover (Barduro) yield was significantly less than other two leguminous crops due to its poor growth habit under unfavourable environment conditions, especially temperature even more number (7) of cuttings could not compensate the total green forage yield. Among oat varieties, the total green forage yield of UPO-212 was significantly more than genie oat while in the case of rye grasses, the total green forage yield of makkhan grass was significantly more than local rye. Comparing the yield of different cuttings it was observed that among leguminous *rabi* season forage crops, green forage yield of berseem (Mescavi) at 1st, 2nd, 3rd, 4th and 5th cuttings was significantly higher compared to lucerne and red clover variety. Higher green forage yield of berseem (Mescavi) might be due to taller plants (Table-4), more numbers of leaves (Table-6), more leaf weight and stem weight due to favourable

temperature for growth and development. In leguminous forage crops leaf weight, stem weight and plant weight have been positively associated with the forage yield **(Jatasra, 1981; Taneja *et al.*, 1987; Suttie, 1999; Tiwana *et al.*, 2003; Hannaway *et al.*, 2004** and **ICAR, 2012)**. Green forage yield of red clover (Braduro) was significantly less compared to other crops at 1st, 2nd and 3rd cuttings. It might be due to shorter plant height at early stage (Table-4) but at later stage more plant height(Table-4), number of tillers/plant (Table-5) and more number of leaves(Table-6) might have attribute to more green forage yield while at 6th cutting green forage yield decreased due to degeneration of reproductive growth portion **(Ledgard *et al.*, 1988., Harris & Kunelius, 1988** and **Taylor *et al.*, 1996)**. The optimum temperature for red clover growth as 25-27°C which was prevalent in the present study also (Appendix- I). At 7th cutting, green forage yield of lucerne (Baralfa IN) was significantly higher compared to red clover. It might be due to taller plants (Table-4), perennial growth habit, drought tolerance, optimum temperature at late summer. Lucerne is drought tolerant because lucerne has a deep root system with a straight taproot that can cover a depth of more than 15 m leading to more water and nutrient uptake **(Hayman and McBride, 1984; Sheaffer *et al.*, 1991; Jasjeet *et al.*, 2011** and **Kokate, 1990)**. At 1st and 2nd cuttings, oat variety UPO-212 had significantly higher green forage yield compared to genie oat. At 3rd, 4th, 5th and 6th cuttings, both the oat varieties had statistically similar green forage yield. Green forage yield of UPO-212 higher at early stage because of its genetic potential and optimum temperature along with taller plants (Table-4) and more number of tillers per plant (Table-5). Superiority of UPO-212 over other varieties in term of green forage yield and dry matter yield due to more plant height, LAI and dry matter accumulation in leaves and stem has also been reported earlier **(Joshi *et al.*, 2005** and **Chandra, 2000)**. Green forage yield of UPO-212 was statistically at par with makkhan grass at 2nd cutting. Among rye grasses at 1st and 6th cuttings both the varieties had statistically similar green forage yield. At 2nd, 3rd, 4th and 5th cuttings, makkhan grass had significantly higher green forage yield compared to local rye. Lower green forage yield of both rye varieties at 1st and 6th cutting might be due to unfavourable temperature at these stages (5.7^0 C and 38.7^0 C) but at 2nd, 3rd, 4th and 5th cuttings higher yield of makkhan grass might be due to more number of tillers per plant, more dry mater accumulation in plants (Table-9) and favourable temperature (Appendix- I). The results corroborate with the **Anonymous (2012)** on rye grass.

Table 12: Dry matter content (%) of different crops at different cuttings

Treatments	Dry matter content (%) of different crops at different cuttings						
	Cutting						
	1	2	3	4	5	6	7
Lucerne (Baralfa IN)	11.6	14.6	13.5	20.2	21.9	24.4	25.9
Red clover (Barduro)	10.0	13.3	17.0	15.8	16.8	18.4	22.0
Berseem (Mescavi)	12.0	13.0	13.0	16.5	20.4	22.2	-
Oat (Genie Oat)	10.7	12.0	14.0	14.6	18.1	18.1	-
Oat (UPO-212)	11.2	13.0	16.0	16.6	21.2	21.0	-
Rye grass(Makkhan grass)	13.3	13.4	16.0	17.5	21.4	21.4	-
Rye grass (Local rye)	12.3	13.6	15.9	15.6	24.7	22.6	-
SEm±	0.3	0.2	0.2	0.5	0.5	0.5	-
CD at 5%	0.8	0.7	0.6	1.3	1.4	1.6	-

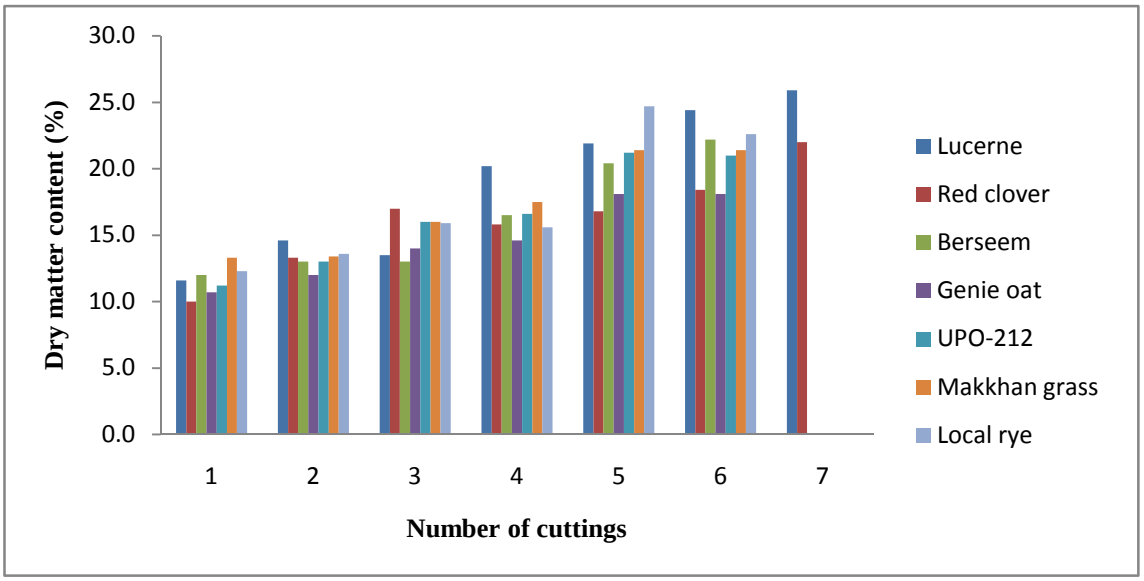


Fig 13: Dry matter content (%) of different forage crops at different cuttings

Dry matter content

The data on dry matter content are presented in table-12 and depicted in figure-13. The analysis of variance is given in Appendix- X.

Among leguminous *rabi* season forage crops, dry mater per cent of berseem (Mescavi) was at par with lucerne (Baralfa IN) at 1st cutting. Increased dry matter content of berseem (Mescavi) from 1st to 6th cuttings might be due to taller plants (Table-4), more number of tillers/plant (Table-5**)**, number of leaves (Table-6) and more

dry matter accumulation in plant (Table-9). Positive correlation of berseem dry matter with stem weight, leaf weight, plant height and leaf weight has been observed by earlier worker **(Jatasra, 1981; Tiwana *et al*., 2003** and **Alfred, 2012)**. Dry matter per cent of red clover (Barduro) was significantly lower compared to remaining crops (except genie oat) at 1st cutting which might be due to shorter plants height (Table-4) and unfavourable environmental condition which led to low accumulation of dry matter but with advancement in crop age, dry matter content increased till May because of the higher value of growth parameters (Tables-4, 5, 6, 7 and 8) on account of favourable temperature (Appendix- I).The results are in accordance with the results reported by **Hakl *et al*. (2003)**, **Dubbs *et al*. (2003)** and **Homolka *et al.* (2012)**. Dry matter per cent of red clover (Barduro) was statistically at par with genie oat at 5th and 6th cuttings while dry matter per cent of lucerne (Baralfa IN) was significantly higher compared to leguminous *rabi* season forage crops and other crops at 2nd, 4th, 5th, 6th and 7th cuttings but at 3rd cutting, dry matter per cent of red clover (Barduro) was significantly higher compared to remaining crops. Increased dry matter content of lucerne (Baralfa IN) from 2nd to 7th cuttings (except 3rd cutting) might be due to increased plants height(Table-4), number of leaves (Table-6), number of tillers/plant(Table-5) as this crop has better drought tolerance capacity due to deep tap roots system (**McDonald *et al*., 2003; Jasjeet *et al*., 2011; Kokate, 1990** and **Monsanto, 2003)**. Among oat varieties, dry matter per cent of UPO-212 was significantly higher compared to genie oat at all the cuttings except at 1st cutting, where both the oat varieties had statistically similar dry mater per cent. The taller plants height (Table-4) and more number of tillers per plant (Table-5) might have enhanced the dry matter content. Superiority of UPO-212 over other oat genotypes has also been reported earlier worker (**Reddy, 1976; Jain, 1994** and **Singh, 1994)**. Among rye grasses, dry matter per cent of makkhan grass was significantly higher compared to local rye at 1st and 4th cuttings, while at 5th cutting, dry mater per cent of local rye was significantly higher than makkhan grass. At 2nd, 3rd and 6th cuttings, both the rye grass varieties had statistically similar dry mater per cent. Dry matter per cent of both rye grass varieties increased with advancing age of crop till 5th cutting but later decreased due to senescence of leaves and degeneration of roots on account increase in temperature (Appendix- I). Variation in yield and nutritive values of rye grass throughout the growing season has been reported earlier (**Johnston *et al*., 1993)** and **Walsh and Birrell, 1987)**.

Table 13: Dry matter yield (q/ha) of different crops at different cuttings

Treatments	Dry matter yield (q/ha)							
	Cutting							
	1	2	3	4	5	6	7	Total
Lucerne (Baralfa IN)	4.2	6.1	22.3	50.4	54.9	55.7	42.6	236.2
Red clover (Barduro)	0.3	1.3	10.3	20.9	22.5	22.6	8.3	86.1
Berseem (Mescavi)	6.6	8.1	29.6	47.5	61.0	10.1	-	162.9
Oat (Genie Oat)	5.7	12.1	18.1	13.6	15.9	1.7	-	67.1
Oat (UPO-212)	7.6	16.6	21.0	15.5	18.1	1.8	-	80.5
Rye grass (Makkhan grass)	5.6	15.7	35.6	22.7	17.0	4.1	-	100.6
Rye grass (Local rye)	5.1	8.9	33.6	17.6	15.7	3.8	-	84.7
SEm±	0.4	0.6	0.4	0.7	0.8	0.5	-	1.9
CD at 5%	1.0	1.8	1.0	2.0	2.4	1.4	-	5.5

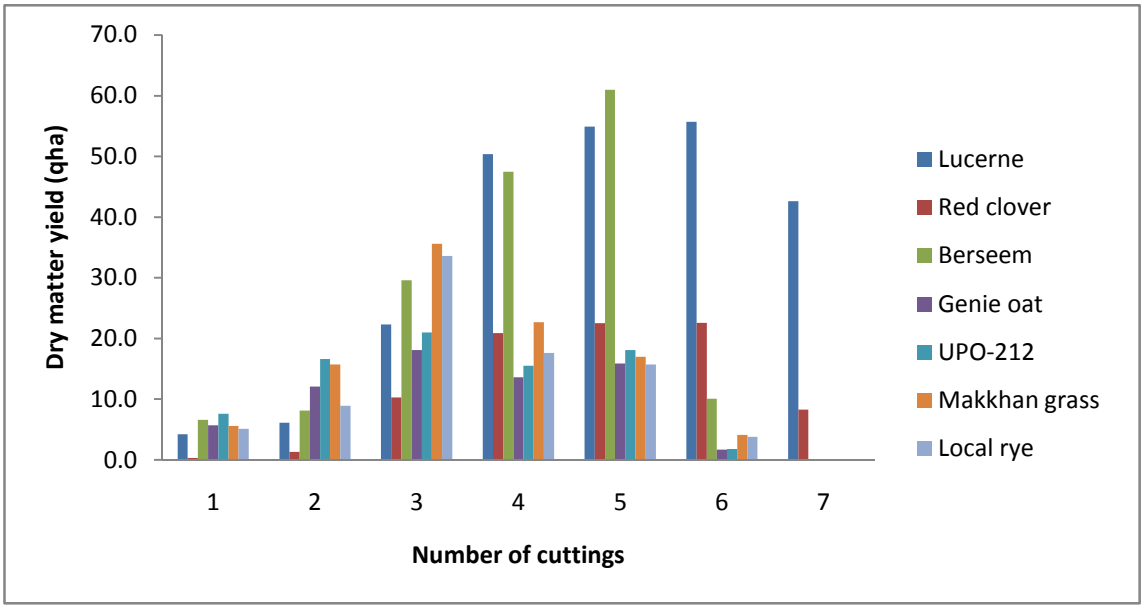


Fig14: Dry matter yield (q/ha) of different forage crops at different cuttings

Dry matter yield

The data pertaining to dry matter yield (q/ha) are given in table-13 and depicted in figure-14. Their analysis of variance is given in Appendix -XI.

The total dry matter yield was significantly more in the case of lucerne (Baralfa IN) followed by berseem (Mescavi) compared to remaining crops which was mainly due to more dry matter per cent (Table-12) and green forage yield (Table-11). The total dry matter yield of red clover (Braduro) was significantly less than other two

leguminous crops due to less green forage production (Table-11) and dry matter per cent (Table-12). Among oat varieties, the total dry matter yield of UPO-212 was significantly more than genie oat. In the case of rye grasses, the total dry matter yield of makkhan grass was significantly more than local rye.

Comparing dry matter yield among leguminous *rabi* season crops at different cuttings it was noticed that dry matter yield of lucerne (Baralfa IN) was significantly higher compared to other crops at 4^{th}, 6^{th} and 7^{th} cuttings, while at 1^{st}, 2^{nd}, 3^{rd} and 5^{th} cuttings, dry matter yield of berseem (Mescavi) was significantly higher compared to other leguminous *rabi* season forage crops (lucerne and red clover). This was also significantly higher compared to remaining crops at 5^{th} cuttings. Increased dry matter yield of berseem (Mescavi) from 1^{st} to 5^{th} cuttings, might be due to favourable environmental conditions for berseem enhancing yield component like taller plants (Table-4), more number of tillers per plant (Table-5) and more number of leaves (Table-6). At 6^{th} cutting, dry matter yield of berseem drastically decreased due to leaf senescence and degeneration of roots. Positive correlation of berseem dry matter with stem weight, leaf weight, plant height and leaf weight has been observed by earlier workers (**Tiwana *et al.*, 2003** and **Jatasra, 1981)**. Dry matter yield of lucerne (Baralfa IN) increased from 1^{st} to 6^{th} cutting. Taller plants (Table-4), perennial growth habit, drought tolerance and optimum temperature for growth (Appendix- I) might have resulted in enhanced dry matter accumulation by lucerne (Baralfa IN) plants. Enhancement in dry matter yield of lucerne from October to April has been reported by **McDonald *et al.* (2003)**. Dry matter yield of red clover was significantly less compared to other crops at 1^{st}, $2^{nd}$and 3^{rd} cuttings which might be due to shorter plants height (Table-4), less number of tillers/plant (Table-5), less number of leaves (Table-6). Unfavourable temperature (5.7^0 C to 21.9^0C) might have resulted in less dry matter yield (**Satell *et al.*, 1998; Barry *et al.*, 1998; Hay & Ryan, 1989** and **Litherland, 2001)**. Among oat varieties, dry matter yield of UPO-212 was significantly higher compared to genie oat at 1^{st}, 2^{nd}, 3^{rd} and 4^{th} cuttings, while at 5^{th} and 6^{th} cuttings both the oat variety had statistically similar dry mater yield. Higher dry matter yield of UPO-212 might be due to genotypic and phenotypic behavior of variety under favourable environment conditions during crop season which led to its increased distribution pattern with the advancement of the crop age (**Singh, 1992** and **Chandra, 2000)**.

Among rye grasses, dry mater yield of both the rye grass varieties was statistically similar at 1st, 5th and 6th cuttings while dry mater yield of makkhan grass was significantly higher compared to local rye at 2nd, 3rd and 4th cuttings. It is might be due to more tolerance of makkhan grass to low temperature (5^0C) as compared to annual rye grass. It has been reported earlier that cool-season grasses grow well between 20^0 and 25^0 C temperature and also can grow at temperatures as low as 5°C to as high as 35° C and they are dormant during the winter months at lower altitudes (**Moser and Hoveland, 1996** and **Rollo *et al.*, 1998)**.

Table 14: Crude protein (%) of different crops at different cuttings

Treatments	Crude protein (%)						
	Cutting						
	1	2	3	4	5	6	7
Lucerne (Baralfa IN)	24.8	23.1	22.0	21.5	20.1	18.4	13.6
Red clover (Barduro)	22.4	21.4	21.5	21.6	21.8	18.1	13.5
Berseem (Mescavi)	25.1	24.6	24.0	22.0	22.6	18.0	-
Oat (Genie Oat)	16.7	16.1	15.3	15.0	14.7	7.6	-
Oat (UPO-212)	16.5	16.0	16.8	14.0	12.7	7.4	-
Rye grass (Makkhan grass)	17.5	16.9	17.0	15.5	15.3	11.0	-
Rye grass (Local rye)	17.3	16.7	16.8	15.3	15.1	10.5	-
SEm±	0.2	0.2	0.2	0.2	0.2	0.3	-
CD at 5%	0.6	0.6	0.7	0.6	0.6	0.8	-

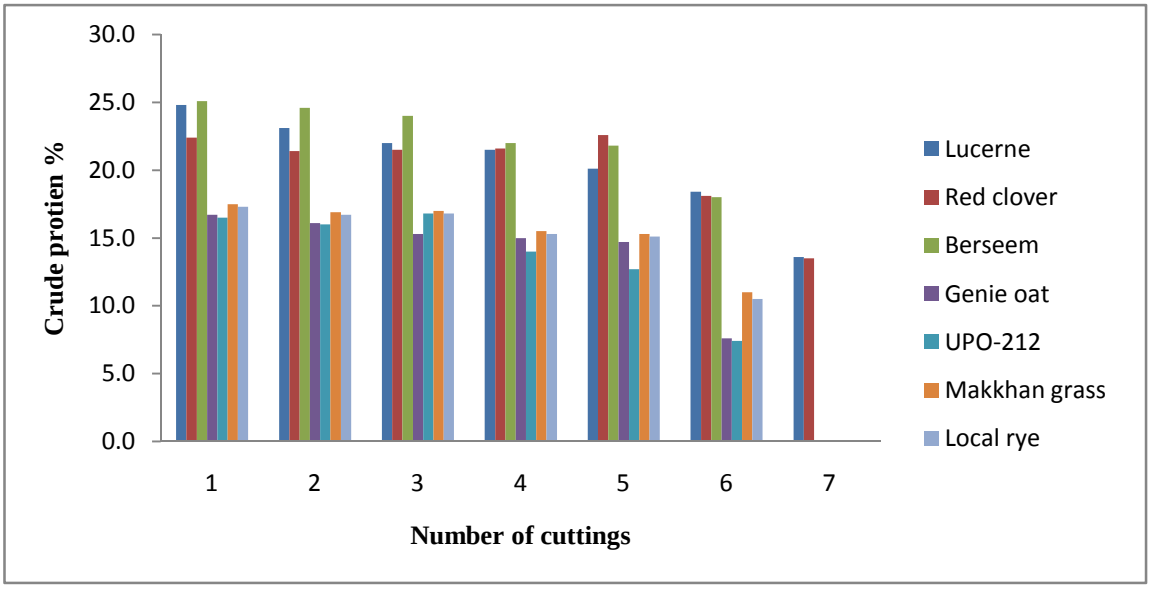


Fig 15: Crude protein (%) of different forage crops at different cuttings

Crude protein content

The data pertaining to crude protein content are given in table-14 and depicted in figure-15. Their analysis of variance is given in Appendix- XII.

In general, crude protein content at each cutting exhibited decreasing trend with the advancing frequency of cuttings. The crude protein content significantly decreased with advancing plant maturity **(Majumdar and Ahmed, 1980)**.

Among leguminous *rabi* season forage crops, crude protein content of berseem (Mescavi) was significantly higher at 2nd, 3rd and 5th cuttings compared to other leguminous crops except at 1st cutting where it was at par with lucerne (Baralfa IN) and at 4th cutting it was at par with both leguminous crops. Genetic potential of berseem and favourable temperatures (Appendix- I) might have helped in better absorption of nitrogen leading to its higher content (Table-23**)** as crude protein content is function of nitrogen content and a constant factor 6.25 (**Hakl *et al.*, 2003; Tiwana *et al.*, 2003; Sharma *et al.*, 1974; Deramus, 1980; Halmos, 1982** and **FAO report 2013)**. Crude protein content of red clover (Barduro) was statistically at par with lucerne and berseem variety at 4th, 6th and 7th cutting. This might be due to more number of tillers per plant (Table-5) and more number of leaves (Table-6) leading to more nitrogen content (Table-23) which ultimately enhanced protein content (**Sheaffer *et al.*, 1991; Hoffman and Broderick, 2001; Homolka *et al.*, 2012** and **Drobna *et al.*, 2006)**. Crude protein content of lucerne (Baralfa IN) was higher but it was statistically at par with berseem and red clover variety at 4th, 6th and 7th cuttings. Crude protein content of lucerne (Baralfa IN) was higher at early stage due to more vegetative growth which might have enhanced nitrogenous substrate content but toward maturity, more senescence of leaves and degeneration of effective roots in summer is decreased crude protein in berseem while lucerne is perennial crops and drought tolerance and can accumulate more nitrogen at later stage leading to better crude protein (**Lancefield *et al.*, 2009; Annicchiarico *et al.*, 2010; Jasjeet *et al.*, 2011** and **McDonald *et al.*, 2003)**. Among oat varieties, crude protein per cent of UPO-212 was significantly higher compared to genie oat at 3rd cutting while both the oat varieties had statistically similar crude protein in plants at 1st, 2nd, 4th and 6th cuttings. Higher crude protein per cent of UPO-212 might be due to more number of leaves at 3rd cutting (Table-6) which accumulate more nitrogen (Table-23). Crude protein content of genie oat significantly higher at 5th

cutting which might be due to more number of leaves (Table-6) but crude protein decreased with advancing age of crop. Results of earlier workers suggest that the crude protein content of different oat varieties ranged from 8.1 to 16.1 per cent at second cutting stage with the negative correlation between dry matter and crude protein yields in oats **(Joshi and Singh, 1982).** Crude protein content of both the rye grass varieties was statistically at par at all the cuttings. Decreasing trend was observed with advancing of crop to maturity due to leaves senescence. The results are in accordance with the results reported by **Morrison (1961), Thompson *et al.* (1990); National Research Council (1996**) and **Anonymous (2012)**.

Table 15: Crude protein yield (q/ha) of different crops at different cuttings

Treatments	Crude protein yield (q/ha)							
	Cutting							
	1	2	3	4	5	6	7	Total
Lucerne (Baralfa IN)	1.0	1.4	4.9	10.8	11.0	10.3	5.8	45.2
Red clover (Barduro)	0.1	0.3	2.2	4.5	5.0	4.1	1.1	17.4
Berseem (Mescavi)	1.7	2.0	7.1	10.4	13.7	1.8	-	36.3
Oat (Genie Oat)	1.0	1.9	2.8	1.9	1.9	0.1	-	9.6
Oat (UPO-212)	1.3	2.7	3.5	2.2	2.3	0.1	-	12.0
Rye grass(Makkhan grass)	1.0	2.7	6.0	3.5	2.6	0.4	-	16.3
Rye grass (Local rye)	0.9	1.5	5.6	2.7	2.4	0.4	-	13.5
SEm±	0.1	0.1	0.1	0.2	0.2	0.2	-	0.4
CD at 5%	0.2	0.3	0.3	0.5	0.5	0.4	-	1.2

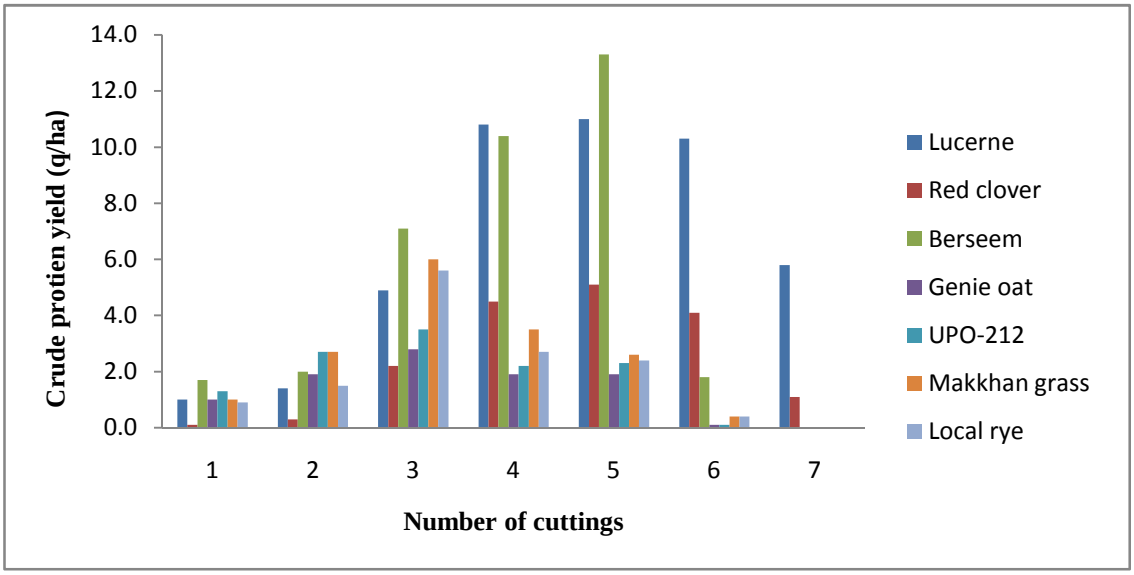


Fig 16: Crude protein yield (q/ha) of different forage crops at different cuttings

Crude protein yield

The data pertaining to crude protein yield (q/ha) are given in table-15 and depicted in figure-16. Their analysis of variance is given in Appendix- XIII.

The total crude protein yield was significantly more in the case of lucerne (Baralfa IN) followed by berseem (Mescavi) compared to remaining crops which was mainly contributed by its dry matter yield (Table-13) and crude protein content (Table-14). The total crude protein yield of red clover (Barduro) was significantly less than other two leguminous crops due to less dry matter yield (Table-13) even more number of cuttings. Among oat varieties, the total crude protein yield of UPO-212 was significantly more than genie oat while in the case of rye grasses, the total crude protein yield of makkhan grass was significantly more than local rye.

Crude protein yield of berseem (Mescavi) at 1^{st}, 2^{nd}, 3^{rd} and 5^{th} cuttings was significantly higher compared to leguminous *rabi* season forage crops and other crops. Crude protein yield of lucerne (Baralfa IN) was significantly higher compared to berseem and red clover variety at 6^{th} and 7^{th} cuttings while it was statistically at par with berseem (Mescavi) at 4^{th} cutting. Higher crude protein yield of berseem (Mescavi) might be due to more dry matter yield (Table-13) and crude protein content (Table-14) as the crude protein yield is a function of dry matter yield and crude protein content in dry matter. At 6^{th} cutting decrease in dry matter yield and crude protein content led to decreased crude protein yield. In the case of Lucerne (Baralfa IN), crude protein yield at 6^{th} and 7^{th} cuttings was higher because of its drought tolerance capacity which helps in production of green forage yield, dry matter yield and crude protein % in summer month too (**Deramus, 1980; Griffin *et al*., 1994** and **Alfred, 2012)**. Crude protein yield of red clover (Barduro) was significantly less compared to remaining crops at 1^{st}, 2^{nd} and 3^{rd} cuttings which might be due to lower production of green forage yield (Table-11) and dry matter yield (Table-13) under unfavourable temperature (5.7^0 C to 21.9^0 C) for growth and development **(Ledgard *et al*., 1988; Brock *et al*., 1989** and **Griffin *et al*., 1994)**. Among oat varieties, crude protein yield of UPO-212 was significantly higher compared to genie oat at 1^{st}, 2^{nd} and 3^{rd} cuttings while at 4^{th}, 5^{th} and 6^{th} cuttings crude protein yield of both the oat varieties was statistically similar. It might be due to higher green forage yield (Table-11), dry matter yield (Table-13), dry matter content (Table-12) and crude protein content (Table-14). Higher crude protein yield of UPO-212 has also been reported by **Thakuria (1992), Pisal *et al.* (1993)** and **Roy (2005)**. Among rye grasses, both the varieties had statistically similar crude protein yield at 1^{st},

5th and 6th cuttings. it is contributed to the higher value of dry matter yield (Table-13) and crude protein content (Table 14). Crude protein yield of makkhan grass was significantly higher compared to local rye at 2nd, 3rd and 4th cuttings. It might be due to dry matter yield production at this stage owing to suitable environmental conditions for proper growth and development as well as higher protein component. The results are in accordance with the results reported by **Walsh and Birrell (1987), Johnston *et al.* (1993)** and **Report of IGFRI (2012)**.

Table 16: Dry matter digestibility per cent of different crops at different cuttings

Treatments	Dry matter digestibility per cent						
	Cutting						
	1	2	3	4	5	6	7
Lucerne (Baralfa IN)	86.0	85.6	80.8	74.4	63.6	58.8	55.2
Red clover (Barduro)	89.6	88.8	86.0	84.8	81.6	75.6	73.2
Berseem (Mescavi)	91.2	80.0	75.6	68.0	60.0	51.6	-
Oat (Genie Oat)	88.4	80.8	78.8	69.2	62.4	60.4	-
Oat (UPO-212)	88.8	78.0	76.8	66.4	61.6	57.6	-
Rye grass (Makkhan grass)	82.8	89.2	88.8	86.8	72.8	66.0	-
Rye grass (Local rye)	90.4	89.2	87.2	86.4	72.0	65.2	-
SEm±	0.9	0.8	0.9	0.8	0.8	1.1	-
CD at 5%	2.6	2.6	2.8	2.3	2.2	3.1	-

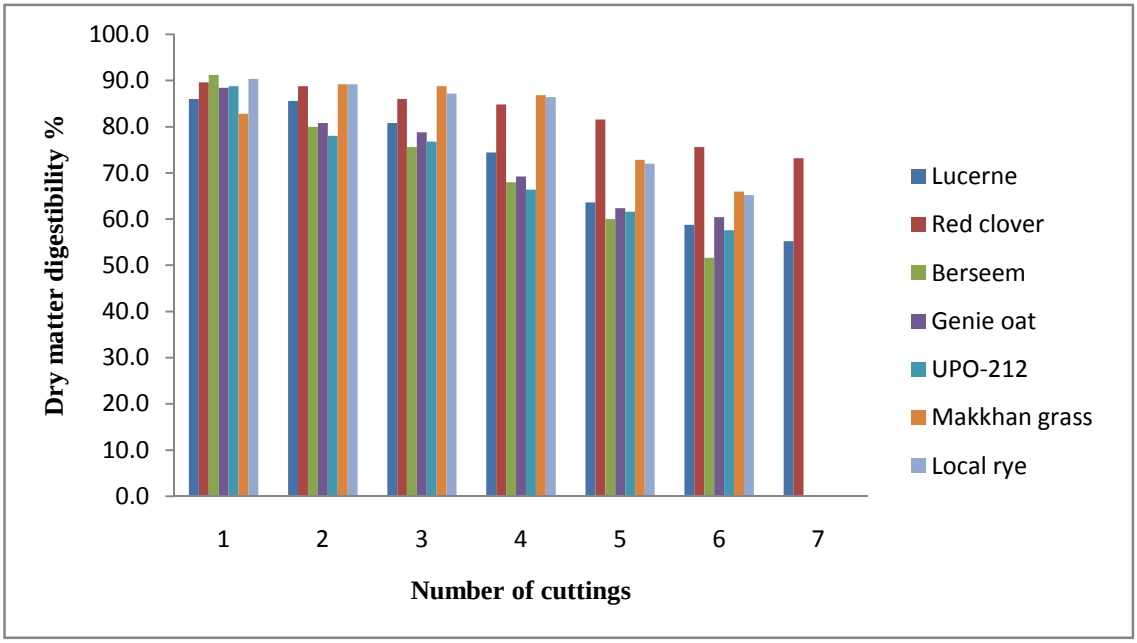


Fig-17: Dry matter digestibility per cent of different crops at different cuttings

Digestibility dry matter content

The data on dry matter digestibility are presented in table-16 and depicted in figure-17. The analysis of variance is given in Appendix- XIV.

In general, the decline in digestibility is associated with increasing lignin content and a reduction in degradability of polysaccharides other than starch **(Taylor and Quesenberry, 1996)**.

Among leguminous *rabi* season forage crops, dry matter digestibility of red clover (Barduro) was significantly higher compared to lucerne and berseem variety from 2nd to 7th cuttings, while at 1st cutting dry matter digestibility of red clover (Barduro) and berseem (Mescavi) was statistically at par. It might be due to lower acid detergent fibre (Table-19) and neutral detergent fibre (Table-18) in red clover (Baraduro) as compared to berseem (Mescavi) and lucerne (Baralfa IN). When red clover and lucerne are of similar fibre content, red clover is more digestible than lucerne providing more energy-dense forage to the diets of lactating dairy cows and also has higher concentrations of readily fermentable carbohydrate (soluble sugars and pectin) and lower concentrations of structural carbohydrate **(Wilson *et al.*, 1991; Wiersma *et al.*, 1998; Barry *et al.*, 1999; Hakl *et al.*, 2003** and **Hoffman and Broderick, 2001**). Dry matter digestibility of berseem (Mescavi) and lucerne (Baralfa IN) was decline with advancement of crop age might be due to more acid detergent fibre (Table-19) and neutral detergent fibre (Table-18) content in plant. The nutritive value of lucerne, in terms of digestibility and protein content, decreases with advancing maturity by 0.3-0.5% per day from early flowering to near maturity stage (**Wiersma *et al.*, 1998; ICAR, 2012** and **McDonald *et al.*, 2003)**. Dry matter digestibility of both the oat varieties was statistically similar at all the cuttings except 2nd and 4th cuttings. It might be due to almost similar fibre content (Table-18, 19). Observation made by earlier workers supports these findings (**Sangha *et al.*, 1980; Joshi and Singh, 1982; Joshi *et al.*, 2005** and **Roy, 2005)**. At 2nd and 4th cuttings, dry matter digestibility of genie oat was significantly higher compared to UPO-212. Among rye grasses, dry matter digestibility of both the rye grass varieties was statistically similar at all the cuttings except at 1st cuttings where dry matter digestibility of local rye was significantly higher compared to makkhan grass. The similarity in dry matter digestibility of both varieties might be due to

more succulence and less fibre (Table- 18, 19) while digestibility decreased with age of crop. The results are in accordance with the results reported by **Minson (1990c)** and **Moore *et al.* (2006)**.

Table 17: Digestible dry matter yield (q/ha) of different crops at different cuttings

Treatments	Digestible dry matter yield (q/ha)							
	Cutting							
	1	2	3	4	5	6	7	Total
Lucerne (Baralfa IN)	3.6	5.2	18.0	37.6	34.9	32.7	23.5	155.5
Red clover (Barduro)	0.3	1.1	8.8	17.7	18.4	17.0	6.0	69.6
Berseem (Mescavi)	6.1	6.5	22.4	32.3	36.6	5.2	-	109.0
Oat (Genie Oat)	5.1	9.7	14.3	9.4	9.9	1.0	-	49.4
Oat (UPO-212)	6.7	12.9	16.1	10.3	11.1	1.0	-	58.2
Rye grass(Makkhan grass)	4.7	14.0	31.6	19.7	12.4	2.7	-	85.0
Rye grass (Local rye)	4.6	7.9	29.3	15.2	11.3	2.5	-	70.9
SEm±	0.3	0.5	0.5	0.7	0.7	0.3	-	1.7
CD at 5%	0.9	1.5	1.4	1.9	2.0	0.9	-	5.0

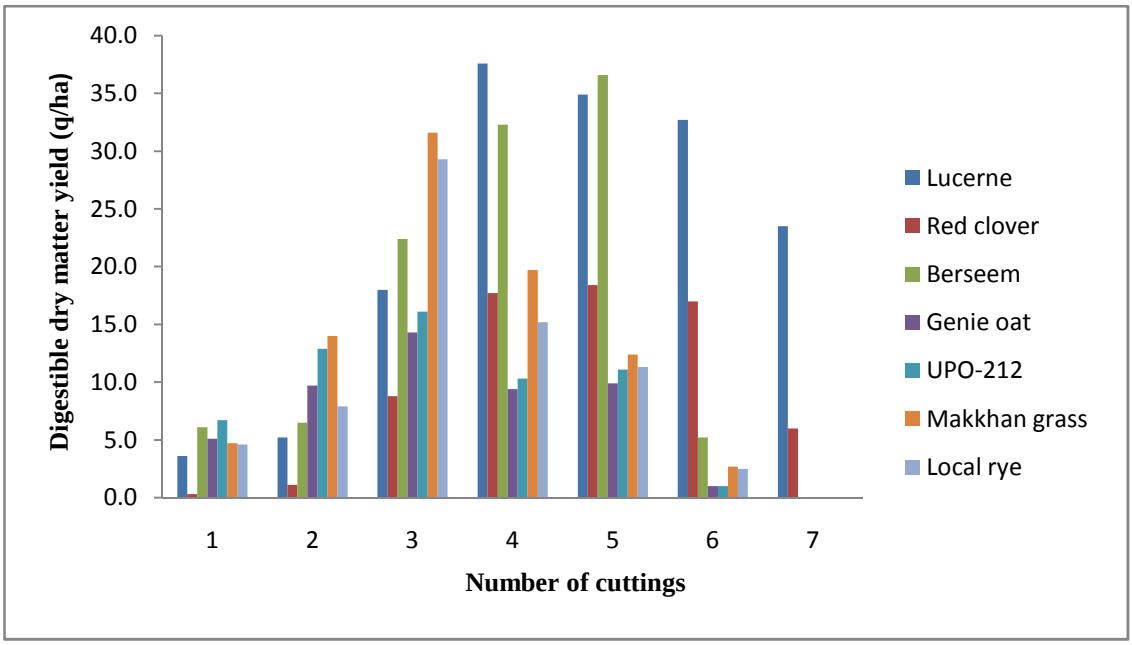


Fig 18: Digestible dry matter yield (q/ha) of different forage crops at different cutting

Digestible dry matter yield (DDMY)

The data on digestible dry matter yield are presented in table -17 and depicted in figure-18. The analysis of variance is given in Appendix- XV.

The total digestible dry matter yield was significantly more in case of lucerne (Baralfa IN) compared to remaining crops which was mainly contributed by its more dry matter yield (Table-13) and more cuttings (7 cuttings). Red clover (Barduro) yield was significantly less than other two leguminous crops due to its poor dry matter yield (Table-13) even more number (7) of cuttings and high digestible dry matter (Table-16) could not compensate the total digestible dry matter yield. Among oat varieties, the total digestible dry matter yield of UPO-212 was significantly more than genie oat. Among rye grasses, the total digestible dry matter yield of makkhan grass was significantly more than local rye.

Comparing cutting wise, it was noticed that among leguminous *rabi* season forage crops, digestible dry matter yield of berseem (Mescavi) was significantly higher compared to lucerne (Baralfa IN) and red clover (Barduro) at 1^{st} and 3^{rd} cutting, while at 2^{nd} and 5^{th} cuttings, digestible dry matter yield of berseem (Mescavi) was higher but it was statistically at par with lucerne (Baralfa IN). Higher digestible dry matter yield of berseem might be due to more dry matter yield (Table-13) and digestible dry matter content (Table-16) as the digestible dry matter yield is a function of these two factor. At later stages increased temperature (Appendix-I) might have caused degeneration of roots and leaves senescence ultimately reduced dry matter yield leading to reduction in digestible dry matter yield **(Jatasra, 1981; Taneja *et al.*, 1987 and Tiwana *et al.*, 2003).** At 4^{th}, 6^{th} and 7^{th} cuttings, digestible dry matter yield of Lucerne (Baralfa IN) was significantly higher compared to remaining crops under study. It might be due to perennial growth habitat and deep root system which enhances drought tolerance capacity of crop resulting in dry mater yield in late summer when yield of other leguminous forage crops drastically reduces **(Jasjeet *et al.*, 2011** and **Kokate, 1990)**. Digestible dry matter yield of red clover (Barduro) was significantly less compared to other crops at 1^{st}, 2^{nd} and 3^{rd} cuttings. It might be due to unfavourable environment condition especially temperature (5.7^0 C-21.9^0 C) which hinder the growth and development ultimately reduced the yield but increase in temperature also increased yield till 5^{th} cutting and decreased at later stage which caused in reduction in digestible dry matter yield. Inverse relationship of advancing forage maturity and declining of

forage quality has been reported earlier **(Hakl *et al.*, 2003)**. Among oat varieties, digestible dry matter yield of UPO-212 was significantly higher compared to genie oat at 1st, 2nd and 3rd cuttings, while at 4th, 6th and 7th cuttings, digestible dry matter yield of both the varieties was statistically similar. Higher digestible dry matter yield of UPO-212 at early stages might be due to higher dry mater yield (Table-13) and dry mater digestibility (Table-16) under favourable environment condition but later on digestible dry matter yield decreased due to less dry mater yield and dry mater digestibility in both varieties of oat. In general UPO-212 had higher digestible dry matter yield compared with genie oat. These results corroborate with the finding of **Deorari (2002)** and **Joshi *et al.* (2005)**. Among rye grasses, both the rye grass varieties had statistically similar digestible dry matter yield at 1st, 5th and 6th cuttings while at 2nd, 3rd and 4th cutting, digestible dry matter yield of makkhan grass was significantly higher compared to local rye. Digestible dry matter yield of both the rye grass varieties increased till 3rd cutting later on decreased due to sensitive to high temperatures and drought. Digestible dry matter yield of makkhan grass was higher than local rye at all cuttings due to its perennial nature and more tolerance to cold winter at early stage and can maintain growth at 5.7^0 C and produce higher green forage yield (Table-11), dry matter yield (Table-13), dry mater digestibility (Table-16) and later stage though, yield decreased but not lower than local rye. Higher yield of makkhan grass upto 3rd cutting has also been reported by **Garwood & Sinclair (1979); Moser and Hoveland** (**1996)** and **Anonymous (2012)**.

Table 18: Neutral detergent fibre content of different crops at different cuttings

Treatments	**Neutral detergent fibre content**					
	Cutting					
	1	**2**	**3**	**4**	**5**	**6**
Lucerne (Baralfa IN)	39.0	42.0	44.0	55.0	58.0	56.0
Red clover (Barduro)	41.0	44.0	46.0	47.0	52.0	50.0
Berseem (Mescavi)	38.0	43.0	51.0	61.0	66.0	64.0
Oat (Genie Oat)	47.0	50.0	56.0	63.0	68.0	64.0
Oat (UPO-212)	46.0	48.0	52.0	61.0	68.0	65.0
Rye grass (Makkhan grass)	44.0	47.0	52.0	64.0	68.0	66.0
Rye grass (Local rye)	43.0	45.0	49.0	65.0	69.0	66.0
SEm±	1.3	2.7	3.1	2.9	3.1	1.9
CD at 5%	3.8	NS	NS	8.6	9.1	5.5

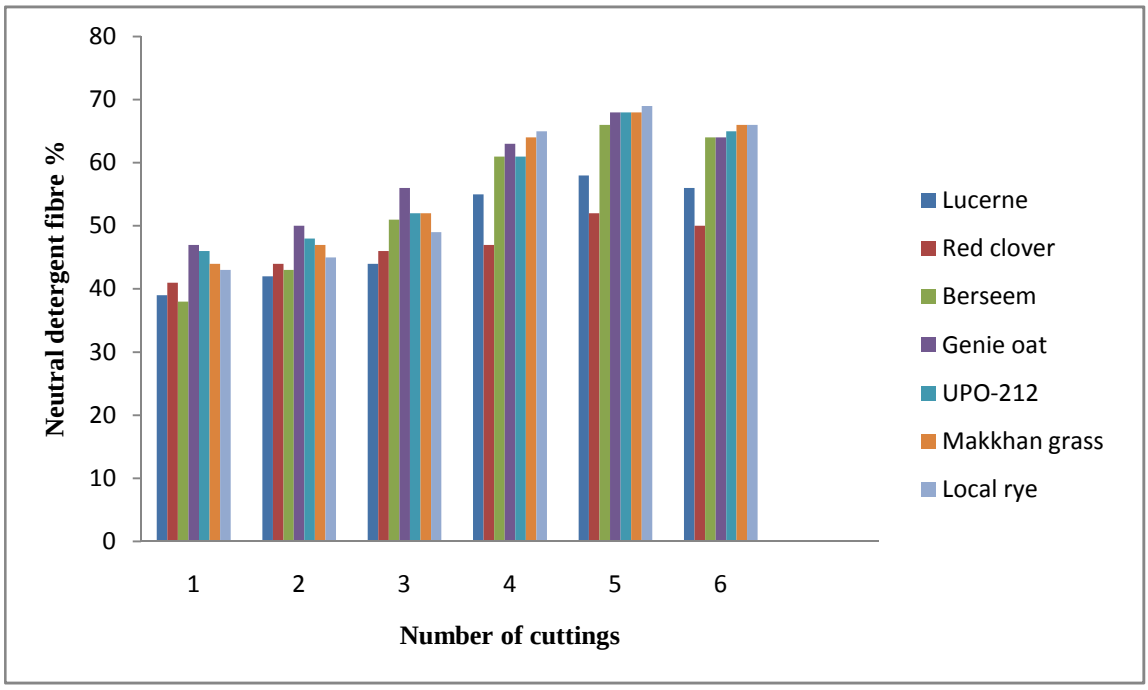


Fig 19: Neutral detergent fibre content of different forage crops at different cuttings

Neutral detergent fibre content

The data on neutral detergent fibre content are presented in table-18 and depicted in figure-19. The analysis of variance is given in Appendix- XVI.

Neutral detergent fibre of all crops was non significant at 2nd and 3rd cuttings. Red clover (Barduro) had higher neutral detergent fibre but it was at par with leguminous cool season forage crops at 1st cutting. The neutral detergent fibre of berseem (Mescavi) was statistically at par with lucerne (Baralfa IN) at 4th and 5th cuttings but significantly higher compared to lucerne and red clover variety at 6th cutting. Neutral detergent fibre per cent of red clover (Barduro) was statistically at par with lucerne (Baralfa IN) at 4th cutting, while it was significantly lower compared to other crops at 5th and 6th cuttings. In general, neutral detergent fibre per cent of leguminous *rabi* season forage crops (berseem, lucerne and red clover) increased which might be due to progressively increased cellulose, hemicelluloses and lignin content in plant with advancement of crop age till 5th cutting and later on decreased due to degeneration of plant parts (**Hakl *et al.*, 2003)**. However, these results contradict with the findings of **Harris *et al.* (1982)**, **Ranjhan (1991) and Yahana (1996**). NDF content was slightly higher in present investigation which might be due

to slight variation in different growth stage under environment condition, especially variation in temperature **(Report of Environment Directorate, Organization for Economic Co-operation and Development Paris, 2005)**. Among oat varieties, neutral detergent fibre per cent of genie oat was higher but it was statistically at par with UPO-212 at 1st 4th, 5th and 6th cuttings. Comparatively lower neutral detergent fibre in UPO-212 than genie oat might be due to less cellulose, hemicelluloses (Table-21) and lignin content in plant but in both the oat varieties NDF content increased with advancement in crop age. The results are in accordance with the results reported by **Mohammad *et al.* (1994)** and **Jain (1994) and Singh (1994)**. Among rye grasses, both the varieties had statistically similar NDF at 1st 4th, 5th and 6th cuttings and increased with advancement in crop age due to increased in cellulose, hemicelluloses and lignin content in plants. Higher NDF content of makkhan grass at early stage might be due to its low temperature tolerance capacity (5^0C) which can grow better than local rye. Higher NDF content in the present investigation might be due to variation in environmental conditions especially variation in temperature. It has been observed earlier that the nutritive value of perennial ryegrass varies throughout the growing season **(Johnston *et al*., 1993)**.

Table-19: Acid detergent fibre content of different crops at different cuttings

Treatments	**Acid detergent fibre content**					
	Cutting					
	1	**2**	**3**	**4**	**5**	**6**
Lucerne (Baralfa IN)	25.6	26.4	29.8	34.8	37.2	35.4
Red clover (Barduro)	26.0	27.0	30.0	31.6	35.4	33.4
Berseem (Mescavi)	29.4	32.6	33.4	34.8	39.4	37.2
Oat (Genie Oat)	27.0	29.0	32.4	33.8	35.8	34.2
Oat (UPO-212)	26.6	27.0	31.6	33.0	35.8	34.8
Rye grass (Makkhan grass)	27.2	29.0	33.0	36.8	39.0	38.0
Rye grass (Local rye)	26.2	28.0	32.0	36.6	38.0	35.8
SEm±	0.6	0.4	0.6	0.6	0.5	0.5
CD at 5%	1.7	1.2	1.6	1.9	1.6	1.6

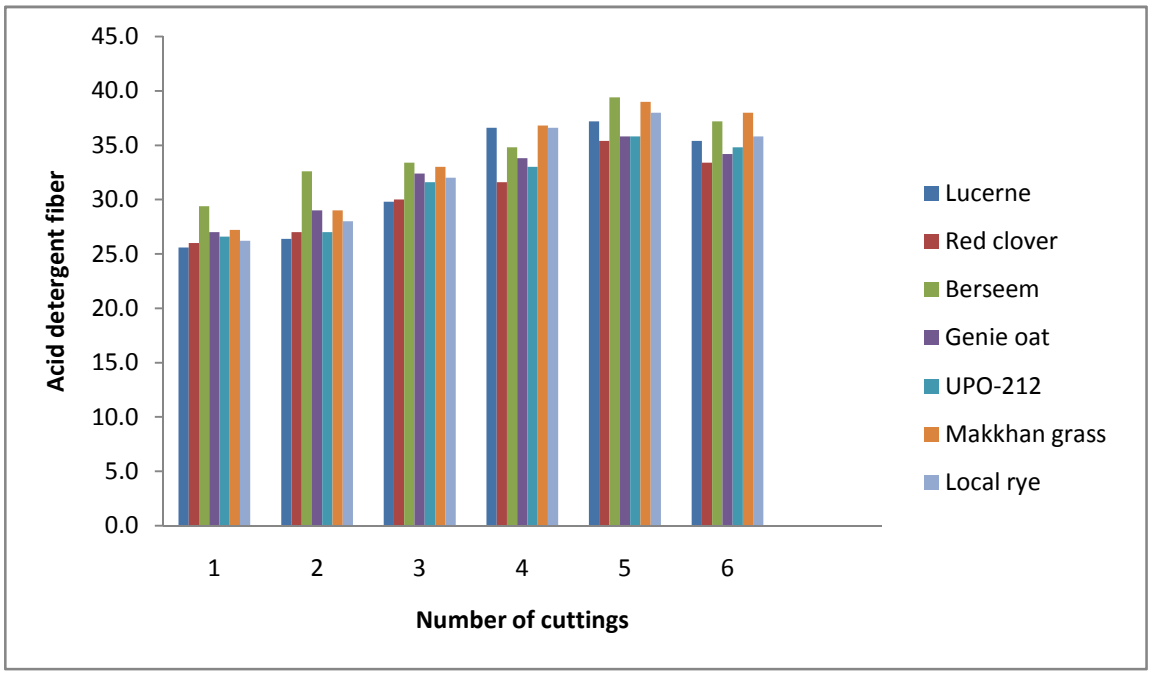


Fig 20: Acid detergent fibre content of different forage crops at different cuttings

Acid detergent fibre content

The data on acid detergent fibre content are presented in table-19 and depicted in figure-20. The analysis of variance is given in Appendix- XVII.

Among leguminous *rabi* season forage crops, acid detergent fibre in berseem (Mescavi) was significantly higher compared to lucerne (Baralfa IN) and red clover (Barduro) at all the cuttings except at 4th cutting. Acid detergent fibre per cent of red clover (Barduro) was statistically at par with lucerne (Baralfa IN) at 1st, 2nd and 3rd cuttings, while it was also statistically similar with oat and rye grass varieties at 1st cutting. In general acid detergent fibre of leguminous *rabi* season forage crops (berseem, lucerne and red clover) increased which might be due to progressively increased cellulose and lignin content in plant with advancement of crop age till 5th cutting while berssen had higher ADF content than lucerne (Baralfa IN) and red clover (Barduro). Inverse relationship of advancing forage maturity and declining of forage quality has been reported by **Hakl *et al*. (2003)**. Among oat varieties, acid detergent fibre in genie oat was higher but it was statistically at par with UPO-212

at all the cuttings except at 2nd cutting where acid detergent fibre of genie oat was significantly higher compared to UPO-212. Comparatively lower acid detergent fibre of UPO-212 than genie oat might be due to less hemicellulose (Table-21) and lignin content in plants but in both the oat varieties ADF content increased with advancement in crop age. The results are in accordance with the results reported by **Mohammad *et al.* (1994), Jain (1994), Singh (1994)** and **Gupta and Pradhan (1974)**. Among rye grass, acid detergent fibre of makkhan grass was higher but it was statistically at par with local rye at all cuttings except at 6th cutting where acid detergent fibre of makkhan grass was significantly higher compared to local rye. Neutral detergent fibre of both rye grasses might have increased with advancement in crop age due to more lignifications of cells at later stages of growth. Higher ADF content of makkhan grass at all cuttings might be due to its genetic makeup. The results are in accordance with the results reported by **(Johnston *et al.*, 1993** and **Smith *et al.*, 2005)**.

Table 20: Cell content (%) of different crops at different cuttings

Treatments	Cell content (%)					
	Cutting					
	1	2	3	4	5	6
Lucerne (Baralfa IN)	60.8	58.0	56.0	45.0	42.0	44.0
Red clover (Barduro)	58.8	56.0	54.0	53.0	48.0	50.0
Berseem (Mescavi)	62.0	56.8	49.0	34.0	33.0	36.0
Oat (Genie Oat)	53.0	50.0	44.0	37.0	32.0	36.0
Oat (UPO-212)	53.8	52.0	48.0	39.0	32.0	35.0
Rye grass (Makkhan grass)	56.0	53.0	48.0	36.0	32.0	31.0
Rye grass (Local rye)	57.2	55.0	51.0	35.0	33.0	34.0
SEm±	1.5	2.7	3.1	2.9	3.1	1.9
CD at 5%	4.3	NS	NS	8.6	9.1	5.5

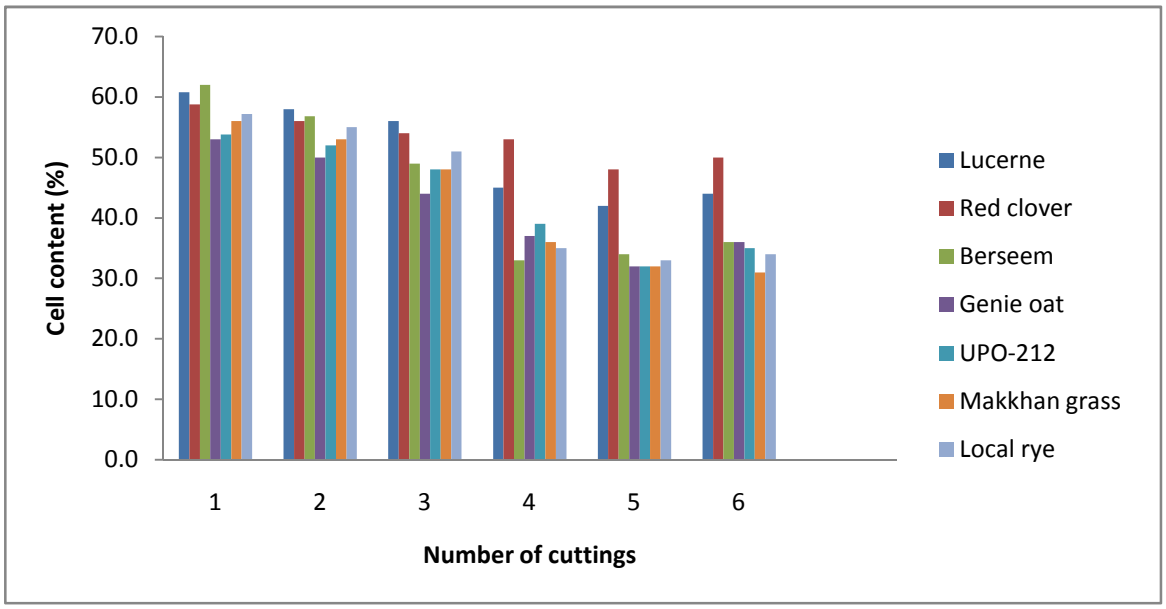


Fig 21: Cell content (%) of different crops at different cuttings

Cell content (%)

In general, cell content of all forage crops decreased with advancement in crop age (Table-20).

All the crops differed significantly with respect to cell content at all the cuttings (Appendix- XVIII).

Cell content of all crops was non significant at 2nd and 3rd cuttings. Cell content of berseem (Mescavi) was statistically at par with lucerne (Baralfa IN) and red clover (Barduro) but significantly more than other crops at 1st cutting. Cell content of berseem (Mescavi) was significantly lower compared to other leguminous *rabi* season forage crops at 4th and 6th cuttings. Higher cell content in berseem (Mescavi) at 1st cutting might be due to lower NDF (Table-18) as inverse relationship exists between cell content and NDF. More cell content indicates better quality of crops **Bosch *et al.* (1992)**. Cell content of all crops decreased till 5th cutting while at 6th cutting slightly increased cell content of all *rabi* season forage crops might be due to temperature effect. The results are in accordance with the results reported by **Ranjhan (1991)** reported the chemical composition of berseem (Mesacvi) fodder as cell content 46.6 to 57.55%. In general, cell content of all the forage crops decreased till 5th cutting. This might be due to increased NDF (Table-18) with increase in temperature **(Deinum, 1966)**. Cell content of red clover (Barduro) was significantly higher compared to all crops at 6th cutting, At 4th and 5th

cuttings it was statistically at par with lucerne (Baralfa IN) but significantly more than berseem (Mesacvi). Cell content of oat varieties was statistically similar at 1st, 4th, 5th and 6th cuttings, however UPO-212 had slightly higher cell content which might be due to lower NDF content. The results are in accordance with the results reported by **Singh *et al.* (2001); Jain (1994)** and **Singh (1994)**. Among rye grasses, cell content of both the rye grass varieties was statistically similar at 1st, 4th, 5th and 6th cuttings. Cell content of rye grass and oat varieties was statistically similar at 4th, 5th and 6th cuttings probably due to almost similar NDF (Table 18).

Table 21: Hemicellulose % of different crops at different cuttings

Treatments	Hemicellulose %					
	Cutting					
	1	2	3	4	5	6
Lucerne (Baralfa IN)	13.6	15.6	14.2	20.2	19.8	20.6
Red clover (Barduro)	15.2	17.0	16.0	15.4	16.6	17.2
Berseem (Mescavi)	8.6	10.2	17.6	24.4	26.6	28.8
Oat (Genie Oat)	20.0	20.8	23.2	29.2	32.2	29.8
Oat (UPO-212)	19.6	21.0	20.4	28.0	32.2	30.2
Rye grass (Makkhan grass)	16.8	18.0	18.8	27.2	29.0	31.0
Rye grass (Local rye)	16.6	16.8	17.0	28.4	31.0	30.2
SEm±	1.3	2.6	3.1	3.2	3.1	1.9
CD at 5%	3.9	NS	NS	NS	9.1	5.8

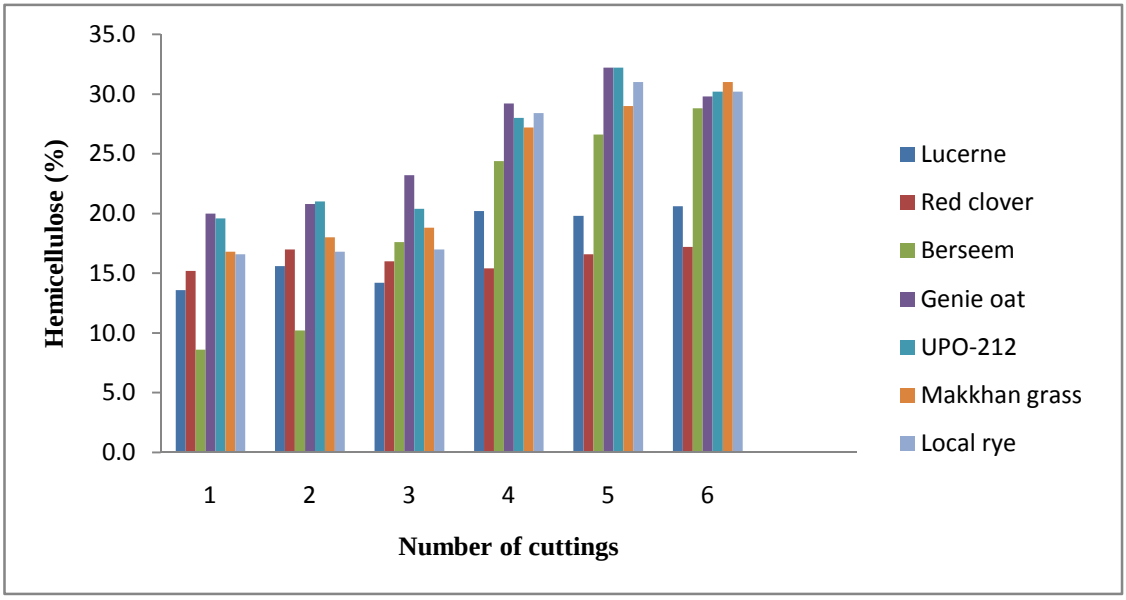


Fig 22: Hemicellulose % of different forage crops at different cuttings

Hemicellulose (%)

The data pertaining to hemicelluloses are given in table-21 and depicted in figure-22. Their analysis of variance is given in Appendix- XIX.

Hemicelluloses of all crops was non significant at 2nd, 3rd and 4th cuttings. It increased in subsequent cuttings till 6th cut in all the forage crops. Among leguminous *rabi* season forage crops, hemicellulose in red clover (Barduro) was statistically at par with lucerne (Baralfa IN) at 1st, 5th and 6th cuttings while hemicelluloses in berseem (Mescavi) was significantly lower compared to all crops at 1st cutting and it was statistically at par with lucerne (Baralfa IN) at 5th cutting and significantly higher compared to other leguminous *rabi* season forage crops (lucerne and red clover) at 6th cutting. Lower the value of hemicelluloses give better quality of forage and fodder. Lower hemicelluloses of berseem (Mescavi) at 1st cutting might be due to more succulent plant parts and good nutritional value **(Fraser *et al.*, 2004** and **Yahana, 1996)**. Less hemicelluloses of red clover (Braduro) at 4th cutting might be due to variation in growth under changing temperature towards advancement in cutting which enhances the proportion of cell wall components (cellulose, hemicellulose, and lignin) as reported by **Bosch *et al.* (1992)**. Hemicellulose of lucerne (Baralfa IN) at 3thand 5th cuttings decreased slightly. Reduction in hemicellulose of lucerne (Baralfa IN) at the later stage has been reported by **Kaushal *et al.* (2006)**. Hemicellulose of both the oat varieties was statistically similar at 1st, 5th and 6th cuttings but hemicellulose content of UPO-212 was slightly decreased at 3rd cutting in the present investigation which is in accordance with the findings of **Gupta and Pradhan (1974)**. Among rye grasses, hemicellulose of both the rye grass varieties was statistically similar at all the cuttings indicating that both the rye grass varieties response in similar ways for producing hemicellulose in their cell wall (**Jarrige and Minson, 1964** and **Johnston *et al.*, 1993))**. In the present investigation also the cell wall content of both rye grass varieties was similar at all the cuttings (Table-21).

Table 22: Ash content of different crops at different cuttings

Treatments	Ash content					
	Cutting					
	1	2	3	4	5	6
Lucerne (Baralfa IN)	17.4	19.6	12.8	12.8	10.0	9.6
Red clover (Barduro)	25.0	20.0	14.4	15.6	10.0	9.6
Berseem (Mescavi)	27.6	30.8	12.6	10.4	8.8	7.6
Oat (Genie Oat)	11.2	12.8	14.4	11.6	10.4	8.8
Oat (UPO-212)	12.6	13.2	15.2	12.8	10.4	8.8
Rye grass (Makkhan grass	18.0	20.0	12.4	12.8	12.0	10.0
Rye grass (Local rye)	18.4	20.0	11.6	12.0	11.2	9.6
SEm±	0.6	0.9	0.7	0.8	0.6	0.9
CD at 5%	1.7	2.6	NS	NS	NS	NS

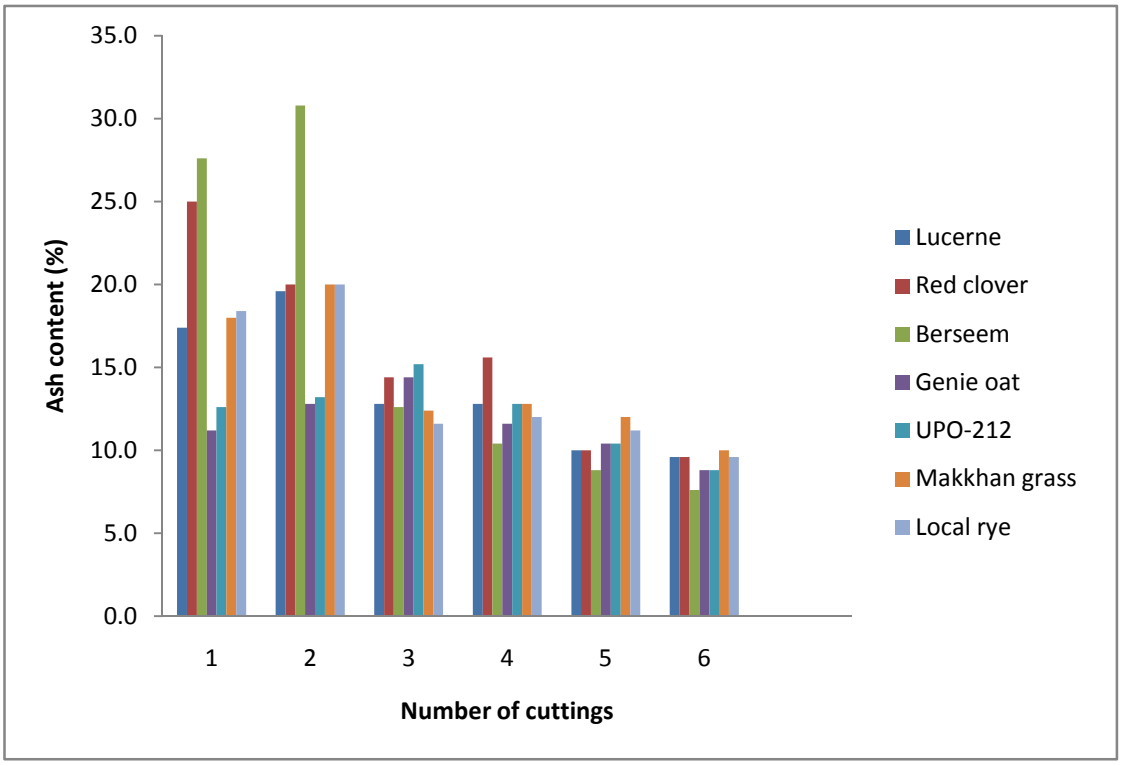


Fig 23: Ash content of different forage crops at different cuttings

Ash content (%)

The data pertaining ash content are given in table-22 and depicted in figure-23. Their analysis of variance is given in Appendix- XX.

Ash content of all the crops increased upto 2nd cutting and decreased in subsequent cuttings. Decreased in mineral contents of oat **(Sangha *el al*., 1980)**, red clover (**Vasiljevic *et al*., 2011)** with advancement in age has been observed in the past. It was non significant among all crops at 3rd, 4th, 5th and 6th cuttings. Ash content of berseem was significantly higher compared to other leguminous *rabi* season forage crops (luceren and red clover) and other crops at 1st and 2nd cuttings. Ash content is indicative of total mineral contents in plants. In the present investigation highest ash content in berseem (Mescavi) is evident from the higher value of N, P and K (Table23, 24 and 25). However, it contradicts with the findings of **Khan (1994)** and **Yahana (1996**) who were of the opinion that ash contents of berseem (Mescavi) increases from January to April. **Report of FAO (2013)** indicated that ash content in berseem ranged from 11.3 to 20.2%, while ash content slightly higher observed in the present investigation might be due to favourable environment condition. Ash content of lucerne (Baralfa IN) was significantly less compared to other two leguminous crops at 1st cutting while at 2nd cutting, it was at par with red clover **Drobna *et al.* (2006)** and **Vasiljevic *et al*. (2011)** observed highest contents of minerals in plants at the beginning of the growing seasons (first and second cuttings) which supports the results of present investigation. Among oat varieties, ash content of UPO-212 was higher but it was statistically at par with genie oat at 1st and 2nd cuttings. It might be due to favourable environment condition and better root development at early stage (**Hoffman *et al*., 2005)**. Among rye grasses, both the rye grass varieties had statistically similar ash content at 1st and 2nd cuttings but significantly more than oat varieties. It suggests that rye grass contain more minerals compared to oat at early stage might be due to better root development of rye grasses at early stage accumulating more nutrients (**Hoffman *et al*., 2005)**. These results are also supported by higher N, P and K contents in rye grasses compared to oat varieties (Table 23, 24 and 25).

Table 23: Nitrogen % of different crops at different cuttings

Treatments	Nitrogen % of different crops at different cuttings					
	Cutting					
	1	2	3	4	5	6
Lucerne (Baralfa IN)	3.97	3.68	3.51	3.41	3.20	2.98
Red clover (Barduro)	3.59	3.45	3.45	3.40	3.49	2.91
Berseem (Mescavi)	5.14	4.02	3.84	3.52	3.61	2.88
Oat (Genie Oat)	2.67	2.58	2.45	2.40	2.35	1.21
Oat (UPO-212)	2.64	2.57	2.68	2.24	2.01	1.19
Rye grass (Makkhan grass)	2.80	2.71	2.70	2.48	2.44	1.76
Rye grass (Local rye)	2.77	2.67	2.64	2.45	2.41	1.68
SEm±	0.03	0.30	0.03	0.03	0.03	0.04
CD at 5%	0.09	0.11	0.11	0.10	0.10	0.13

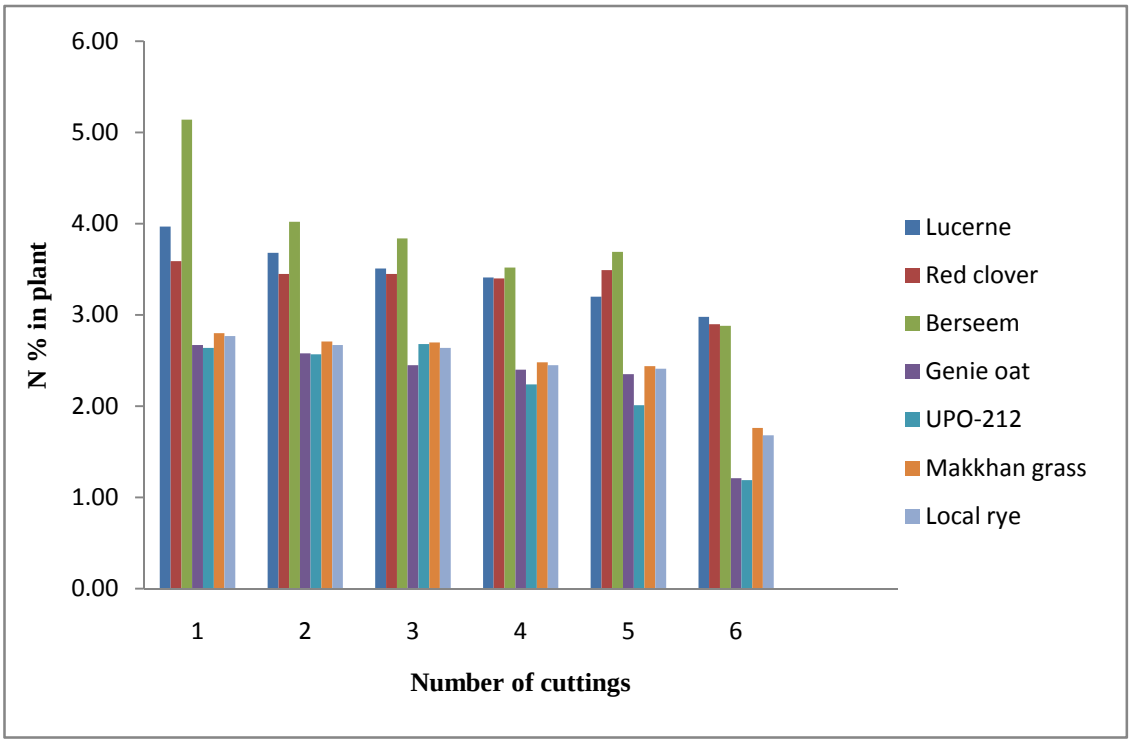


Fig 24: Nitrogen % of different forage crops at different cuttings

Nitrogen content (%)

The data pertaining to nitrogen content in plants are given in table-23 and depicted in figure-24.Their analysis of variance is given in Appendix- XXI.

In general, decrease in leaf:stem ratio with advancement in age has been attributed to the decreased in nitrogen content of plants **(Tyrolova and Vyborna, 2008).** In the present investigation also nitrogen content decreased with advancement in age (Table-23).

Nitrogen content of all crops was higher in 1st cutting and decreased in subsequent cuttings. Full dose of nitrogen to leguminous crops and half dose of nitrogen to other crops was applied as basal which might have made more availability of nitrogen to crop plants at first cutting. Nitrogen content of berseem (Mescavi) was significantly higher compared to leguminous *rabi* season forage crops (lucerne and red clover) and other crops at all the cuttings except at 6th cutting where all the three leguminous crops had similar nitrogen content but significantly more than other crops. Higher nitrogen content in leguminous forage crops at 6th cutting compared to other crops might be due to better root system and more active nodulation in the roots fixing more atmospheric nitrogen **(Halmos, 1982** and **Fraser *et al.*, 2004**). On the other hand, other crops did not get additional nitrogen at later stages leading to reduce nitrogen content. Lucerne (Baralfa IN) plants contained significantly more nitrogen compared to red clover (Barduro) at 1st and 2nd cutting but at 5th cutting red clover (Barduro) contained more nitrogen compared to lucerne (Baralfa IN). The nutritive value of red clover (Barduro) forage is influenced by the growing year and environmental conditions (**Taylor *et al.*, 1996** and **Tamm *et al.*, 2003)** which might have caused variation in nitrogen content in the present investigation. Among oat varieties, nitrogen content of genie oat was higher but it was statistically at par with UPO-212 at 1st, 2nd and 6th cuttings while nitrogen content of genie oat was significantly higher compared to UPO-212 at 4th and 5th cuttings. It might be due to long duration of genie oat than UPO-212 and less senescence of number of leaves (Table-6). Nitrogen content of UPO-212 was significantly higher compared genie oat at 3rd cutting. It might be due to more number of leaves (Table-6). Among rye grasses, nitrogen content of makkhan grass was higher but it was statistically at par with local rye at all cuttings. This might be due to genetic factor, tolerance to change in temperature and more dry mater accumulation through

plant (Table-9).The results are in accordance with the results reported by **Moser and Hoveland (1996)** and **Crush *et al.* (2011)**.

Table 24: Phosphorus content (%) of different crops at different cuttings

Treatments	Phosphorus % of different crops at different cuttings					
	Cutting					
	1	2	3	4	5	6
Lucerne (Baralfa IN)	0.30	0.32	0.35	0.37	0.38	0.37
Red clover (Barduro)	0.28	0.31	0.34	0.36	0.37	0.36
Berseem (Mescavi)	0.32	0.34	0.36	0.37	0.38	0.36
Oat (Genie Oat)	0.26	0.30	0.32	0.31	0.30	0.29
Oat (UPO-212)	0.26	0.30	0.33	0.31	0.30	0.28
Rye grass (Makkhan grass)	0.27	0.30	0.33	0.32	0.31	0.30
Rye grass (Local rye)	0.27	0.29	0.32	0.31	0.31	0.30
SEm±	0.003	0.004	0.003	0.004	0.004	0.004
CD at 5%	0.01	0.01	0.01	0.01	0.01	0.01

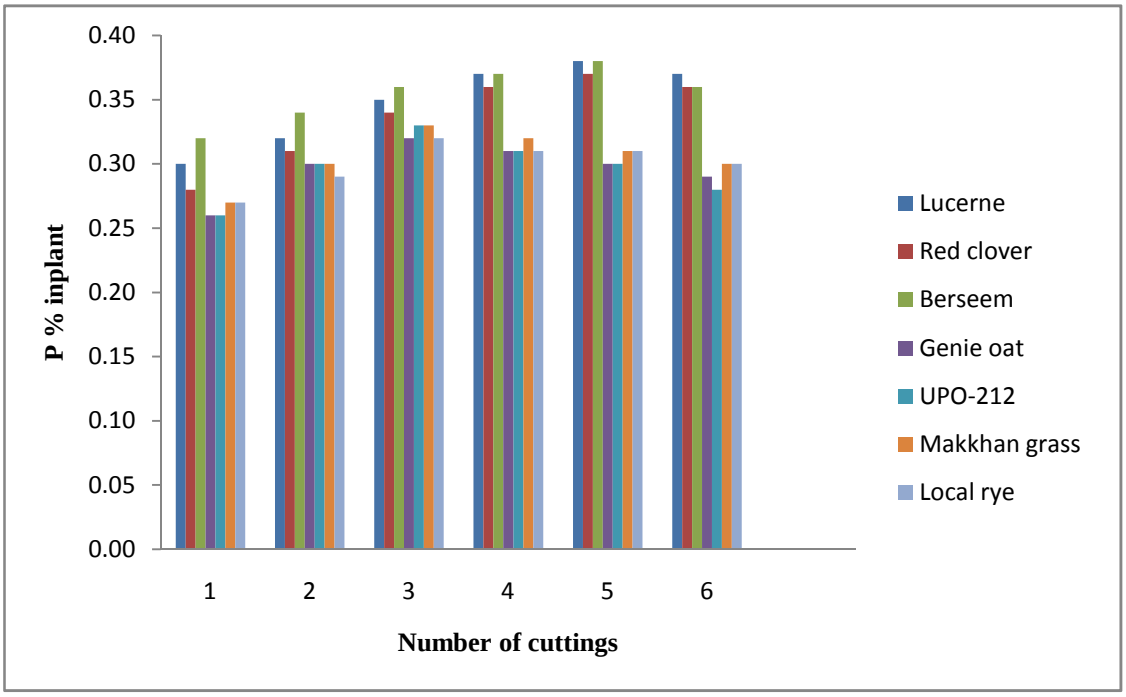


Fig 25: Phosphorus content (%) of different forage crops at different cuttings

Phosphorus content (%)

The data pertaining to phosphorus content are given in table-24 and depicted in figure-25. Their analysis of variance is given in Appendix -XXII.

The phosphorus content in plants was least at 1st cutting and increased in subsequent cuttings till 5th cut in leguminous crops and till 3rd cutting in other crops. It might be due to proper growth and development of plant at initial stage which might have led to more uptake of minerals but at later stages decreased due to unfavourable environment condition and degeneration of roots (**Mayland *et al.*, 1976)**. Among leguminous *rabi* season forage crops, phosphorus content of berseem (Mescavi) was higher but it was statistically at par with lucerne (Baralfa IN) at 3rd and 4th cuttings while at 1st and 2nd cuttings phosphorus content of berseem (Baralfa IN) was significantly higher compared to lucerne (Baralfa IN) and red clover (Barduro) however, it was statistically similar at 5th and 6th cuttings in all the leguminous crops. It might be due to tap root system which uptake the phosphorus from deeper layer for better growth and development of nodules while at later stage decreased due to degeneration of roots. It has been observed earlier that P and K contents decreased significantly with the increase of the defoliation (**Mezni *et al.*, 2013** and **Yahana, 1996)**. Oat and Rye grass varieties contained similar phosphorus at all the cuttings.

Table 25: Potassium % of different crops at different cuttings

Treatments	Potassium % of different crops at different cuttings					
	Cutting					
	1	2	3	4	5	6
Lucerne (Baralfa IN)	2.12	2.14	2.30	2.70	2.58	2.65
Red clover (Barduro)	1.93	1.95	2.10	2.23	2.29	2.26
Berseem (Mescavi)	2.16	2.20	2.42	2.62	2.63	2.60
Oat (Genie Oat)	1.27	1.30	1.45	1.43	1.41	1.38
Oat (UPO-212)	1.27	1.28	1.42	1.41	1.39	1.37
Rye grass (Makkhan grass)	1.38	1.40	1.43	1.40	1.38	1.35
Rye grass (Local rye)	1.35	1.37	1.41	1.39	1.36	1.33
SEm±	0.004	0.01	0.006	0.009	0.006	0.008
CD at 5%	0.01	0.03	0.02	0.03	0.02	0.02

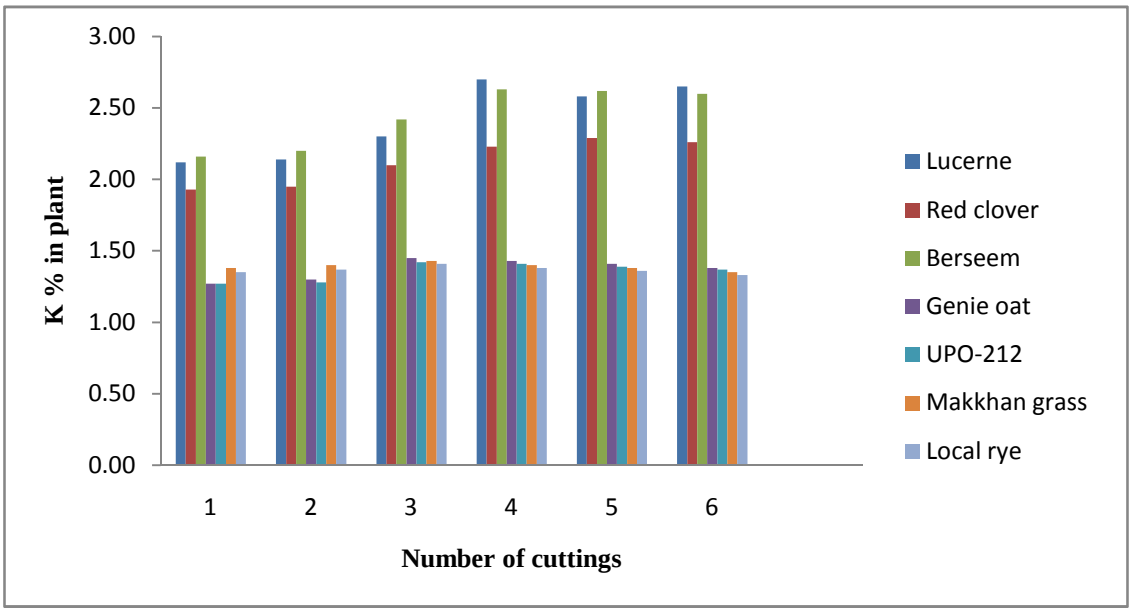


Fig 26: Potassium % of different forage crops at different cutting

Potassium content (%)

The data pertaining to potassium content are given in table-25 and depicted in figure-26. Their analysis of variance is given in Appendix- XXIII.

Potassium content increased with increases in cutting frequency upto 5th cut in case of leguminous crops and upto 3rd cut in other crops. This might be due to relatively favourable environmental conditions for legumes upto 5th cutting and unfavourable condition, especially temperature for other crops after 3rd cutting **(Mezni *et al*., 2013)**. Potassium content in berseem (Mescavi) was significantly higher compared to leguminous and other *rabi* season forage crops at all cuttings except 4th and 6th cuttings, while potassium content in lucerne (Baralfa IN) was significantly higher compared to leguminous and other crops *rabi* season forage crops at 4th and 6th cuttings. Potassium content of all leguminous *rabi* season forage crops increased till 5th cutting after that decreased with increasing cutting frequency. This result is contradicting with finding of **Mezni *et al*. (2013)** who reported that P and K contents decreased significantly with the increase of the defoliation frequency. This might be due to location and environment effect. However, **Yahana (1996), reported of Environment Directorate, Organization for Economic Co-operation and Development Paris (2005)** and **Dragomir (2006)** supported the present finding. Among oat varieties, potassium content in genie oat was significantly higher compared with UPO-212 at 3rd cutting while it was statistically similar with UPO-212 at 1st, 2nd, 4th, 5th and 6th cuttings.

Among rye grasses, potassium content of makkhan grass was significantly higher compared to local rye at 1st cutting while at 2nd, 3rd, 4th, 5th and 6th cuttings makkhan grass was statistically at par with local rye with respect to potassium content. Among oat and rye grass varieties the potassium content increased till 3rd cutting and at later stages decreased. Potassium content in oat has been found quite high at the early stages but steadily decreased with advancing maturity **(Mayland *et al.*, 1976)**.

Table 26: Green forage and dry matter productivity per day of different forage crops

Treatments	Green forage productivity per day (q/ha)	Dry matter productivity per day (q/ha)
Lucerne (Baralfa IN)	4.73	0.98
Red clover (Barduro)	2.08	0.36
Berseem (Mescavi)	4.65	0.78
Oat (genie oat)	2.25	0.32
Oat (UPO-212)	2.44	0.38
Rye grass (Makkhan grass)	2.90	0.48
Rye grass (Local rye)	2.44	0.40
$SE_{m\pm}$	0.04	0.01
CD at 5 %	0.12	0.03

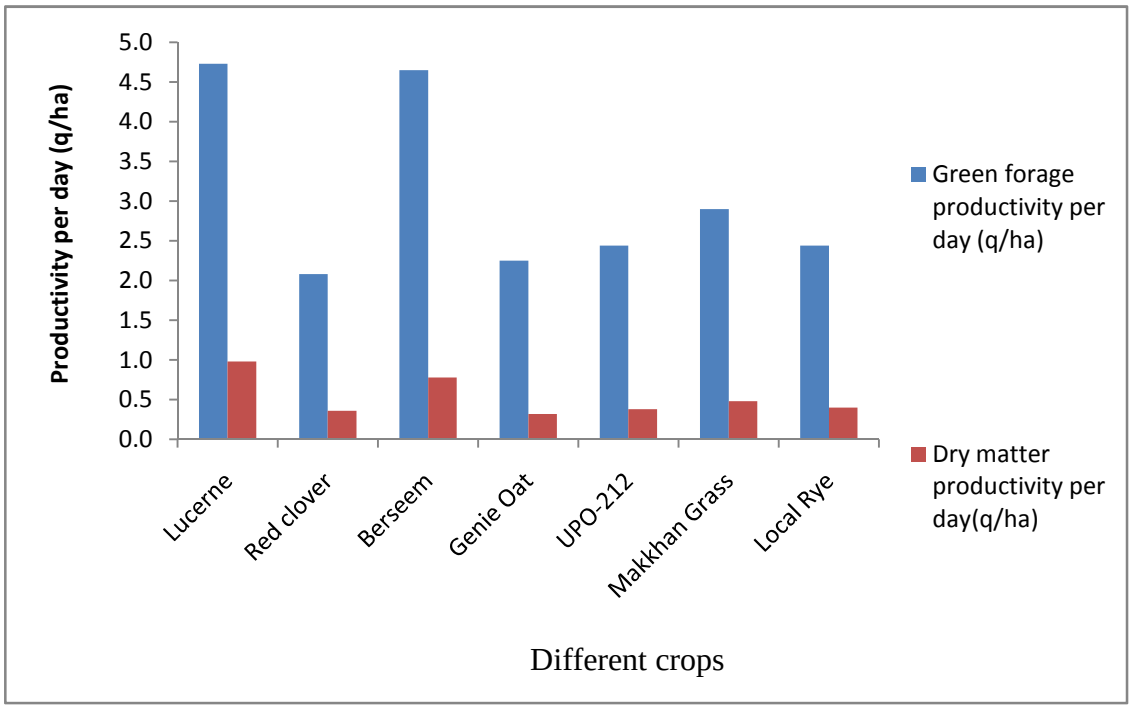


Fig 27: Green forage and dry matter productivity per day of different forage crops

Green forage and dry matter productivity per day

The data on green forage and dry matter productivity per day are presented in table-26 and depicted in figure-27. The analysis of variance is given in Appendix-XXIV.

The productivity per day of newly introduced Baralfa IN variety of lucerne giving 7 cuttings was comparable to that of local Mescavi variety of berseem which gave 6 cuttings, however, the dry matter productivity per day of Baralfa IN was significantly more compared to berseem. The productivity per day of Barduro variety of red clover was significantly less than other crops. Oat and rye grass varieties gave six cuttings. The productivity per day of oat variety UPO-212 was significantly more compared to newly introduced variety genie oat. In case of rye grass varieties, the newly introduced Makkhan grass variety had significantly higher green forage and dry matter productivity per day compared to local rye grass.

Baralfa In variety of lucerne had shown more promising as reflected by higher productivity per day under *Tarai* agro-climatic condition. This newly introduced variety had higher dry matter accumulation (Table-9), L:S ratio (Table-10), green forage yield (Table-11), dry matter content (Table-12) and dry matter yield (Table-13) which might have led to higher productivity per day compared to other legumes crops. Similar were the observations on UPO-212 variety of oat and Makkhan grass variety of rye grass reflecting into more productivity per day.

Summary and Conclusions

Chapter 5 SUMMARY AND CONCLUSIONS

The present investigation entitled **"GROWTH, YIELD AND QUALITY OF *RABI* SEASON FORAGE CROPS UNDER *TARAI* REGION OF UTTARAKHAND"** was conducted at Forage Agronomy Block of Instructional Dairy Farm, Nagla, G.B. Pant University of Agriculture and Technology, Pantnagar (Udham Singh Nagar), Uttarakhand during *Rabi* season of 2012-2013. The experiment laid out in Randomized Block Design with five replications. Treatments consisted of seven winter season forage crops viz. Lucerne, Red clover, Berseem, Rye grass (Makkhan grass and Local rye), and Oat (UPO-212 and Genie Oat). The salient findings of the study are summarized in this chapter and listed below:

1. Plant height of berseem (Mescavi) was more compared to red clover (Barduro) and lucerne (Baralfa IN) while shorter plants were observed in red clover (Barduro). Among oat varieties, plants of UPO-212 were taller than genie oat. Among rye grasses, local rye had more plants height than makkhan grass.

2. Berseem (Mescavi) had more number of tillers than red clover and lucerne variety. Among oat varieties, tillers of UPO-212 were more compared to genie oat. Among rye grasses, makkhan grass had more tillers than local rye.

3. More leaves were observed in lucerne (Baralfa IN) plants and least in berseem (Mescavi) plants compared to remain leguminous *rabi* season forage crops. Among oat varieties, leaves were more in genie oat than UPO-212. Among rye grasses, local rye had more number of leaves compared with makkhan grass.

4. Dry matter accumulation through leaves was highest in lucerne (Baralfa IN) and least in berseem (mescavi) than other leguminous forage crops. Among oat varieties, dry matter accumulation through leaves was more in genie oat compared with UPO-212. Among rye grasses, makkhan grass had more dry matter accumulation through leaves than local rye.

5. Dry matter accumulation through stem was highest in berseem (Mescavi) plants and least in red clover (Barduro) than remaining leguminous *rabi* season forage crops. Among oat varieties, dry matter accumulation through stem was more in

genie oat than UPO-212. Among rye grasses, dry matter accumulation through stem was more in local rye than makkhan grass.

6. Lucerne (Baralfa IN) plants accumulated highest dry matter than red clover and berseem variety. Among oat varieties, dry matter accumulation by crop was more in genie oat than UPO-212. Among rye grasses, dry matter accumulation by crop was more in makkhan grass than local rye.
7. Lucerne (Baralfa IN) and red clover (Barduro) had more leaf:stem ratio than berseem (Mescavi). Among oat varieties, leaf:stem was more in genie oat than UPO-212. Among rye grasses, leaf:stem was more in makkhan grass than local rye.
8. Highest green forage yield, dry matter yield, crude protein yield and digestible dry matter yield was obtained from lucerne (Baralfa IN) crop and least from red clover (Barduro) than remain leguminous *rabi* season forage crops. Among oat varieties, green forage yield, dry matter yield, crude protein yield and digestible dry matter yield was higher in the UPO-212 than genie oat while among rye grasses, these yields was higher in the makkhan grass than local rye.
9. Among leguminous *rabi* season forage crops, dry matter per cent was more in the lucerne (Baralfa IN) compared to red clover (Barduro) and berseem (Mescavi). Among oat varieties, dry matter per cent of UPO-212 was more than genie oat. Dry matter per cent of both rye grass varieties was almost similar.
10. Crude protein per cent was highest in berseem (Mescavi) plants than lucerne (Baralfa IN) and red clover (Barduro). Among oat varieties, crude protein per cent was higher in genie oat than UPO-212. Crude protein per cent was higher in makkan grass compared with local rye.
11. Dry matter digestibility was higher in red clover (Barduro) compared to Lucerne (Baralfa IN) and berseem (Mescavi) while lowest digestibility was observed in berseem (Mescavi) crop than other leguminous *rabi* season forage crops. Among oat varieties, dry matter digestibility of genie oat was more than UPO-212. Dry matter digestibility of makkhan grass was slightly higher than local rye.

12. NDF, ADF and Hemicellulose per cent of berseem (Mescavi) was higher among leguminous *rabi* season forage crops. Among oat varieties, higher NDF, ADF and Hemicellulose per cent was observed in genie oat compared with UPO-212. Among rye grasses, NDF, ADF and Hemicellulose per cent of makkhan grass was slightly higher than local rye.

13. Cell content of red clover (Barduro) was highest and least in berseem (Mesacvi) compared with remaining leguminous crops. Among oat varieties, UPO-212 showed slightly higher cell content compared to genie oat. Among rye grasses, cell content of local rye was relatively higher than makkhan grass.

14. Among leguminous *rabi* season forage crops, Ash content of red clover (Barduro) was mostly similar to berseem (Mescavi) crop while ash content of lucerne (Baralfa IN) was lowest among leguminous *rabi* season forage crops. Among oat varieties, ash content of UPO-212 was higher compared to genie oat. Among rye grasses, ash content of makkhan grass was higher compared to local rye.

15. P and K contents were higher in the berseem (Mescavi) plants compared with Lucerne (Baralfa IN) and red clover (Barduro). Among oat varieties, P content of both varieties was similar while K content of genie oat was higher than UPO-212. Among rye grasses, P and K contents in makkhan grass was higher compared to local rye.

16. N per cent was highest in berseem (Mescavi) plants than lucerne (Baralfa IN) and red clover (Barduro). Among oat varieties, N per cent was higher in genie oat than UPO-212. Among rye grasses, N per cent was higher in makkan grass compared with local rye.

Conclusion

On the basis of the present investigation it is concluded that among leguminous *rabi* season forage crops lucerne, among oats UPO-212 and among rye grasses Makkhan grass, were found to have higher yield and quality of fodder and therefore can be suggested to cultivate under *Tarai* region of North India. However, it required further study for conformity of results.

Literature Cited

LITERATURE CITED

Adam Queen., Hugh Earl and William Deen 2009. Light and Moisture Competition Effects on Biomass of Red Clover Under seeded To Winter Wheat. *Agronomy Journal*. 101(6): 1511-1521.

Aklilu, M.G. 2005. Studies on growth, yield and quality of forage oat (*Avena sativa* L.) varieties under different level of nitrogen. M. Sc. Thesis submitted G.B. Pant University of Agriculture and Technology, Pantnagar 196 p.

Alam, S.M. and Sharif, M. 1997. Chemical composition and evaluation of berseem fodder grown in Punjab. *Pak. J. Sci.& Ind. Res*.,20(2): 94-95.

Alfred, S. 2012. Evaluation of herbicides for weed management in berseem (*Trifolium alexandrinum* L.).M.Sc. Thesis submitted to G.B. Pant Uni. of Agric. And Tech., Pantnagar 98 p.

Amrane, R. and Michaeletdoreau, B. 1993. Effect of maturity stage of Italian ryegrass and lucerne on ruminal nitrogen degradability. *Ann. Zootech*. 42: 31-37.

Anonymous. 2012. Report of royal barenburg group, Advanta winter forage pdf. www.nutrifeed.in/pdf/. Date 2/2/14.

Anonymous 2011-2012. Ministry of Agriculture government of India. 150 p.

AOAC, 1965. Official methods of analysis. Association of official Agricultural Chemicals. 10th ed. pp. 744-745.

Annichiarico, P., Scotti, C., Carelli, M. and Pecetti, L. 2010. Questions and avenues for lucerne improvement. *Czech. Journal of Genetic Plant Breeding*, 46 (1): 1-13.

Arinze, E.A., Schoenau, G.J., Sokhansanj, S. and Adapa, P. 2003. Aerodynamic separation and fractional drying of alfalfa leaves and stems. A review and new concept. *Drying Technology* 21 (9):1669-1698.

Arnott, R.A. and Ryle, G.J.A. 1982. Leaf surface expansion on the main axes of white and red clovers. *Grass and Forage Science* 37: 227–233.

Avice, J.C., Ourry, A., Lemaire, G., Volenec, J.J. and Boucaud, J. 1996. Root protein and vegetative storage protein are key organic nutrients for alfalfa shoot regrowths. *Crop Science* 37: 561-570.

Australian Government 2008. The biology of *Lolium multiflorum* Lam, (Italian ryegrass), *Lolilum perenne* L. (Perennial ryegrass) and *Lolium arundinaceum* (Schreb.) Darbysh (Tall fescue). pp.1-83.

Bajpai, L. D., Arora, S. P. and Relwai, L.L. 1976. Nitrate accumulation in oats as influence by nitrogen and stage of plant growth. *Forage Res*., 2 (2): 175-177.

Bali, A.S. and Shah, M.S. 1998a. Performance of different of oat (*Avena Sativa* L.) cultivar to cutting management and planting dates in rice-oat cropping system. *Forage Res*., 24 (3): 169-170.

Balocchi, Oscar, A. and Ignacio, F. Lopez 2009. Herbage production, nutritive value and grazing performance of diploid and tetraploid perennial rye grass cultivars (*Lolium perenne* L.). *Chilean J.Agric. Research*, 69 (3) : 4331-339.

Bargo, F., Muller, L.D., Kelver, E.S. and Delahoy, J.E. 2003. Invited review: Production and digestion of supplemented dairy cows on pasture. *Journal of Dairy Science*, 86 : 1- 42.

Barry, T.N. and Wilson, P.R. 1998. Growth, voluntary food intake and digestion in farmed temperate and tropical deer. *Acta Veterinaria Hungarica* 46 (3): 369-380.

Barry, T.N., Wilson, P.R. and Kemp, P.D. 1999. A review of forage grazing systems toproduce venison according to market signals. Proceedings New Zealand Society of Animal Production 59: 140-144.

Belyea, R., Restrepo, R.; Martz, F. and Ellersieck, M. 1999. Effect of year and cutting on equations for estimating net energy of alfalfa forage. *Journal of Dairy Science*, 82 : 1943 - 1949.

Beever, D., Offer, N. and M. Gill. 2000. The feeding value of grass and grass products. Chapter 7 in Grass: Its Production and Utilisation, 3rd ed., A. Hopkins, ed. Oxford, UK: British Grassland Society, Blackwell Science Publications. 838 p.

Beever, D. E. and Thorp, C. 1996. Advances in the understanding of factors influencing the nutritive value of legumes. In: Younie, D. (ed.) *Legumes in Sustainable Farming Systems*. Occasional Symposium No. 30, *British Grassland Society*, Reading, pp. 194-207.

Blair, G.1997. Matching pasture to the Australian environment. Chapter 5. In: JV Lovett, JM Scott, eds, *Pasture Production and Management*, edition 1.Inkata press, Victoria. pp. 88-109.

Black A.D., Laidlaw, A.S., Moot, D.J. and P. O'Kiely 2009. Comparative growth and management of white and red clovers. *Irish Journal of Agricultural and Food Research* 48: 149-166.

Bocher, L. 2010. Reasons to make forage first in the ration. Greener horizon for crops, cows and communities. U.S Dairy Forage Research Centre education materials. 178 p.

Bokde, S. 1968. Effect of different levels of nitrogen application and cutting intervals on the yield and quality of fodder oats. *Indian J. Agric. Sci.,* 38: 887-930.

Bosch, M.W., Tamminga, S., Post, G., Leffering, C.P. and Muylaert, J.M. 1992. Influence of stage of maturity of grass silages on digestion processes in dairy cows. 1. Composition, nylon bag degradation rates, fermentation characteristics, digestibility and intake. *Livestock Production Science*, 32 : 245 - 264.

Bounejmate, M. 1997. Berseem (*Trifolium alexandrinum* L.). In: Jaritz, G.; Bounejmate, M., Production et utilisation des cultures fourragères au Maroc, INRA, Rabat (Maroc), 144-147.

Brink, G.E. and Fairbrother, T.E. 1988. Cool- and warm-season forage legume potential for the southeastern USA. *Trop. Grassland* 22 (3): 116-125.

Brock, J.L., Caradus, J.R. and Hay, M.J.M. 1989. Fifty years of white clover research in New Zealand. Proceedings New Zealand Grassland Association 50 : 25-39.

Brown, H.E., Moot, D.J. and Teixeira, E.I. 2006. Radiation use efficiency and biomass partitioning of lucerne (*Medicago sativa*) in a temperate climate. *European Journal of Agronomy* 25: 319-327.

Burgess, P.L., Grant, E.A. and Nicoloision, J.W.G. 1972. Feeding value of forage oats. *Canadians J. Agric. Sci*. 52: 443-450.

Buttery, P. J. 1977. Aspects of biochemistry of rumen fermentation and their implication in ruminant productivity. In: Recent Advances in Animal Nutrition. Edit., W. Haresign and D. Lewis, Butterworths, London. pp. 8-12.

Buxton, D. R., Hornstein, J. S. W. F., Wedin, and Marten, G. C. 1985. Forage quality in stratified canopies of alfalfa, birdsfoot trefoil, and red clover. *Crop Sci*., 25: 273-279.

Buxton, D. R., and Redfearn, D. D. 1997. Plant limitation to fibre digestion and utilization. Conference: New Development in Forage science contributing to enhanced fibre utilization by Ruminants. *Journal of Nutrition* 127(5): 8145-8185.

Callow, M. N., Lowe, K. F., Bowlder, T. M., Lowe, S. A. and Gobius, N. R. 2003. Dry matter yield, forage quality and persistent of tall fescue (*Festuca arundinacea* L.) cultivars compared with perennial ryegrass (*Lolium perenne* L.) in subtropical environment. *Australian journal of experimental Agriculture* 43:1093-1099.

Chakraborty, T., Mandal, S. and Haldar, S. 1999. Effect of different levels of nitrogen and cutting on growth, forage and grain yield of oats (*Avena Sativa* L.). *Crop Res*., 18 (1): 39-45.

Campbell, B. D. and Kunelius, H. T. 1984. Performance of over drilled red clover with different sowing rates and initial grazing managements. *New Zealand Journal of Experimental Agriculture* 12: 71-81.

Chandra, 2000. Studies on the seed yield of promising Oat (*Avena Sativa* L.) genotype under different cutting management. M. Sc. Thesis submitted G.B. Pant University of Agriculture and Technology, Pantnagar. 102 p.

Charles, J.P. 1976. Experience of grass/legume mixtures compared to pure stands in Switzerland. Fourrages, 66:77-92.

Charlton, J.F.L., Stewart, A.V. 2006. Pasture and Forage Plants for New Zealand. Grassland Research and Practice Series No 8, Third Edition. New Zealand Grassland Association. pp.128

Cherney, J.H. and Marten, G.C. 1982. Small grain crops forage potential, biological and chemical determinants of quality and yield. *Crop Sci*., 22 (2): 227-231.

Chynoweth, R.J., Rolston M.P. and McCloy, B.L. 2010. Plant growth regulators: a success story in perennial ryegrass seed crops. Massey University, Palmerston North, NewZealand. In: Proceedings of a joint symposium between the Agronomy Society of New Zealand and the New Zealand Grassland Association,(13 & 14) pp. 131-137.

Clark, D.A. and Thom, E.R. 1996. Milk production from pastures and pasture silage with different levels of endophyte infection. Proceedings New Zealand Society of Animal Production 56: 292-296.

Clark D.A., Matthew C. and Crush J.R. 2001. More feed for New Zealand dairy systems. *Proceedings of the New Zealand Grassland Association* 63: 283-288.

Clark C.E.F., Clark, D.A., Waugh, C.D., Roach, C.G., Glassey, C.B., Woodward, S.L., Minneé, E.M.K. and Woodfield, D.R. 2010. Systems to increase grazable forage production in the Waikato: A progress report on the tall fescue and perennial ryegrass component of these systems. *Proceedings of the New Zealand Grassland Association* 72: 49-54.

Coblentz, W. K., Fritz, J. O., Fick, W. H., Cochran, R. C. and Shirley, J. E. 1998. *In situ* dry matter, nitrogen, and fiber degradation of alfalfa, red clover, and eastern gamagrass at four maturities. *Journal of Dairy Science,* 81: 150 -161.

Cochram, W. G. and Cox, G. M. 1966. Experimental design. 2nd Edn. Jhon Willy and Sons, Inc., New York. 522 p.

Collins, M. and K. Moore. 1995. Postharvest processing of forages. Forages Volume II: The Science of Grassland Agriculture, R. Barnes, D. Miller, and C. Nelson, eds. Ames, Iowa: Iowa State University Press. pp. 147.

Cooper, J.P. 1973. Genetic variation in herbage constituents. *In:* Chemistry and biochemistry of herbage. G.W. Butler and R.W. Bailey (eds). Vol.2. Academic Press, London, pp. 379-417.

Conrad, H.R. and Klopfenstein, T.J. 1988. Role in livestock feeding - greenchop, silage, hay and dehy. In: Hanson, A.A., Barnes, D.K. and Hill, R.R., Jr. (eds) *Alfalfa and Alfalfa Improvement*. Agronomy Monograph No. 29, ASA/CSSA/SSSA, Madison, Wisconsin, pp. 539-566.

Coronado, M.H.E., Aries, H.O.R., and Ortiz, M.A.F. 1995. Evaluation of six cultivars of oats for intensive forage production at three sowing dates. Tecnica-Pecuaria-en- Maxico, 33 (2): 74-86.

Cosgrove, G.P. and Hodgson, J. 2003. Diet selection by deer, principles, practice and consequences. Proceedings New Zealand Grassland Association. 100 p.

Crush J. R., Evans, J.P.M. and Cosgrov, G.P. 2011. Chemical composition of rye grass (*Lolium perenne* L.) and Prairie grass (Bromus willdenowii Kunth) pastures. *New Zealand J.Agric. Research*. 32 (4): 461-468.

Cunliffe, K.V., Vecchies, A. C., Jones, E.S., Kearney, G.A., Froster, J.W., Spangenberg, G. C. and Smith, K. F. E. 2004.Assessment of gene flow using tetraploid genotype of perennial ryegrass (*Lolium perenne* L.). *Australian journal of experimental Agriculture* 55: 389-396.

Das, A. and Singh, G.P. 1999. Effect of different levels of berseem (*Trifolium alexandrinum* L.) supplementation of wheat straw on some physical factors regulating intake and digestion. *Anim. Feed Sci. Technol*., 81 (1-2): 133-149.

Deinum, 1966. Influence of some climatological factors on the chemical composition and feeding value of herbage. *Proc. 10th Int. Grassld Congr.,* Helsinki, pp. 415 - 418.

Delagarde, R., Peyraud, J. L. and Delaby, L. 2000. Vertical distribution of biomass, chemical composition and pepsin-cellulase digestibility in a perennial ryegrass sward: interaction with month of year, regrowth age and time of day. *Animal Feed Science and Technology,* 84 (1/2), 49-68.

Deo, G.D. and Rai, S.D. 1975. Effect of management practices on seed production and seed quality of oat (*Avena sativa* L.) *seed Res.,* 5(1): 45-50.

Deorari, V. 2002. Studies on growth and seed yield of promising oat (*Avena sativa* L.). genotypes under varying levels of nitrogen. M. Sc. Thesis submitted G.B. Pant University of Agriculture and Technology, Pantnagar. 150 p.

Deramus, H.A. 1980. Quality of selected forage legumes throughout the growing season in Arkansas. Dissert. Abst. Int., B 41 (5):1598.

Deo, G.D. 1974. Effect of management practices of the forage, seed and nutrient yields of oats (*Avena sativa L.*). M.Sc. Thesis submitted to G.B. Pant University of Agriculture and Technology, Pantnagar. 165 p.

De Villiers, J.F., Botha, W.A. and Smith, M.F. 1993. The effect of stocking rate on the performance of ewes and lambs on Italian ryegrass. *South African Journal of Animal Science*. 23: 43 - 50.

Dhont, C., Castonguay, Y., Nadeau, P., Belanger, G. and Chalifour, F. P. 2002. Alfalfa root carbohydrates and regrowths potential in response to fall harvest. *Crop Science* 42: 754-765.

Dinic, B., Dordevic, N., Andelkovic, B., Sokolovic, D. and Terzic, D. 2010b. Management of the fermentation process in ensilaged livestock feed. *Biotechnology in Animal Husbandry* 26 (1-2) : 105-115.

Dirven, J. G. P. and Deinum, B. 1977. The effect of temperature on the digestibility of grasses. An analysis. *Forage Res*., 3: 1-17.

Douglas, J. A. 1986.The production and utilization of lucerne in New Zealand. *Grass and Forage Science*. 41: 81-128.

Drobna, J. and Jancovic, J. 2006. Estimation of red clover (*Trifolium pratense* L.) forage quality parameters depending on the variety, cut and growing year. *Plant Soil Environ*. 52 (10): 468–475.

Dubbs, T.M., Vanzant, E.S., Kitts, S. E., Bapst, F.F., Fieser, B.G. and Howlett, C.M. 2003. Characterization of season and sampling method effects on measurement of forage quality in fescue-based pastures. *Journal of Animal Science*. 81: 1308 - 1315.

Dubey, K.M., Dubey R.K., Agrawal, S.B. and Thakur G. S. 1995. Effect of nitrogen levels and cutting systems on fodder yield of two oat (*Avena sativa* L.) cultivars. *J.Soil and Crops*. 5 (1) : 40-45.

Echarte, L., Rothstein, S, and Tollenaar, M. 2008. The response of leaf photosynthesis and dry matter accumulation to nitrogen supply in an older and a newer maize hybrid. *Crop Sci.*, 48 :656 - 665.

Elizalde, J. C.; Merchen, N. R. and Faulkner, D.B. 1999. *In situ* dry matter and crude protein degradation of fresh forages during the spring growth. *Journal of Dairy Science*, 82: 1978-1990.

Ensminger, M. E., Oldfield, J. E. and Heinemann, W. W. 1990. Feeds & Nutrition.2nd Edition. Ensminger Publishing Co., Clovis, CA, USA. 220 p.

ENV/JM/MONO 2005. Environment Directorate Organization for economic co-operation and development Paris. 58 p.

FAO, 2001. Production Year Book. pp. 55-72.

FAO, 2013. Grassland Index. A searchable catalogue of grass and forage legumes. FAO, Rome, Italy. http://www. fao.org/ag/AGP/AGPC/doc/Gbase/data/ pf000346.htm. Accessed: Feb. 10, 2014.

Frame, J. 1998. *Medicago sativa* L. *Food and Agriculture Organisation.* On line at http://www.fao.org/ag/AGP/AGPC/doc/Gbase/data/pf000346.htm. Accessed: Jan. 12, 2014.

Fraser, J., McCartney, D., Najda, H. and Mir, Z., 2004. Yield potential and forage quality of annual forage legumes in southern Alberta and northeast Saskatchewan. *Can. J. Plant Sci*., 84 (1): 143-155.

Fulkerson, W. J. and Slack, K. 1995. Leaf number as a criterion for determining defoliation time for *Lolium perenne*: 2. Effect of defoliation frequency and height. *Grass and Forage Science.* 50 : 16-20.

Fulkerson, W. J., Neal, J. S., Clark, C. F., Horadagoda, A., Nandra, K. S. and Barchia, I., 2007. Nutritive value of forage species grown in the warm temperate climate of Australia for dairy cows: *Grasses and legumes. Livest. Sci*., 107 (2-3): 253-264.

Gabra, M. A., Hafez, S. I. and Abdel-Malik, W. H. 1990. Guar (*Cyamopsis tetragonoloba* L.), a promising leguminous forage in Egypt. II. Content and apparent balance of some major and minor elements. Third International Symposium on Feed Manufacturing and Quality Control, 7 to 9 May 1990, Cairo, Egypt. 6 p.

Gallardo, M. R., Castillo, A. R., Bargo, F., Abdala, A. A., Maciel, M. G., Perez-Monti, H., Castro, H. C. and Castelli, M. E. 2005. Monensin for lactating dairy cows grazing mixed alfalfa pasture and supplemented with partial mixed ration. *Journal of Dairy Science*, 88: 644 -652.

Garwood, E. A. and Sinclair, J. 1979. Use of water by six grass species.2. Root distribution and use of soil water. *Journal of Agricultural science,* Cambridge 93:25-35.

Ghosh, D. C. 1985. Influence of nitrogen, phosphorus and cutting management on growth and yield of oat. *Indian Journal of Agronomy*. 30 (2): 172-176.

Gilliland, T. J., Barrett, P. D. and Mann, R. L. 2002. Canopy morphology and nutritional quality traits as potential grazing value indicators for *Lolium perenne* varieties. *Journal of Agricultural Science,* 139 (3): 257-273.

Gill, A. S. and Niranjan, K. P. 1974. Effect of nitrogen application and cutting management on fodder yield of oats (kent). Annual report, IGFRI, Jhansi. 136 p.

Gills, A. S., Niranjan, K. P. and Mannikar, N. D. 1988. Studies on nitrogen fertilization and cutting management in relation to fodder yield of oats. *Indian J. of Agric. Res.,* 22 (1): 30-40.

Goering, H. K. and Van Soest. P. J. 1970. Forage Fiber Analysis (apparatus, reagents, prosedures and some applications). USDA Agricultural Handbook No. 379.

Goplen, B.P., Howarth, R. E., Sarkar, S. K. and Lesin, K. 1980. A search for condensed tannins in annual and perennial species of Medicago, Trigonella, and Onobrychis. *Crop Sci*., 20: 801-804.

Gohl, B. 1982. Les aliments du bétail sous les tropiques. FAO, Division de Production et Santé Animale, Roma, Italy.http:/pasturepicker.com. FAO. AGAlMiscJ70125. Accessed:2/10/2012. 4 p.

Grassland Society of Southern Australia Inc 2008b. Perennial ryegrass. Pasture spices Database, Grassland Society of Southern Australia Inc., hosted by university of Melbourne. 66 p.

Graves W., Williams, B. and C. Thomsen. 1996. Berseem clover, winter annual forage for California agriculture. DANR Publisher, USA. pp. 15-22.

Griffin, T.S., Cassida, K.A., Hesterman, O.B. and Rust, S.R. 1994. Alfalfa maturity and cultivar effect on chemical in situ estimates of protein degradability. *Crop Sci*., 34: 1654–1661.

Gupta, P.C. and Pradhan , K . 1974. Variability in protein, cell wall constituents and in-vitro nutrient digestibility in some important strains of fodder oats harvested at different stages of growth. *Indian J.Agric. Sci.,* 359-363.

Gupta, P. C., Singh, R. and Pradhan, K. 1976. Variability in protein, cell wall constituent and *in vitro* nutrient digestibility in some important strains of fodder oats harvested at different stages of growth. *Indian. J.Agric. Sci.* 46 (8): 359-36.

Hakl, J., Santrucek, J. and Kalista, J. 2003. Forage quality of new Czech strains of hybrid alfalfa. Forage conservation. In: Proc. 11th Int. Sci. Symp., Nitra: 76–77.

Hall, E. 2007. Red Clover. Pastures Australia, a collaboration between AWI, GRDC, MLA, RIRDC and Dairy Australia. http:/pasturepicker.com. FAO. AGAlMiscJ70125.September 10, 2013, 16:03.

Hannaway, D.B. and Larson, C. 2004. Berseem Clover (*Trifolium alexandrinum* L.). Oregon State University, Species Selection Information System. http://www.fao.org/ag. HTM. 15/1/2014

Harris, W. and Pineiro, J. 1980. erformance of mixtures of ryegrass cultivars and prairie grass with red clover under two grazing frequencies. III. Herbage production and short numbers in the second year. *New Zealand Journal of Agricultural Research*, 23: 339-348.

Harris, L.E., Leehe, T.F., Kearl, L.C., Fonnesbeck, P.V. and Lloyd, H. 1982. Inter feed stuffs Institute, Utah State University, Logan, Utah 84322.USA. 5 p.

Harris, W. and Kunelis, H.T. 1988. Production of pastures in the second year after drilling of red clover and ryegrass. *New Zealand Journal of Experimental Agriculture*, 16: 17-20.

Hasina, G., Beena Saeed., Amir, Z. K., Shazma, A., Nasrullah, A., Robina, K. and Iqbal Hussain 2013. Forage yield of berseem and shaftal in response of late planting dates and methods in Peshawar valley. *Journal of Agricultural and Biological Science*. 1(1): 1 – 4.

Hay, R.J.M., Kelly, R.W. and Ryan, D.L. 1978. Some aspects of the performance of "Grasslands Pawera" red clover in Southland. *Proceedings of the NZ Grassland Association* 38*:* 246-251.

Hay, R.J.M. and Ryan, D.L. 1983. An evaluation of Pawera red clover with perennial grasses in a summer-dry environment. Proceedings New Zealand Grassland Association 44: 91-97.

Hay, R. J. M. and Ryan, D.L. 1989. A review of 10 years' research with red clovers under grazing in Southland. Proceedings New Zealand Grassland Association 50: 181-187.

Hay, R.K.M. and Porter, J.R. 2006. The Physiology of Crop Yield (2nd Edition). Blackwell Publishing Ltd, Oxford, UK, 314 p.

Hayman, J. M. and McBride, S.D. 1984. The Response of Pasture and Lucerne to Irrigation. Technical Report 17, Winchmore Irrigation Research Station, Ministry of Agriculture and Fisheries, 79 p.

Heichel, G.H., Vance, C.P., Barnes, D.K. and Henjum, K.I. 1985. Dinitrogen fixation and N and dry matter distribution during 4 year stands of birdsfoot-trefoil and red clover. *Crop Sci*., 25, 101-105.

Hoffman, P.C., Sievert, S.J., Shaver, R.D., Welch, D.A. and Combs, D.K. 1993. *In situ* dry matter, protein, and fiber degradation of perennial forages. *Journal of Dairy Science*, 76, 2632 - 2643.

Hoffman, P. and Broderick, G. 2001. Red Clover Forages for Lactating Dairy Cows. Focus on Forage, University of Wisconsin, 3, 1-2.

Hoffman, P.C. and Tysom, D. 2005. How much ash are you feeding your cows. Hoards Dairyman. University of Wisconsin Board of reagent. 149 (20): 659.

Homolka, P., Koukolova, V., Podsednicek, M. and A. Hlavackova 2012. Nutritive value of red clover and lucerne forages for ruminants estimated by *in vitro* and *in vivo* digestibility methods. *Czech J. Anim. Sci.,* 57 (10): 454–568.

Hughes, K.A. and Haselmore, R.M. 1983. Winter oats. change in nutritive value during development of crop. *Newseland Agric. Sci.*15(4) : 155 (*cf.Nut Abstr. Review* (B) 53(4): 18 (5).

Hyslop, M. G., Kemp, P.D. and Hodgson, J. 1998. Primary investigations into the persistence of a vegetatively reproductive red clover cv. Astred in mixed swards. *Proceedings Agronomy Society of NZ* 28 : 17-122.

ICAR (Indian Council of Agricultural Research, New Delhi) 2012. Handbook of Agriculture pp. 1353-1417.

IGFRI (Indian Grassland & Fodder Research Institute, Jhansi), 2011. Annual report of AICRP on Forage crops. 204 p.

IGFRI (Indian Grassland & Fodder Research Institute, Jhansi), 2012. Annual report of AICRP on Forage crops. 186 p.

Jackson, M.L. 1973. Soil chemical analysis. Prentic hall of India Pvt. Ltd., New Delhi. pp.111-204.

Jain, A.K. 1994. Effect of cutting management on the seed production of forage oat varieties. M.Sc. Thesis submitted to G.B. Pant Uni. of Agric. And Tech., Pantnagar. 131 p.

Jarrige, R. and Minson, D.J. 1964. Digestibility constituents of English ryegrass, S24 and cocksfoot, S37, especially the glucoside constituents (in French). *Ann. Zootech.*, 13: 117 - 150.

Jasjeet, D., Pankaj, K., Tiwari B.N. and Rakesh, P. 2011. Chemo- pharmacological aspects of alfalfa: A Review. *Journal of Advanced Scientific Research*. 2 (1): 50-53.

Jatasra, D.S. 1981. Components of green fodder and dry matter yields in Egyptian clover. *Forage Res*., 7: 163-163.

Johnston, J.E., Singh, A. and Clark, E.A. 1993. Sward height in grazing management: vertical profile in sward quality 17th International Grassland Congress, Rockhampton, Australia, pp. 890-891.

John, A. and Lancashire, J. A. 1981. Aspects of the feeding and nutritive value of Lotus species. Proceedings New Zealand Grassland Association 42: 152-159.

John, A. and Kelly, K. E. 1988. Physical breakdown of forages during rumination. Proceedings New Zealand Society of Animal Production 48: 247-248.

Joshi, Y.P. 1980. Physiological basis of forage yield in different varieties of oats (*Avena sativa* L.). M.Sc. Thesis submitted to G.B. Pant Uni. of Agric. And Tech., Pantnagar. 185 p.

Joshi, Y.P. 1985. Studies on effects dates of sowing on the growth, yield and quality of different varieties of oats (*Avena sativa* L.). Ph.D. Thesis submitted to G.B. Pant University of Agriculture and Technology, Pantnagar. 202 p.

Joshi, Y.P. and Bhilare, R.L. 2006. Weed management in berseem (*Trifolium alexandrinum* L.). *Pantnagar J. of. Research*. 4 (1): 15-17.

Joshi, Y. P. and Bhilare, R.L. 2006. Effect of row spacing on growth and yield of cowpea varieties. *Pantnagar J. of. Research*. 4 (2): 19-20.

Joshi, Y.P. and Singh, V. 1982. Studies on the production potential and forage quality of different varieties of oats (*Avena sativa* L.) *Forage Res*. 8 (1): 49-54.

Joshi, Y.P., Singh, V. and Verma, S.S. 1993. Response of forage oat to sowing date and cutting management. *Forage Res*. 19 (2): 156-160.

Joshi, Y.P., Singh, V. and Verma, S.S. 1997. Effect of nitrogen and cutting managements on herbages yield of oat varieties. *Forage Res*. 22 (4): 249-252.

Joshi, Y. P., Singh, V., Verma, S. S. and Pandey, C.S. 2000. Effect of cutting management on on herbages and seed yield on oat genotypes. *J. Farming System Res. & Dev*. 6: 74 -78.

Joshi, Y. P., Singh, H. and Bhilare, R. L. 2005. Response of cutting management on effects on growth, forage yield and quality of oat varieties. *Pantnagar J. of. Research*. 3 (1): 17-18.

Jung, G.A., Van Wijk, A.J.P., Hunt, W.F. and Watson, C.E. 1996. Ryegrasses. Chapter 19. In: L.E. Moser, *et al*., editors *Cool-Season Forage Grasses*.ASA Monograph 34 Madison, USA. pp. 605–641.

Kandi A.A., Salma A. M., El-Moursy, S.A. and Abido, W.A. 2005. Production of Egyptian clover as affected by seeding rate and cutting schedule 2- chemical dry matter analysis. *Pakistan Journal of Biological Science,* 8 (12): 1766 -1770.

Kanwaljit, K. and Gupta, B.K. 1987. *In vitro* digestibility of structural carbohydrates of oat fodder at different stage of maturity. *Indian J. Dairy Sci.*, 40 (4) : 454-457.

Katic, S., Milic, D., Karagic, D., Vasiljevic, S., Glamocic, D. and Jajic, I. 2009. Variation of protein, cellulose and mineral contents of lucerne as influenced by cultivar and cut. *Biotechnology in Animal Husbandry*. 25 (5-6):1189-1195.

Kaushal 2006. *Asian-Aust. J. Anim. Sci.* 19 (12): 1722-1727.

Kelly, K. E. and Sinclair, B. R. 1989. Size, structure of leaf and stalk components of digesta regurgitated for rumination in sheep offered five forage diets. *New Zealand Journal of Agricultural Research* 32: 365-374.

Kenny, P. T. and Reed, K. F. M. 1984. Effects of pasture type on growth and wool production of weaner sheep during summer and autumn. *Australian Journal of Experimental Agriculture and Animal Husbandry* 24: 322-331.

Kemp P. D., Matthew, C. and Lucas R. J. 2004. Pasture species and cultivars. In 'New Zealand pasture and crop science'. (Eds J White, J Hodgson).(Oxford University Press: Melbourne). Proceedings of the New Zealand Grassland Association 72: 185-190

Khalil, A. and Durrani, F. R. 1989. Nutritional evaluation of tropical legume and cereal forage growth in Pakistan. *Trop. Agric.* (Trinidad), 67(4): 313-316.

Khan, A. D. 1994. Nutritional evaluation of berseem (*Trifolium alexandrinum*) protein concentrate and residue. Ph.D. Thesis, Department of Animal Nutrition, University of Agriculture, Faisalabad. 190 p.

Khatta,V. and Katoch, B. S. 1981. Nutrient components of some forages available in sub-mountainous region of Himachal Pradesh. *Forage Res.*, 7: 149-159.

Kilcher, M.R. and Troelsen, J.E. 1973. Contribution and nutritive value of the major plant components of oats through progressive stages of development. *Can. J. Plant Sci*. 53 : 251-256.

Kim, W.H,, Seo, S., Jeong, K.H., Choi, S.H., Kim, M. J. and Lee, S.C. 1999. Formation of yield and seed quality of oats in relation to sowing date and sowing rates. *Korean Journal of Animal Science,* 41(2): 215-220.

Kokate, K.M. 1990. Dairy cattle production. Forage production from leguminous crops. *BAIF Development Research Foundation,* pp. 160.

Korte, C.J. and Sheath, G.W. 1978. Herbage dry matter production: the balance between growth and death. *Proceedings of the New Zealand Grassland Association* 40: 152-161.

Koukolova V., Homolka P., Koukol O. and Jancik F. 2010. Nutritive value of *Trifolium pratense* L. for ruminants estimated from *in situ* ruminal degradation of neutral detergent fibre and *in vivo* digestibility of organic matter and energy. *Czech Journal of Animal Science,* 55: 372-381.

Kudrayatsev, V.A., Alzhanova, R.M., Vershinina, K.T., Pastukhova, V.M. and Zotikor, V. I. 1978. Morphogenesis, kinetics of biomass accumulation and some indices of nitrogen metabolism in annual cereals sown in late summer. Referativnyl Zhurnal (1976) 1. 55.643 (c.f. *Herb. Abstr*., 46: 3441).

Kumar, H. and Rai, S.D. 1976. Effects of different rates and source of nitrogen on the yield and quality of forage oats (*Avena sativa* L.). *Forage Res*. 2 (2): 131-136.

Laca, E.A., Ungar, E.D. and Seligman, N. 1992. Effects of sward height and bulk density on bite dimensions of cattle grazing homogeneous swards. *Grass and Forage Science,* 47 (1): 91-102.

Laidlaw, A.S. and Stewart, T.A. 1987. Clover development in the sixth to ninth year of a grass/clover sward as affected by out-of-season management and spring fertilizer nitrogen application. *Research and Development in Agriculture* 4: 155–160.

Laidlaw, A.S. and Reed, K.F.M. 1993. Plant improvement: the evaluation and extension process. *In:* Baker, M.J. ed. *Grasslands for our world: proceedings of the 17th international grassland congress, held in February 1993, in New Zealand and Queensland*. SIR, Wellington, pp. 385-392.

Laidlaw, A.S. and Teuber, N. 2001. Temperate forage grass-legume mixture: advantages and perspectives. *Proceedings of the XIX International Grassland Congress. Brazil.* pp. 85-92.

Lambert, M.G., Clark, D.A., Grant, D.A. and Costall, D.A. 1986b. Influence of fertilizer and grazing management on North Island moist hill country. 3. Performance of introduced and resident legumes. *New Zealand Journal of Agricultural Research* 29: 11-21.

Lamp, C. A., Forbes, S. J. and Cade, J. W. 2001.Grasses of temperate Australia-A field guide. Inkata Press (1st edition) and CH Jerram & Associate science publishers. 44 p.

Lancefield, G. D., Ball, D. M., Hannock, D., Andrae, J. and Smith R. 2009. Growing Alfalfa in the South. *National Alfalfa and Forage Alliance* 2009. 65 p.

Lantinga, E. A. and Groot, J. C. J. 1996. Optimisation of grassland production and herbage feed quality in an ecological context. *In:* Groen, A.F. and Van Bruchem, J. eds. Utilization of local feed resources by dairy cattle: perspectives of environmentally balanced production systems: symposium proceedings Wageningen Institute of Animal Sciences (WIAS), Wageningen, The Netherlands, 29 September 1995. Wageningen Pers, Wageningen, 58-66. EAAP Publication no. 84.

Lazeby, A. 1997. Selection and breeding of pasture plants, Chapter 7. In: JV Lovett, JM Scott, eds, *Pasture Production and Management*, edition 1.Inkata press, Victoria. pp.133-154.

Ledgard, S.F. and Brier, G. J. 1988. NZ cultivars for Waikato dairy pasture: establishment, production and N fixation during the first year. Proceedings New Zealand Grassland Association 49: 207-211.

Limagrain, 2011. Growers Guide to Lucerne. *United Kingdom, Rothwell, Market Rasen, Lincolshire LN7 6DT.*, pp.1-5.

Litherland, A. L. 2001. Crops to improve diet quality. *Handout for AgResearch Systems Group Pasture Quality Workshops*. 7 pp.

Longland, A., Pilgrim, R. and Jones, I. 1995. Comparison of oven drying vs. freeze drying on the analysis of non-starch polysaccharides in gramminaceous and leguminous forages. Proc. Br. Soc. Anim. Sci. 60 p.

Lowe, K.F., Bowdler, T.M., Casey, N.D. and Moss, R.J. 1999b. Performance of temperate perennial pasture in Australian subtropics 1. Yield, persistence and pasture quality. *Australian journal of experimental Agriculture* 39: 663-676.

Lowe, K.F., Callow, M.N., Bowdler, T.M., Lowe, S.A., White, J.A. and Gobius, N. 2008. The performance of irrigated mixtures of tall fescue, ryegrass and white clover in subtropical Australia. 1. The effect of sowing mixture combinations, nitrogen, and over sowing on establishment, productivity, botanical composition and persistence. *Tropical Grasslands* 42, 126.

Lowien, J. and Harris, C. 2004. NSW, Tall fescue.3.State of NSW, Department of Primary Industries. 24 p.

Lyttleton, J. W. 1973. Proteins and nucleic acids. *In:* Chemistry and biochemistry of herbage. G.W Butler and RW Bailey (eds.) Vol. 1. Academic Press, London, pp. 63 - 100.

MAFF (UK Ministry of Agriculture, Fisheries and Food). 1992. Feed composition. UK Tables of Feed Composition and Nutritive Value for Ruminants, 2nd ed. Canterbury, UK: Chalcombe Publications. 102 p.

Maiga, H.A., Marx, G.D., Crary, V.C. and Linn, J.G. 1997. Alternative feeds for Dairy cattle in Northwest Minnesota: An Update. Dairy update issue 126: 1-8.

Mandal, S. and Chakraborty,T. 1998. Effect of phosphorus sources with different doses on growth and forage yield of berseem. *Forage Res.* 24 (2): pp. 119-120.

Marshall, C. 1990. Source-sink relations of interconnected ramets. In: van Groenendael J, de Kroon H, eds. *Clonal growth in plants : regulation and function.* The Hague, The Netherlands: SPB Academic Publishing, 23-41.

Marten, G.C. and Hovin, A.W. 1980. Harvest schedule, persistence, yield, and quality interactions among four perennial grasses. *Agron. J.* 72: 378-387.

Mayland, H.F., Grunes, D.L. and Lazar, V.A. 1976. Grass tetany hazard of cereal forages based upon chemical composi-tion. *Agron. J.* 68: 665.

McCarty, L.B. 2001. Best Golf Course Management Practices. Prentice-Hall, Inc. Upper Saddle River, NJ. 362 p.

McDonald, W., Nikandrow, A., Bishop A., Lattimore, M., Gardner, P., Williams, R. and Hysons, L. 2003. Lucerne for pasture and fodder. Agfact.2.2.2.25, 3rd edition, NSW, Agriculture, Orange, NSW. pp. 1-39.

Mehrez, A.Z. and Orskov, E.R. 1977. A study of the artificial -hag technique for determining the digestibility of feeds in the rumen *Journal of Agricultural Science* Cambridge 88: 645

Mendhe S. N., Zope, S.R., Nandanwar, R.S. and Suryavanshi, B.M. 1995. Effect of cutting management and phosphorus on berseem. *Forage Res.* 21(1): 49-53.

Mezni M., Haffani, S., Khamassi, N. and Albouchi, A. 2013. Effects of the defoliation height on the growth, mineral uptake and soluble carbohydrate contents in berseem clover (*Trifolium alexandrinum L.) var.* Khadhraoui. *IOSR Journal of Agriculture and Veterinary Science*. 2 (5): 78-91.

Mills, A., Smith, M. C., Lucas, R. J. and Moot, D. J. 2008. Dryland pasture yields and botanical composition over 5 years under sheep grazing in Canterbury. *Proceedings of the New Zealand Grassland Association* 70: 37-44.

Milne, G.D., Shaw, R., Powell, R., Pirie, B. and Pirie, J. 1997. Tall fescue use on dairy farms. *Proceedings of the New Zealand Grassland Association* 59: 163-167.

Minnee, E. 2011. Thesis Master of Science in Biological Sciences at The University of Waikato., An evaluation of tall fescue (*Lolium arundinaceum* L.) as an alternative to perennial ryegrass (*Lolium perenne* L.) for use on dairy farms in the Waikato. 129 p.

Minson, D.J. 1990b. Protein. *In:* Forage in ruminant nutrition. D.J. Minson (ed.) Academic Press, New York, pp. 265 - 289.

Minson, D.J. 1990c. Calcium. In Forage in Ruminant Nutrition. D. J. Minson, ed. Academic Press, Inc., San Diego, California. pp. 208-229

Mislevy, P. 1973. Apical meristem stage and tiller height as criteria in harvesting annual grasses. *Proc. Soil and Crop Sci. Soc. Of Florida*., 32: 9-11.

Mitchell, K.J. 1956. Growth of pasture species under controlled environment. 1. Growth at various levels of constant temperature. *N.Z. J. Sci. Technol.* 38A: 203-216.

Mohammad, D., Hussain, A., Khan, S. and Bhatt, M.B. 1994. Green forage yield, dry matter yield and chemical composition of oat with advances in maturity. *Pakistan J. Sci. and Industrial Res*. 37 (5): 198-200.

Mojumdar, A.B. and Ahmad, S.T. 1980. Evaluation of quality parameters in some diploid, tetraploid and hexaploid oats. *Forage Res*., 6: 145-150.

Monsanto. 2003. Safety, Compositional and Nutritional Assessment of Roundup Ready Alfalfa Events J101 and J103. U.S. FDA/CFSAN. BNF. 84 p.

Moore, G., Sanford, P. and Wiley, T. 2006. Perennial pastures for Western Australia, Department of Agriculture and Food Western Australia, Bulletin 4690, Perth. 2 p.

Moot, D.J., Matthew, C., Kemp, P.D. and Scott, W.D. 2007. Growth of Pastures and Supplementary Crops. In 'Pasture and Supplements for Grazing Animals'. (Eds PV Rattray, IM Brookes, W Nichol). (New Zealand Society of Animal Production: Hamilton. 228 p.

Morrison, F.D. 1961. *Feeds and Feeding*, abridged, 9th edition (Morrison Publishing Company, Claremont, Ont.,1961). http://www.fao.org/ag. HTM. 15/1/2014

Mosely, G. and Jones, G.R. 1979. Some factors associated with the difference in nutritive value of artificially dried red clover and perennial ryegrass for sheep. *British Journal of Nutrition* 42: 139-147.

Moser, L. and Hoveland, C. 1996. Cool-season forage grasses overview. Cool-Season Forage Grasses, L. Moser, D. Buxton, and D. Casler, eds. Madison, WI: USA Publishers. 12 p.

Mukharjee A.K. and Mandal, S.R. 2000. Effect of dates of sowing, cutting management and levels of P application on seed yield of shaftal and berseem. *Enviro. and Econ*. 18(2): 506-508.

Munro, J.M.M. Davies, D.A. and Evans, W.B.1992. Animal production evaluation of herbage varieties. 1. Comparison of Aurora with Frances, Talbot and Melle perennial ryegrass when grown alone and with clover. *Grass and Forage Science,* 47 (3): 259-273.

Nair, P.S. and Gupta, Y.K. 1978. Path coefficient analysis of the first order and second order component of fodder yield of oats (*Avena sativa L.*). *Agri. Res. J. Kerala,* (1976), 14(2): 138-144. (*c.f. Herb.Abstr*. 48: 4331).

Nandanwar, R.S., Deshmukh, H.B.S.V., Solanke,V.M. and Patil, A.N. 1992. J. *soils and Crops*. 2: 62-65.

Narasimhlu, P. and Kunelius, H. T. 1994. Mineral composition of red clover treated with growth regulators in early spring *Grass and Forage Science.* 49 (2): 146-152.

Nie, Z. N., Chapman, D. F., Tharmaraj, J. and Clements, R. 2004. Effects of pasture species mixture, management, and environment on the productivity and persistence of dairy pastures in south-west Victoria. 1. Herbage accumulation and seasonal growth pattern. *Australian Journal of Agricultural Research.* 55: 625-636.

NRC (National Research Council) 1971. Atlas of Nutritional Data on United States and Canadian Feeds. National Academy of Science, Washington, D.C., USA. 90 p.

NRC (National Research Council). 1982. United States – Canadian Tables of Feed Composition (Third Revision) National Academy Press, Washington D.C., USA. 98 p.

National Research Council 1996. Nutrient Requirements of Domestic Animals Series*: Nutrient Requirements of Beef Cattle*, 7th revised edition (National Academy Press, Washington). 249 p.

National Research Council. 2007. Nutrient Requirements of Horses, 6th ed., National Academies Press, Washington, D.C. 148 p.

Oberoi, P.S. 1981. Effect of various nitrogen and stage of maturity on nutritive value of oats (*Avena sativa* L.) by in-vitro technique. Thesis Abstr. NDRI, 6(2): 93-94 (*c.f. Herb.Abstr*. 48: 433).

O'Donovan, M. 2001. *The influence of grass cultivars on milk production*. Teagasc, Fermoy. Teagasc Report no. ARMIS- 4572.

Olsen, S.R., Cole, C.W., Watenabe, F.S. and Dean, L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA. Circ. 939 p.

Ostgard, O. 1990. *In vitro* digestibility of dry matter in varieties of barley, Oats and triticale harvested at different stage of maturity. *Norsk-Landburks Forsking*. 4 (4): 313-320.

Palaniswamy, K.M. 1975. Leaf area in rice as influenced by varieties, nitrogen and different growth stage. *Madras Agric.J*. 62 (8): 524-526.

Peterson, P.R., Sheaffer, C.C. and Hall, M.H. 1992. Drought effects on perennial forage legume yields and quality. *Agronomy Journal*, 84: 774-779.

Popp, J.D., McCaughey, W.P., Cohen, R.D.H., McAllister, T.A. and Majak, W. 2000. Enhancing pasture productivity with alfalfa: A review. *Can. J. Plant Sci*. 80: 513-519.

Prasad, D.K. and Mukherji, S.K. 1988. Effect of sowing time and stage of cutting on the herbage and subsequent seed production of oat. *Seed Res*., 16 (2): 218-221.

Rai, S.D., Arora, K.N. and Verma, M.L. 1976. Effect of sowing dates, seed rate and cutting management on the forage yield and nutritive value of oats. *Indian J. Agronomy*. 21(1): 7-10.

Rana, D.S., Joon, R.K., Das, B. and Yadav, B.D. 1990. Effect of sowing time and cutting management on fodder yield and quality of oat (*Avena sativa*. L.) varieties. *Forage Res.* 16 (2): 153-156.

Ranjhan, S.K. 1991.Chemical composition and nutritive value of Indian feeds and feeding of farm animals. ICAR Krishi Anusandhan Bhavan, PUSA, New Delhi. 127 p.

Rao, C., Patil, B.D., Krishnan, P.R., Sreenath and Mishra, U.S. 1978. Analysis of growth attributes in relation to fodder yield in oat (*Avena sativa* L.) plant types. *Forage Res.* 4: 143 -148.

Ray, S.K. and Pradhan, A.C. 1992. Forage and grain yields of oat (*Avena sativa*. L.) as influenced by phosphorus levels and cutting management in soils of West Bangal. *Indian J. Agron*. 37 (4): 823-825.

Ray, H.Y.M., Auser, P., Blahut-Beatty, L., McKersie, B., Bowley, S., Westcott, N., Coulman, B., Lloyd, A. and Gruber, M.Y. 2003. Expression of anthocyanins and proanthocyanidins after transformation of alfalfa with maize Lc. *Plant Physiology*. 132: 1448-1463.

Reddy, B.S. and Tomar, P.S. 1976. Nitrogen and phosphorus requirements of fodder oats under variable crop sequence. *Forage Res*. 11 (1): 55-62.

Reddy, S.R. 2012. Book Principals of crop production. 528 p.

Rollo, M.D., Sheath, G.W., Slay, M.W.A., Knight, T.L., Judd, T.G., and Thomson, N.A. 1998. Tall fescue and chicory for increased summer forage production. *Proceedings of the New Zealand Grassland Association* 60: 249-253.

Roy, D. 2005. Effect od sowing dates on growth, grain yield and forage quality of oat (*Avena sativa* L.) Varieties. M.Sc. Thesis submitted to G.B. Pant Uni. of Agric. And Tech., Pantnagar. 187 p.

Rumbaugh, M.D. 1990. Special purpose forage legumes. In: J.Janick and J.E. Simon (eds.). Advances in New Crops. Timber Press, Portland, Oregon. pp. 137-147.

Sandhu, H.S., Brar, S.S. and Puri, K.P. 1976. Effect of nitrogen and phosphorus on yield and quality oat fodder. *J. Res* , *PAU*. 13(2): 151-155.

Sadhu, A.C., Patel, J.R., Patel, P.C. and Patel, B.G. 1990. Cutting and nitrogen management studies in different genotypes of oats. *Forage Res*. 16 (2): 107-113.

Sangha, G.S. and Kier, D.S. 1980. Effect of harvesting stage, phosphorus and nitrogen on fodder yield and quality of pure and mixed stand of oats and sanji. *J. Res*., *PAU Ludhiana* , 17(4): 354- 362 .

Sarkar, S.K., Howarth, R.E. and Goplen, B.P. 1976. Condensed tannins in herbaceous legumes. *Crop Sci*. 16: 543-546.

Satell, R., Dick, R., Hemphill, D., McGrath, D. 1998. Red clover (*Trifolium pratense*). In: Using Cover Crops in Oregon, EM 8704. Oregon State University Extension Services**.** pp.1-3

Selman, M. 1975. The effect of species, varieties, nitrogen rates and cutting date on yield and quality of whole crop cereals. *Exotl. Husbandry*. 28: 92-98 .

Semiadi, G. and Barry, T. N. 1993. Growth and venison production from red deer grazing red clover or perennial ryegrass/white clover pasture. *New Zealand Journal of Agricultural Science* 121: 265-271.

Sharma, S.K. and Mudgal, V.D. 1966. Studies on the lignin and cellulose content of fodder crops and effect of lignifications on cellulose digestion. *Indian J. Dairy Sci*. 19: 100 -105.

Sharma, V.V. and Murdia, P.C. 1974. Utilization of berseem hay by ruminants. *J. Agr. Sci*., 83 (2): 289-293.

Sharma, M.P., Mecbeath, D.K. and Vandenborn, W.H. 1977. Studies on the biology of wild oats. II growth *Can. J. Pl. Sci.* 57: 811-817.

Sharma, S.K. and Dixit, R.S. 1986. Effect of cutting management and nitrogen levels on yield of oat fodder and economics of nitrogen fertilization. *Narendra Dev J. of Agric.Res* .1(2); 159-162 (*C.F. Herb. Abstr.*, 58(10): 2069).

Sharma, S.K. and Bhunia, S.K. 2001. Response of oat to cutting management, method of sowing and nitrogen levels and cutting schedule. *Indian J. Agric. Sci.,* 46 (3): 563-567.

Sheaffer, C.C., Lacefield, G.D. and Marble, V.I. 1988. Cutting schedules and stands. In: Hanson, A.A., Barnes, D.K. and Hill, R.R., Jr (eds) Alfalfa and Alfalfa Improvement. Agronomy Monograph No 29, ASA/CSSA/SSSA, Madison, WI, USA pp. 411-437.

Sheaffer C.C., University of Minnesota, 1990. PENNSTATE College of Agricultural Sciences Cooperative Extension, Cutting management of alfalfa, red clover, and birdsfoot trefoil. Agronomy Facts 7. 4 p.

Sheaffer, C.C. and Marten, G.C. 1991. Kura clover forage yield, forage quality and stand dynamics. *Canadian Journal Plant Science* 71: 1169-1172.

Singh, A.P. and Gupta, S.C. 1973. Studies on the nutrient yield and possible toxic and physiologically active constituents in forage crops. Annual Reports, IGFRI, Jhansi. 193 p.

Singh, L.N., Katoch, D.C. and Verma, R.K. 1978. Note on the response of forage oat to different levels of nitrogen and phosphorus on mid hills of Himachal Pradesh. *Indian J. Agric. Sci.,* 43 (8): 826-827.

Singh, K.P., Tomar, P.S. and Singh, K.P. 1975. Nutrition of forage oat under cutting management. *J. Res. HAU. Hissar*, 5(1): 1-3.

Singh, S. P., Yadav, B. S. Thakur, G. S. and Narashinghani, V. G. 1980. Note on correlation coefficient and path analysis studies on fodder oats. *Indian Journal. Agricultural. Science*. 50 : 973- 975.

Singh, V.P. 1992. Analysis of seed yield variation of forage oat under different cutting management and nitrogen levels. Ph.D. Thesis submitted to G.B. Pant Uni. of Agric. And Tech., Pantnagar. 201 p.

Singh, R.K. 1994. Studies on the analysis of seed yield varieties to promising oat varieties under different cutting management. Ph.D. Thesis submitted to G.B. Pant Uni. of Agric. And Tech., Pantnagar. 198 p.

Singh, R.R., Agrawal, I.S. and Verma, J.S. 2001. Chemical composition and production potential of different strains of fodder oat. *Indian J. Anim. Nutr.* 18 (2): 165-171.

Singh, H. 2004. Effect of cutting management on forage yield and quality of oat (*Avena sativa* L.) varieties. M. Sc. Thesis submitted to G.B. Pant Uni. of Agric. And Tech., Pantnagar. 194 p.

Smith, D. 1974. Vegetative response of silage oats fertilized in the growth chamber with various levels of nitrogen and potash. *J. PL. Nutr*., 2(5): 547-555.

Smit, H.J. and Elgersma, A., 2004. Diurnal fluctuations in vertical distribution of chemical composition in a perennial ryegrass (*Lolium perenne* L.) sward during the season. *In:* Lüscher, A., Jeangros, B., Kessler, W., et al. eds. *Land use systems in grassland dominated regions: proceedings of the 20th general meeting of the European Grassland Federation, Luzern, Switzerland, 21-24 June 2004*. Hochschulverlag AG an der ETH Zurich, Zurich, 951-953.

Smit, H.J., Tast, B.M., Taweet, H.Z., Tammingat, S. and Elgersma, A. 2005. Effect of perennial ryegrass (*Lolium perenne* L.) cultivars on herbage production,

nutritional quality and herbage intake of grazing dairy cows. *Grass and Forage Science*, 60: 297-309.

Soetrisno, E., Barry, T.N., Wilson, P.R., Ardgson, J. and Purchas, R.W. 1994. Effects of grazing red clover or perennial ryegrass/white clover pastures upon growth and venison production from weaner red deer. *NZ Journal of Agricultural Research* 37: 19-27.

Solanki, K.R., Paroda, R. S. and Chaudhary, B.S. 1973. Componen**t** of green fodder yields in oats **(***Avena sativa* L.) *HAU, J.Res*., 3: 20-23.

Stanacev, V., Dunic, D., Kovcin, S., Drinic, M., Puvaca, N. and Stanacev, V. 2010. Nutritive value of the genetically divergent genotype lucerne (*Medicago sativa* L.). *African Journal of Agriculture Research* 5 (11): 1284-1287.

Steen, R.W.J. and McIlmoyle, W.A., 1982. An evaluation of red clover silage for beef production. *Anim. Prod*., 34 (1): 95-101

Steinshamn, H., 2010. Effect of forage legumes on feed intake, milk production and milk quality - a review. *Anim. Sci. Pap. Rep*., 28 (3): 195-206.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for the estimation of available nitrogen. *Current Science* 25: 259-260.

Suttie, J.M., 1999. Berseem clover (*Trifolium alexandrinum* L.). A searchable catalogue of grass and forage legumes, FAO. http:/feedipedia.org/node/244. Accessed on 21/12/2012.

Tamm, S. and Bender, A., 2003. Variation of agronomic and quality characteristics of red clover. *Czech J. Genet. Plant Breed*., 39: 319–321.

Taneja, K.D. Gill, P.S. and Jatasra, D.S. 1987. Effect of dates of sowing on the fodder and seed yield of Berseem under the different level of nitrogen and phosphorus. *Forage Res*.13(1): 33-37.

Taylor, N.L. and Quesenberry, K.H., 1996. Red Clover Science. *Current Plant Sciences and Biotechnology in Agriculture*, 28, 65-67.

Terry, R.A. and Tilley, J.M.A. 1964. The digestibility of the leaves and stems of perrenial ryegrass, cockfoot, timothy, tall fescue, lucerne and saifoin, as measured by an *in vitro* procedure. *Journal of the British Grassland Society*, 19: 363-372.

Tomar, V. P. S. 1980. Performance of different single and two cuts entries. Annual Report, ICAR: 94-95.

Thomas, C., Aston, K. and Daley, S.R., 1985. Milk production from silage 3.A comparison of red clover with grass silage. *Anim. Prod.*, 41 (1): 23-31.

Thom, E.R., Clark, D.A., Van Vught, V.T. and Waugh C.D. 1998a. Pasture species and drought impact on milk yield 1.Milk yield responses in the Waikato. *Proceedings of the New Zealand Grassland Association* 60: 39-44.

Thompson, K.F. and D.P. Poppi 1990. Livestock Production from Pasture. In: *Pastures*, R.H.M. Langer, ed. (Oxford University Press, Melbourne, 1990). pp. 263-283.

Tiwana, M.S. and Puri, K.P. 1980. Forage production potential of oats, barely and triticale varieties. *Indian J.Agron.*, 25 (1): 149-150.

Tiwana U.S. and Puri, K P. 2003. Response of berseem to Sulphur under different fertilizer levels. *Forage Res.* 29 (2): 94-96.

Tseng, M.T., Yeh, H. and Lin, J.C. 1979. Forage production, protein content and subsequent regrowth of NTU. Selection No.10 oats in relation to cutting date. *J. Agric. Assoc.*, China. 107: 26-44.

Trivedi, A.K. 1995. Eefect of split dose of nitrogen on yield and quality of forage oat(*Avena sativa* L.). M. Sc.Thesis submitted to G.B. Pant Univ. of Agri. And Tech., Pantnagar. 145 pp.

Tyrolova, A. and Vyborna, A. 2008. Effect of the stage of maturity on the leaf percentage of lucerne and the effect of additives on silage characteristics. *Journal of Animal science,* 53 (8): 330-335.

Ulyatt, M.J., Lancashire, J.A. and Jones, W.T. 1977. The nutritive value of legumes. Proceedings of the New Zealand Grassland Association 38: 107-118.

Underwood, E.J. 1977. Trace Elements in Human and Animal Nutrition, Fifth Edition. W. Merty (editor). Academic Press, Orlando, Florida, U.S.A. 319 p.

Ussher, G. 1986. Case study information reflecting farmer use of Pawera red clover in northern Northland. Proceedings New Zealand Grassland Association 47: 179-182.

USDA, U. 2006b. USDA forest services. http://www.fs.fed.us/aboutus/history/time-line. 6/8/2013.

Vasiljevic, S., Katic, S., Mihailovic, V., Cupina B., Milic, D., Mikic, A., Karagic, D. J. and Pataki, I. 2005. Effect of cutting date on quality of red clover forage. Offered Papers of the XX International Grassland Congress Grasslands – a Global Resource, Dublin, Ireland, 26 June – 1 July 2005, 269 p.

Vasiljevic, S., Glamocic, D., Jajic, I., Katic, S., Cupina B., Milic, D., and Mikic, A., 2008. Fibre fractions of red clover (*Trifolium pratense* L) at different harvests over two seasons. EGF, Grassland science in Europe, 13: 510-513.

Vasiljevic, S., Cupina, B., Krastic, D., Pataki, I., Katanski, S. and Milosveik, B. 2011. Seasonal changes of protein, structural carbohydrates, fats and minerals in herbage dry matter of red clover (*Trifolium pratense* L.). *Biotechnology in Animal Husbandry* 27 (4): 1543-1550.

Van Soest, P.J. 1965. Symposium on factors influencing the voluntary intake of herbage by ruminants: voluntary intake in relation to chemical composition and digestibility. *J. Anim. Sci., Camb*. 24: 834 - 843.

Van Wijk, A.J.P., Boonman, J.G. and Rumball, W. 1993. Achievement and perspective in the breeding of forage and legumes. In:Baker M.J. (ed.) 17th International *Grassland congress, Wellington*, New Zealand, pp: 379-384.

Verma, N.C., Singh, A.P., Rakib, A. and Gupta, S.C. 1974. Nutrition value of oat as influenced by stage of growth and conservation practices. International Dairy Congress, held at New Delhi, Dec. 6. 1974., I.E. pp. 66-67.

Verma, S.S. 1984. Studies on growth yield and quality of forage oats (*Avena sativa* L.) under different levels of nitrogen and cutting management. Ph.D. Thesis submitted to G.B. Pant Univ. of Agri. And Tech., Pantnagar. 205 p.

Verma, S.S. and Singh, V. 1987. Quality of forage oat in relation to nitrogen fertilization. *Forage Res*. 13 (2): 77-83.

Vilela, H., Gomida, J.A. and Maestri, M. 1980. Effect of plant age aat the first cut and of intervals between cuts on herbage yield, soluble carbohydrates contents in stem base, LAI and light interception in forage oats **(***Avena byzantia* L.) Universidade federal de vicosa, vicosa, mines Gerais, Brazil (*c.f. Herb. Abstr*. 50 : 1033).

Villax, E.J., 1963. La culture des plantes fourragères dans la région méditerranéenne occidentale. Les cahiers de la recherche agronomique N°17. Institut National de la Recherche Agronomique, Rabat**.** Feedipedia.org. A programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/248.19/11/2013.

Waghorn, G.C., Shelton, I. D. and Sinclair, I. D. 1990. Distribution of elements between solid and supernatant fraction of digesta in sheep given six diets. *New Zealand Journal Agricultural Research.* 33: 259-269.

Waldo, D.R. 1986. Effect of forage quality on intake and forage-concentrate interactions. *Journal of Dairy Science*. 69: 617-631.

Waller, R.A. and Sale, P.W.G. 2001. Persistence and productivity of perennial ryegrass in sheep pastures in south-western Victoria: a review. *Australian Journal of Experimental Agriculture*. 41: 117-144.

Walsh, G.L. and Birrell, H.A. 1987. Season variations in the chemical composition and nutritive valus of five pasture species in south-western Victoria. *Australian Journal of Experimental Agriculture*. 27: 807-816.

Warman, P.R. and Sampson, H.G. 1994. Effect of sulfur additions on the yield and elemental composition of red clover and ryegrass. *Gomm. Soil Sei. PI. Anal.*, 25: 1471 - 1481.

Wiersma, D.W., Smith, R.R. and Mlynarek, M.J. 1998. Harvest management effects on red clover forage yield, quality and persistence, *J. Prod. Agric*. 11, 3: 309-313.

Williams, W.A., Graves, W.L. and Cassaman, K.G. 1990. Nitrogen fixing by irrigated berseem clover versus soil nitrogen supply. *J. agric. Crop Sci*. 3: 202-207.

Wilson, J.R., Deinum, B. and Engels F.M. 1991. Temperature effects on anatomy and digestibility of leaf and stem of tropical and temperate forage species. *Netherlands Journal of Agricultural Science.* 39: 31-48.

Yahana, A. 1996. Studies on chemical composition of different varieties of indigenous fodder as influenced by different stage of growth. Ph.D. thesis submitted to University of the Punjab, Lahor. pp. 49-60.

Yoelao, K., Jackson, M.G. and Ishwar S. 1970. The effect of wilting berseem and lucerne herbage on voluntary dry-matter intake by buffalo heifers. *J. Agricultural Crop Sci.* 74 (1): 47-51

Zanin, V. 1998. A new nutritional idea for man: lucerne leaf concentrate. Association for the promotion of leaf concentrate in nutrition. Online at 156 http://www.nutrition-luzerne.org/anglais/pdf/EtudeZaninenglish. 14/1/2013.

Appendices

Appendix - I

Standard meteorological weather data during crop season (2012-13)

Daily Weather Data October, 2012

Date	Temperature ^{0}C		R. Humidity %		Rainfall (mm)	Wind Velocity (Km/hr)	Sun shine hrs.	Evap. (mm)
	Max.	Min.	0712 am	1412 pm				
1	34.1	23.0	90	57	000.0	1.9	08.9	3.5
2	33.8	23.4	88	56	000.0	1.1	08.7	3.6
3	33.1	23.9	87	60	000.0	1.1	07.0	2.9
4	32.1	21.0	88	60	000.0	1.5	02.4	2.4
5	32.0	18.9	93	59	000.0	2.9	08.9	3.6
6	31.9	18.4	85	59	000.0	3.5	09.4	3.6
7	32.6	18.4	86	50	000.0	2.4	09.9	4.8
8	33.0	19.4	74	54	000.0	2.7	09.2	3.8
9	32.0	17.8	90	57	000.0	4.7	10.0	3.8
10	32.2	18.9	87	56	000.0	2.4	09.2	2.8
11	31.0	18.9	85	46	000.0	2.5	08.1	2.9
12	31.8	16.2	91	48	000.0	2.6	08.9	3.4
13	31.5	16.4	89	42	000.0	2.5	08.8	3.3
14	31.6	17.0	79	44	000.0	1.9	09.5	3.0
15	31.9	17.8	87	45	000.0	2.3	09.3	3.7
16	32.0	17.9	87	51	000.0	4.1	08.2	3.0
17	31.0	15.3	89	40	000.0	2.5	05.9	2.7
18	31.2	13.9	76	35	000.0	3.3	09.6	3.7
19	31.0	14.3	91	34	000.0	2.0	09.7	4.0
20	31.5	14.4	89	35	000.0	1.5	09.4	3.0
21	31.2	13.6	87	36	000.0	1.7	09.5	3.2
22	30.0	13.6	93	33	000.0	1.6	08.9	3.5
23	30.6	11.9	92	33	000.0	2.5	09.2	3.5
24	30.8	13.9	91	36	000.0	5.0	09.2	3.8
25	29.5	11.4	93	38	000.0	3.2	08.6	3.4
26	28.0	12.9	89	35	000.0	1.8	07.9	2.7
27	29.0	12.7	90	33	000.0	1.8	08.3	2.3
28	28.4	10.8	91	35	000.0	2.4	07.8	2.7
29	29.6	10.4	94	36	000.0	1.8	09.7	2.4
30	30.0	12.3	90	34	000.0	2.3	07.1	2.1
31	31.0	12.9	89	34	000.0	1.5	09.4	3.5
Total	969.4	501.6	2730	1371	**0.0**	75	266.6	100.6
Averg.	**31.2**	**16.1**	**88**	**44**	**-**	**2.4**	**8.6**	**3.2**

Daily Weather Data November, 2012

Date	Temperature ^{0}C		R. Humidity %		Rainfall (mm)	Wind Velocity (Km/hr)	Sun shine hrs.	Evap. (mm)
	Max.	Min.	0712 am	1412 pm				
1	30.0	12.3	84	35	000.0	1.6	08.5	2.9
2	30.2	11.9	89	38	000.0	1.7	09.3	2.4
3	29.1	11.5	80	35	000.0	2.1	07.6	3.2
4	28.8	12.8	88	36	000.0	2.3	08.2	2.3
5	29.0	13.	89	35	000.0	1.3	07.2	2.0
6	28.2	12.4	91	38	000.0	1.5	04.8	1.9
7	27.0	12.9	89	38	000.0	2.4	00.0	2.1
8	27.8	10.8	93	31	000.0	2.0	03.7	1.8
9	28.0	10.0	90	36	000.0	2.5	07.1	2.6
10	27.0	11.4	89	38	000.0	2.1	07.4	2.5
11	26.8	12.8	90	37	000.0	5.0	06.5	3.2
12	28.0	10.4	90	40	000.0	1.8	05.2	2.6
13	27.0	10.3	90	40	000.0	1.8	06.5	1.8
14	26.2	8.8	95	41	000.0	2.0	02.4	1.7
15	26.6	9.4	90	41	000.0	1.5	07.0	2.1
16	27.0	10.0	90	42	000.0	1.6	07.1	2.4
17	27.2	9.9	90	38	000.0	2.8	08.4	2.8
18	28.5	9.7	90	37	000.0	1.9	08.2	2.7
19	29.4	9.5	90	37	000.0	2.0	08.5	2.4
20	28.0	9.1	92	36	000.0	2.0	08.5	2.6
21	27.6	9.4	91	36	000.0	1.7	08.6	2.2
22	27.2	9.1	92	40	000.0	1.7	08.0	2.1
23	25.8	8.5	94	39	000.0	2.7	06.7	3.0
24	25.2	8.3	92	39	000.0	2.0	05.3	3.4
25	26.4	6.4	94	39	000.0	2.5	07.5	3.7
26	26.2	6.8	94	37	000.0	6.8	08.6	4.2
27	24.1	5.9	97	37	000.0	2.6	07.9	2.9
28	24.0	5.8	94	39	000.0	2.3	08.3	3.0
29	23.7	7.9	92	39	000.0	2.6	07.5	2.3
30	26.0	11.6	93	37	000.0	3.9	06.9	5.6
Total	816	298.6	2722	1131	**0.0**	70.7	207.4	80.4
Averg.	**27.2**	**9.9**	**90**	**37**		**2.3**	**6.9**	**2.6**

Daily Weather Data December, 2012

Date	Temperature ^{0}C		R. Humidity %		Rainfall (mm)	Wind Velocity (Km/hr)	Sun shine hrs.	Evap. (mm)
	Max.	Min.	0712 am	1412 pm				
1	25.3	6.3	95	35	000.0	6.2	08.7	2.7
2	25.1	6.8	92	40	000.0	2.4	08.7	2.3
3	24.4	6.1	90	30	000.0	2.4	08.9	1.6
4	24.6	6.0	92	35	000.0	4.8	09.1	2.5
5	24.6	5.8	93	49	000.0	5.5	08.5	2.1
6	23.5	5.5	95	46	000.0	3.9	07.4	2.3
7	23.5	6.7	94	47	000.0	3.0	07.6	3.7
8	23.2	6.9	94	51	000.0	2.1	03.9	2.3
9	22.8	7.8	94	49	000.0	1.6	02.9	2.3
10	24.2	7.6	92	51	000.0	2.5	06.4	3.0
11	26.2	9.8	9	46	000.0	1.8	07.6	3.6
12	24.8	6.9	94	46	000.0	7.3	04.3	4.6
13	23.5	10.1	93	43	000.0	3.2	07.7	4.0
14	24.5	13.0	91	55	000.0	4.9	06.9	5.0
15	21.4	8.0	94	46	000.0	4.6	00.7	3.3
16	24.6	10.9	93	43	000.0	2.4	04.3	3.2
17	23.3	9.4	95	43	000.0	7.7	00.7	2.8
18	23.0	8.3	95	56	000.0	11.7	08.1	3.8
19	20.7	6.9	94	54	000.0	3.3	03.3	1.7
20	20.6	4.9	97	84	000.0	4.4	05.1	2.5
21	15.0	10.2	88	80	000.0	3.9	00.0	0.8
22	14.5	7.4	94	59	000.0	2.8	00.0	0.9
23	18.0	4.8	96	62	000.0	1.6	00.0	1.2
24	20.2	4.9	97	78	000.0	3.0	06.0	1.6
25	15.0	9.9	95	85	000.0	3.4	00.0	0.6
26	13.0	9.4	95	86	000.0	5.2	00.0	0.5
27	12.9	8.9	95	58	000.0	3.2	00.0	0.6
28	18.2	2.9	100	74	000.0	2.2	01.2	1.0
29	20.5	2.3	97	62	000.0	2.6	07.1	1.9
30	21.4	3.5	97	53	000.0	2.8	08.3	2.0
31	18.4	3.9	100	66	000.0	4.1	02.1	1.0
Total	660.9	221.8	2840	1712	**0.0**	120.5	145.5	71.4
Averg.	**21.3**	**7.1**	**91**	**55**	**-**	**3.8**	**04.6**	**2.3**

Daily Weather Data January, 2013

Date	Temperature ^{0}C		R. Humidity %		Rainfall (mm)	Wind Velocity (Km/hr)	Sun shine hrs.	Evap. (mm)
	Max.	Min.	0712 am	1412 pm				
1	15.5	4.7	100	67	000.0	6.8	04.2	1.0
2	14.0	1.4	100	62	000.0	2.4	00.5	0.6
3	17.1	4.4	97	94	000.0	4.3	07.5	0.9
4	9.0	4.9	100	74	000.0	5.8	00.0	0.5
5	12.1	4.4	100	91	000.0	3.8	00.0	0.7
6	8.6	3.8	100	94	000.0	4.0	00.0	0.4
7	7.5	3.9	100	91	000.0	6.7	00.0	0.5
8	7.2	2.4	99	94	000.0	7.1	00.0	0.5
9	6.0	+0.4	97	78	000.0	2.3	00.0	0.3
10	9.3	1.3	100	77	000.0	1.8	00.0	0.4
11	13.1	-0.8	100	59	000.0	1.5	01.2	0.5
12	17.4	2.8	97	93	000.0	2.1	05.3	0.9
13	21.2	5.4	97	35	000.0	3.2	07.3	1.4
14	23.5	5.9	91	52	000.0	2.8	07.7	2.1
15	22.6	6.0	97	39	000.0	2.4	04.9	1.2
16	23.5	7.9	86	43	000.0	5.1	05.9	1.1
17	24.5	10.7	77	37	000.0	2.9	06.5	2.4
18	26.5	14.0	92	72	017.8	8.2	05.9	5.6
19	18.1	7.4	99	58	023.4	12.6	00.1	3.0
20	20.0	8.4	97	78	000.0	7.1	07.4	2.2
21	15.5	6.8	100	91	000.0	4.1	02.4	1.1
22	15.0	8.7	97	88	000.0	3.1	02.5	0.7
23	14.6	8.0	97	77	000.0	4.7	01.4	1.0
24	15.2	8.4	97	67	000.0	5.5	04.5	1.2
25	18.0	7.1	97	75	000.0	4.4	06.3	1.3
26	16.0	6.9	94	90	000.0	3.4	03.7	1.1
27	12.6	7.9	97	90	000.0	3.4	00.4	0.5
28	11.8	6.9	100	82	000.0	2.0	00.0	0.5
29	17.5	4.6	100	52	000.0	3.3	01.7	0.6
30	21.6	5.4	96	49	000.0	2.5	05.7	1.2
31	23.0	5.8	94	43	000.0	2.0	04.2	1.6
Total	497.5	175.4	2995	2192	**41.2**	131.3	97.2	37
Averg.	**21.3**	**7.1**	**91**	**55**	**-**	**3.8**	**04.6**	**2.3**

Daily Weather Data February, 2013

Date	Temperature ^{0}C		R. Humidity %		Rainfall (mm)	Wind Velocity (Km/hr)	Sun shine hrs.	Evap. (mm)
	Max.	Min.	0712 am	1412 pm				
1	24.2	6.1	89	42	000.0	2.4	07.2	2.0
2	24.5	10.5	85	44	000.0	1.7	08.8	1.7
3	22.5	8.3	94	52	000.0	0.7	02.2	1.0
4	24.5	14.3	80	60	000.0	0.7	04.6	1.1
5	21.3	14.2	91	93	009.2	6.6	00.2	4.0
6	15.5	13.3	94	62	026.7	9.8	00.0	5.7
7	23.5	10.7	95	49	012.4	7.0	04.7	4.0
8	24.0	7.6	94	62	000.0	7.7	06.9	1.4
9	21.2	7.2	97	54	000.0	3.4	05.7	1.3
10	23.2	8.3	92	42	000.0	3.5	06.9	1.8
11	23.5	7.2	93	46	000.0	2.8	08.5	2.0
12	24.0	8.6	92	50	000.0	4.2	09.2	2.1
13	25.0	8.2	92	50	000.0	4.3	07.0	1.9
14	24.0	7.4	93	51	000.0	4.3	0.69	2.0
15	24.5	10.4	87	66	000.0	3.7	07.7	1.9
16	21.0	13.1	93	94	006.0	10.4	01.2	2.6
17	15.0	10.9	90	60	053.6	12.8	00.0	8.2
18	20.0	7.7	89	57	000.0	5.2	07.3	1.9
19	21.8	9.4	97	61	000.0	4.6	10.1	2.3
20	21.0	9.2	95	49	000.0	3.3	03.2	1.6
21	23.5	9.3	95	48	000.0	5.3	09.5	2.0
22	24.2	10.3	77	47	000.0	2.6	03.2	1.5
23	26.0	11.9	89	91	000.0	2.8	08.9	2.2
24	18.6	10.4	90	51	024.2	10.3	01.2	4.0
25	25.2	10.0	93	50	000.0	3.3	10.0	2.3
26	25.0	9.4	97	49	000.0	4.9	10.0	2.6
27	26.0	11.0	84	48	000.0	2.8	08.9	2.3
28	25.8	11.3	94	46	000.0	4.5	09.3	2.1
Total	638.5	276.2	2551	1574	132.1	135.6	163.09	69.5
Averg.	**22.8**	**9.9**	**90**	**56**	**-**	**4.8**	**05.8**	**2.5**

Daily Weather Data March, 2013

Date	Temperature ^{0}C		R. Humidity %		Rainfall (mm)	Wind Velocity (Km/hr)	Sun shine hrs.	Evap. (mm)
	Max.	Min.	0712 am	1412 pm				
1	25.0	10.3	95	45	000.0	14.0	10.0	4.5
2	25.0	9.9	95	47	000.0	9.4	09.8	3.0
3	24.5	11.4	97	45	000.0	3.5	06.9	1.5
4	27.0	12.9	93	49	000.0	4.3	08.7	2.6
5	28.0	13.0	92	47	000.0	3.0	09.0	2.8
6	29.5	13.5	89	45	000.0	3.0	10.0	3.2
7	30.0	11.0	93	49	000.0	4.2	09.4	3.4
8	28.4	13.8	91	44	000.0	1.5	08.3	2.6
9	29.2	13.4	93	44	000.0	1.7	08.9	2.3
10	29.0	13.6	86	50	000.0	4.1	09.0	3.7
11	28.9	13.9	86	45	000.0	6.0	08.0	3.4
12	30.1	13.4	88	44	000.0	2.1	09.2	2.8
13	29.0	11.0	90	46	000.0	2.4	07.1	3.0
14	30.0	14.3	78	45	000.0	1.7	09.4	3.0
15	29.8	14.8	91	50	013.4	2.9	07.8	7.0
16	28.2	12.6	91	47	000.0	4.3	08.8	3.3
17	29.5	11.4	90	39	000.0	3.9	09.6	3.8
18	28.0	11.9	90	38	000.0	9.6	10.0	5.6
19	27.8	13.5	93	50	000.0	8.1	09.3	4.2
20	29.0	14.8	90	46	000.0	1.1	09.3	2.8
21	30.0	14.4	93	46	000.0	1.4	05.7	2.7
22	30.7	14.9	91	49	000.0	2.4	09.4	4.8
23	29.2	15.1	90	37	000.0	1.6	08.0	3.2
24	31.4	17.4	78	35	000.0	2.0	08.2	3.4
25	31.0	16.0	79	36	000.0	1.1	08.5	3.9
26	30.0	12.8	83	40	000.0	2.2	10.2	5.5
27	29.8	12.7	91	42	000.0	2.7	08.5	4.2
28	30.0	14.7	87	38	000.0	1.5	06.5	3.5
29	31.5	16.9	89	38	000.0	1.3	08.8	3.4
30	30.4	12.4	91	37	000.0	2.7	05.1	4.7
31	31.1	15.4	87	38	000.0	4.8	10.5	7.0
Total	901	417.1	2770	1351	**13.4**	114.5	267.9	114.8
Averg.	**29.1**	**13.5**	**89**	**44**	**-**	**3.7**	**08.6**	**3.7**

Daily Weather Data April, 2013

Date	Temperature ^{0}C		R. Humidity %		Rainfall (mm)	Wind Velocity (Km/hr)	Sun shine hrs.	Evap. (mm)
	Max.	Min.	0712 am	1412 pm				
1	31.0	16.3	88	34	000.0	1.4	10.0	4.5
2	32.6	13.4	87	30	000.0	1.2	10.4	4.8
3	34.0	20.9	69	30	000.0	1.7	10.9	3.6
4	34.2	14.9	74	27	000.0	1.5	08.8	5.1
5	31.9	13.9	87	25	000.0	8.7	10.5	8.5
6	31.5	12.4	81	24	000.0	15.5	10.5	10.0
7	33.0	12.9	76	16	000.0	6.4	10.8	7.4
8	36.1	15.4	79	16	000.0	15.0	10.5	9.6
9	37.0	15.9	87	27	000.0	9.4	10.9	9.7
10	38.0	19.5	59	27	000.0	7.4	10.6	9.4
11	38.1	17.0	62	27	000.0	5.5	06.8	6.5
12	36.2	16.8	72	18	000.0	5.0	09.2	7.8
13	36.4	16.4	66	18	000.0	5.3	10.6	8.2
14	36.7	22.9	61	19	000.0	8.1	10.4	10.6
15	36.0	16.8	71	24	000.0	6.1	07.0	7.7
16	35.0	16.9	54	22	000.0	4.3	10.5	7.0
17	36.7	21.9	60	24	000.0	5.3	09.4	8.2
18	35.5	17.9	62	25	000.0	4.3	10.6	7.4
19	35.7	15.9	52	27	000.0	6.7	10.1	7.6
20	36.2	19.2	43	25	000.0	7.0	10.9	8.4
21	34.4	18.1	81	38	008.4	13.7	05.2	9.4
22	29.3	17.5	73	40	000.0	10.0	09.3	6.5
23	30.2	18.4	62	35	000.0	4.4	10.4	5.7
24	32.8	20.4	69	35	000.0	4.1	10.1	5.7
25	35.0	19.8	64	31	000.0	5.1	08.3	6.0
26	36.8	20.4	60	32	000.0	5.6	08.5	7.1
27	35.5	18.4	72	27	000.0	6.1	07.0	6.1
28	38.0	19.9	56	27	000.0	13.1	10.4	12.6
29	36.5	18.9	63	22	000.0	11.9	08.7	11.0
30	39.0	20.4	64	19	000.0	8.5	11.0	12.8
Total	1049.3	529.4	2054	791	008.4	208.3	288.3	234.9
Averg.	**35.0**	**17.6**	**68**	**26**	**-**	**6.9**	**09.6**	**7.8**

Daily Weather Data May, 2013

Date	Temperature ^{0}C		R. Humidity %		Rainfall (mm)	Wind Velocity (Km/hr)	Sun shine hrs.	Evap. (mm)
	Max.	Min.	0712 am	1412 pm				
1	40.5	20.1	62	21	000.0	8.8	10.8	11.2
2	39.6	18.0	71	21	000.0	8.9	10.8	13.0
3	38.1	15.5	57	20	000.0	9.0	11.0	12.3
4	37.8	17.5	54	19	000.0	5.1	11.0	11.1
5	39.1	21.2	56	27	000.0	4.0	10.6	10.3
6	38.0	20.9	53	36	000.0	7.5	05.7	9.0
7	37.6	20.4	57	30	000.0	5.7	09.0	8.5
8	38.8	18.4	60	19	000.0	6.9	09.5	9.5
9	41.0	20.0	54	19	000.0	8.9	10.8	13.0
10	41.8	18.4	51	18	000.0	7.1	11.7	10.8
11	40.0	19.9	63	20	000.0	2.0	06.4	9.3
12	40.2	22.4	50	50	000.0	3.5	07.2	11.2
13	31.2	18.4	62	26	001.2	1.9	00.4	4.9
14	36.6	22.4	65	20	000.0	3.3	11.0	8.6
15	39.0	23.4	63	21	000.0	3.5	10.0	9.0
16	40.0	20.9	53	32	000.0	3.8	10.7	11.2
17	37.5	23.9	54	31	000.0	1.9	05.3	7.4
18	38.2	23.5	58	35	000.0	3.1	09.0	8.6
19	39.0	25.4	62	40	000.0	2.7	07.7	9.0
20	38.5	27.4	68	42	000.0	3.0	07.6	10.0
21	39.5	28.4	67	47	000.0	2.8	00.0	8.2
22	38.0	28.7	68	49	000.0	5.1	00.0	9.2
23	38.5	29.7	86	41	000.0	3.7	00.0	9.5
24	39.5	28.4	70	45	000.0	5.4	02.4	10.0
25	38.4	29.5	66	48	000.0	2.6	10.1	9.4
26	39.0	30.0	68	42	000.0	2.6	07.9	10.6
27	41.2	28.9	65	39	000.0	2.8	09.8	10.2
28	40.8	26.3	59	36	000.0	6.0	08.6	11.0
29	40.0	28.4	61	33	000.0	2.3	10.5	9.2
30	39.6	22.4	62	37	000.0	3.1	09.5	8.8
31	38.2	25.4	69	40	000.0	2.7	10.6	9.4
Total	1205.2	724.1	1914	1004	**001.2**	139.7	245.6	303.4
Averg.	**38.9**	**23.4**	**62**	**32**	**-**	**4.5**	**07.9**	**9.8**

Daily Weather Data June, 2013

Date	Temperature ^{0}C		R. Humidity %		Rainfall (mm)	Wind Velocity (Km/hr)	Sun shine hrs.	Evap. (mm)
	Max.	Min.	0712 am	1412 pm				
1	36.5	24.9	74	49	Trace	2.8	09.4	9.4
2	33.5	25.8	68	43	000.0	2.0	00.3	6.8
3	36.9	27.4	75	47	000.0	2.2	05.6	7.0
4	36.0	26.4	64	40	000.0	1.9	06.5	7.6
5	38.6	28.4	67	51	000.0	2.1	08.2	9.0
6	37.5	28.9	70	70	000.0	2.3	02.8	9.0
7	31.6	22.4	83	58	019.8	3.3	00.0	5.3
8	34.1	27.3	76	61	000.0	4.9	05.9	9.5
9	35.0	28.4	79	62	000.0	1.4	06.0	5.0
10	33.7	27.5	89	53	003.8	2.0	00.1	4.3
11	36.0	23.5	93	71	034.0	5.4	02.3	8.2
12	29.4	24.9	72	53	015.2	9.0	00.6	4.4
13	36.2	25.3	82	53	Trace	8.2	11.6	8.2
14	35.2	26.7	74	56	000.0	3.8	07.9	5.7
15	34.6	27.9	73	60	000.0	8.7	03.4	6.2
16	33.0	24.5	74	71	001.2	8.8	01.6	4.0
17	30.5	23.4	95	95	069.4	18.0	00.2	Of
18	25.0	22.0	91	72	130.6	17.6	00.0	Of
19	29.0	24.0	81	65	000.0	6.1	02.0	2.5
20	32.2	24.9	89	67	000.0	5.2	10.7	4.0
21	33.4	27.5	83	55	000.0	5.2	06.6	4.0
22	36.0	28.4	85	68	000.0	3.7	01.8	5.1
23	32.8	24.4	89	83	001.4	10.8	00.0	4.0
24	31.0	25.4	92	79	041.0	4.0	00.0	4.0
25	29.2	24.4	98	93	141.8	6.7	00.0	Of
26	28.1	24.5	96	68	110.4	8.7	00.9	Of
27	32.2	24.6	93	70	010.0	4.4	01.8	3.6
28	32.5	25.2	90	68	000.4	4.1	04.5	3.4
29	31.6	25.9	82	63	000.0	4.1	03.8	3.0
30	34.0	25.6	91	75	024.4	6.3	04.6	5.4
Total	995.3	770.4	2468	1919	**603.4**	173.7	109.1	148.6
Averg.	**33.2**	**25.7**	**82**	**64**	**-**	**5.8**	**03.6**	**5.7**

APPENDIX - II

Analysis of variance for Plant height

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	9.03	4.68	16.46	2.03	1.60	11.53
Treatments	6.0	41.52**	52.76**	106.13**	257.86**	267.92**	292.76**
Error	24.0	4.10	3.62	3.66	2.93	3.73	5.60

**Significant at 5% level

APPENDIX – III

Analysis of variance for number of tillers per plant

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	0.37	3.24	4.40	8.46	0.70	1.63
Treatments	6.0	2.06**	12.708**	16.41**	14.06**	39.62**	30.49**
Error	24.0	0.16	1.41	1.79	2.23	2.34	1.92

**Significant at 5% level

APPENDIX – IV

Analysis of variance for number of leaves

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	10.74	283.75	438.46	145.19	31.21	7.94
Treatments	6.0	10160.66**	22271.93**	4516.86**	9564.23**	19459.85**	16705.90**
Error	24.0	27.19	139.63	929.02	398.75	39.80	7.64

**Significant at 5% level

APPENDIX – V

Analysis of variance for dry matter accumulation through leaves

Source	d.f.	Mean sum of square						
		I	**II**	**III**	**IV**	**V**	**VI**	**Total**
Replication	4.0	2.72	0.58	1.36	3.91	15.48	8.12	107.28
Treatments	6.0	2.58ns	29.04**	35.97**	15.34**	41.33*	57.02**	245.70**
Error	24.0	1.78	2.35	1.07	2.88	11.07	1.91	23.95

**Significant at 5% level

APPENDIX – VI

Analysis of variance for dry matter accumulation through Stem

Source	d.f.	Mean sum of square						
		I	**II**	**III**	**IV**	**V**	**VI**	**Total**
Replication	4.0	0.25	0.26	4.19	9.38	36.20	19.1	133.60
Treatments	6.0	0.52*	8.67**	32.18**	42.68**	27.23ns	50.97**	180.10**
Error	24.0	0.19	1.30	3.91	5.89	14.11	3.44	29.78

**Significant at 5% level

APPENDIX – VII

Analysis of variance for dry matter accumulation through Plants/m row length

Source	d.f.	Mean sum of square						
		I	**II**	**III**	**IV**	**V**	**VI**	**Total**
Replication	4.0	5.27	1.60	7.27	25.09	105.92	50.35	300.51
Treatments	6.0	5.30ns	65.21**	127.18**	74.91**	123.51*	206.99**	615.97**
Error	24.0	3.51	6.80	7.06	14.94	49.06	10.12	106.17

**Significant at 5% level

APPENDIX – VIII

Analysis of variance for leaf: stem ratio

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	0.33	0.11	0.27	0.007	0.003	0.002
Treatments	6.0	1.92**	1.47**	0.92**	0.35**	0.12**	0.11**
Error	24.0	0.315	0.093	0.191	0.053	0.010	0.008

**Significant at 5% level

APPENDIX – IX

Analysis of variance for green forage yield

Source	d.f.		Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**	**Total**
Replication	4.0	3.85	123.72	52.12	33.98	5.81	15.44	477.04
Treatments	6.0	2119.58**	9095.28**	18895.70**	30882.10**	44220.51**	34147.85**	359313.3**
Error	24.0	33.32	101.85	9.85	7.87	21.71	3.88	312.55

**Significant at 5% level

APPENDIX – X

Analysis of variance for dry matter content

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	1.04	1.04	0.34	1.08	0.63	2.68
Treatments	6.0	5.78**	3.15**	11.70**	16.12**	33.01**	25.57**
Error	24.0	0.38	0.27	0.19	1.02	1.21	1.48

**Significant at 5% level

APPENDIX – XI

Analysis of variance for dry matter yield

Source	d.f.	Mean sum of square						
		I	**II**	**III**	**IV**	**V**	**VI**	**Total**
Replication	4.0	0.48	2.22	0.29	2.44	0.20	3.13	12.97
Treatments	6.0	27.74**	146.73**	409.88**	1188.96**	1956.11**	1940.36**	18663.90**
Error	24.0	0.64	1.90	0.60	2.42	3.41	1.08	17.53

**Significant at 5% level

APPENDIX – XII

Analysis of variance for crude protein content

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	0.19	0.09	0.24	0.15	0.33	0.85
Treatments	6.0	75.93**	66.76**	56.12**	71.45**	94.32**	126.84**
Error	24.0	0.19	0.21	0.27	0.23	0.19	0.40

**Significant at 5% level

APPENDIX – XIII

Analysis of variance for crude protein yield

Source	d.f.	Mean sum of square						
		I	**II**	**III**	**IV**	**V**	**VI**	**Total**
Replication	4.0	0.03	0.07	0.04	0.15	0.04	0.12	1.10
Treatments	6.0	1.11**	3.43**	16.54**	73.78**	110.52**	69.05**	935.12**
Error	24.0	0.03	0.07	0.04	0.15	0.14	0.08	0.84

**Significant at 5% level

APPENDIX – XIV

Analysis of variance for dry matter digestibility

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	9.03	3.83	9.71	3.14	3.42	11.53
Treatments	6.0	41.52**	116.72**	140.80**	420.76**	315.92**	292.76**
Error	24.0	4.10	3.96	4.51	3.14	2.82	5.60

**Significant at 5% level

APPENDIX – XV

Analysis of variance for digestible dry matter yield

Source	d.f.	Mean sum of square						
		I	**II**	**III**	**IV**	**V**	**VI**	**Total**
Replication	4.0	0.34	1.18	1.81	3.77	0.33	1.31	12.06
Treatments	6.0	22.16**	101.26**	336.14**	578.73**	674.90**	708.00**	6632.63**
Error	24.0	0.44	1.40	1.18	2.20	2.22	0.49	14.69

**Significant at 5% level

APPENDIX - XVI

Analysis of variance for neutral detergent fibre

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	1.83	8.24	71.43	9.64	31.07	45.36
Treatments	6.0	57.50**	40.60ns	81.67ns	203.09**	214.05**	218.33**
Error	24.0	8.41	36.66	46.85	42.98	48.57	17.44

**Significant at 5% level

APPENDIX – XVII

Analysis of variance for acid detergent fibre

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	1.71	0.76	3.33	1.71	0.47	1.60
Treatments	6.0	7.85**	22.12**	10.16**	20.78**	13.90**	15.58**
Error	24.0	1.68	0.79	1.58	2.05	1.54	1.53

**Significant at 5% level

APPENDIX – XVIII

Analysis of variance for cell content

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	1.99	8.24	71.43	9.64	31.07	45.35
Treatments	6.0	56.79**	40.60ns	81.67ns	203.10**	214.05**	218.33**
Error	24.0	11.02	36.66	46.85	42.98	48.57	17.44

**Significant at 5% level

APPENDIX – XIX

Analysis of variance for hemicellulose per cent

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	6.40	10.04	67.74	9.96	35.26	46.24
Treatments	6.0	75.63**	66.38ns	44.03ns	133.50*	194.89**	155.99**
Error	24.0	8.87	35.39	49.16	51.26	48.07	19.52

**Significant at 5% level

APPENDIX – XX

Analysis of variance for ash content

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	0.45	1.54	3.26	1.14	2.17	2.46
Treatments	6.0	178.80**	177.52**	8.71*	12.76*	5.07*	3.85ns
Error	24.0	1.74	3.81	2.35	3.48	1.97	3.66

**Significant at 5% level

APPENDIX – XXI

Analysis of variance for nitrogen content in crop plant

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	0.005	0.003	0.008	0.004	0.016	0.013
Treatments	6.0	1.955**	1.714**	1.471**	1.822**	2.502**	3.264**
Error	24.0	0.006	0.007	0.007	0.006	0.006	0.010

**Significant at 5% level

APPENDIX – XXII

Analysis of variance for phosphorus content in crop plant

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	0.0008	0.0005	0.004	0.0006	0.0002	0.0003
Treatments	6.0	0.002**	0.001**	0.001**	0.005**	0.008**	0.009**
Error	24.0	0.0005	0.0009	0.0005	0.0007	0.0008	0.0009

**Significant at 5% level

APPENDIX – XXIII

Analysis of variance for potassium content in crop plant

Source	d.f.	Mean sum of square					
		I	**II**	**III**	**IV**	**V**	**VI**
Replication	4.0	0.004	0.002	0.006	0.006	0.0007	0.016
Treatments	6.0	0.846**	0.857**	1.062**	1.587**	2.710**	2.263**
Error	24.0	0.0009	0.006	0.002	0.004	0.002	0.003

**Significant at 5% level

APPENDIX – XXIV

Analysis of variance for green forage and dry matter productivity per day of different forage crops

Source	d.f.	Mean sum of square	
		Green forage productivity per day	Dry matter productivity per day
Replication	4.0	0.011	0.0003
Treatments	6.0	6.439**	0.3184**
Error	24.0	0.007	0.0004

**Significant at 5% level

VITA

***Mr. Brajkishor Prajapati**, the author of this manuscript was born on 10th November, 1987 in Kotma Colliery, at district Anuppur in Madhya Pradesh. He passed high school and intermediate from Govt. Excellence School (Raghuraj-2) Shahdol in 2004 and 2006 with first division, respectively. He has completed his B.Sc. (Ag.) Honors from Kerala Agricultural University (Trichur) in 2012. Then he entered the prestigious premises of G.B. Pant University of Agriculture & Technology, Pantnagar for his M.Sc. (Ag.) programme with major in Agronomy and successfully completed in June, 2014. He also received **National Talent Scholarship of ICAR** and **Junior Research Fellowship of ICAR** during the degree programme.*

Permanent address:

Brajkishor Prajapati
Kotma Colliery Bhalumada
Hallow Block Ward No-17
Mau.Abdul Kalam Aajad
Q. No. - H/34
Distt: Anuppur, Madhya Pradesh
Pin- 484336
E-mail: brajkishorprajapati1@gmail.com

Name : Brajkishor Prajapati **Id.No.** : 44087
Sem. & Year of admission: 1st sem., 2012-2013 **Degree** : M.Sc. (Ag.)
Major : Agronomy **Deptt**. : Agronomy
Thesis title : GROWTH, YIELD AND QUALITY OF *RABI* SEASON FORAGE CROPS UNDER *TARAI* REGION OF UTTARAKHAND
Advisor : Dr. Kewalanand

ABSTRACT

The experiment was conducted at Forage Agronomy block of Instructional Dairy Farm (IDF), Nagla of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand, India during *rabi* season of 2012-13. The experiment was laid out in Randomized Block Design consisting seven (7) treatments with five (5) replications. Growth, yield and quality of native and exotic cultivated forage crop's varieties was determined along with their cuttings potential.

UPO-212 and exotic Genie oat (Netherland) varieties of oat, local rye and exotic Makkhan grass (Advanta) varieties of rye grass, Mascavi variety of berseem, exotic Baralfa IN (Netherland) variety of lucerne and exotic Barduro (Netherland) variety of red clover were tested for their yield attributes, yield and quality.

The dry matter per cent, green forage yield, dry matter yield, crude protein yield, and digestible dry matter yield was highest from lucerne variety Baralfa IN than remaining leguminous *rabi* season forage crops. Among oat varieties, dry matter per cent, green forage yield, dry matter yield, crude protein yield and digestible dry matter yield was highest in the UPO-212 than genie oat while among rye grasses, yields was higher in the rye grass variety makkhan grass than local rye. Crude protein per cent, neutral detergent fibre content, acid detergent fibre content and hemicellulose per cent of berseem was higher than lucerne variety Baralfa IN and red clover variety Barduro, while among oat and rye grass varieties, genie oat and makkhan grass had higher respective quality characters. Dry matter digestibility was higher in red clover variety Barduro than remaining leguminous *rabi* season forage crops. Among oat and rye grass varieties, dry matter digestibility was more in genie oat and makkhan grass respectively.

On the basis of the present investigation it is concluded that exotic lucerne variety Baralfa IN, Oat variety UPO-212 and Rye grasses variety Makkhan grass, best option for *rabi* season forage crops.

(Kewalanand)
Advisor

(Brajkishor Prajapati)
Author

नाम	: ब्रजकिशोर प्रजापति	**परिचयांक**	: 44087
सत्र एवं प्रवेश वर्ष	: प्रथम षटमास 2012–13	**उपाधि**	: स्नातकोत्तर (कृषि)
मुख्य विषय	: शस्य विज्ञान	**विभाग**	: शस्य विज्ञान विभाग

शोध शीर्षक : **उत्तराखण्ड के तराई क्षेत्र में रबी मौसम की चारा फसलों की बढ़वार, उपज एवं गुणवत्ता**

परामर्शदाता : **डॉ0 केवलानन्द**

सारांश

चारें की विभिन्न फसलों की किस्में जई की यू.पी.ओ–212 एवं गिन्नी जई, राई घास की स्थानीय राई एवं मक्खन घास, बरसीम की मेस्कावी, ल्यूसर्न की बाराल्फा इन एवं रेडक्लोवर की बारडो की बढवार, उपज एवं गुणवत्ता मूल्यांकन हेतु वर्ष 2012–13 रबी मौसम में शैक्षणिक डेयरी फार्म नगला, गोविन्द बल्लभ पंत कृषि एवं प्रौद्योगिकी विश्वविद्यालय पंतनगर (उधमसिंह नगर), उत्तराखण्ड, भारत के चारा एग्रोनॉमी प्रक्षेत्र में पॉच (5) पुनावृत्तियों के साथ रेन्डामाइज ब्लॉक डिजाइन में परीक्षण किया गया।

ल्यूसर्न की किस्म बाराल्फा इन में हरा चारा उपज, शुष्क पदार्थ उपज, क्रूड प्रोटीन उपज, सुपाच्य पदार्थ उपज एवं शुष्क पदार्थ प्रतिशत बाकी फलीदार रबी मौसम की चारा फसलों से अधिक पाया गया। जई की किस्मों में यू.पी.ओ–212 का हरा चारा उपज, शुष्क पदार्थ उपज, क्रूड प्रोटीन उपज, सुपाच्य पदार्थ उपज एवं शुष्क पदार्थ प्रतिशत सबसे अधिक पाया गया। राई घास की विदेशी किस्म मक्खन घास की उपज स्थानीय राई घास की अपेक्षा अधिक पायी गई।

बरसीन की मेस्कावी किस्म में क्रूड प्रोटीन प्रतिशत, तटस्थ ि डटर्जेंट फाइबर प्रतिशत, एसिड डिटर्जेंट फाईबर प्रतिशत और हेमीसेल्यूलोज, ल्यूसर्न की किस्म बाराल्फा इन और रेडक्लोवर की बारडो किस्म से अधिक पाया गया। जई की किस्म गिन्नी जई एवं राई की किस्म मक्खन घास में उपरोक्त गुण उच्च मात्रा में पाए गए।

शुष्क पदार्थ सुपाच्य रेडक्लोवर की किस्म बारडो में शेष रबी मौसम की फलीदार फसलों से अधिक पाया गया। जई की किस्म गिन्नी जई एवं राई की किस्म मक्खन घास में उपरोक्त गुण उच्च स्तर के पाए गए।

वर्तमान शोध से यह निष्कर्ष निकलता हैं कि ल्यूसर्न की किस्म बाराल्फा इन, जई की किस्म यू.पी.ओ–212 एवं राई की किस्म मक्खन घास रबी मौसम में उत्तराखण्ड के तराई क्षेत्रों के लिए अधिक वृद्वि, उपज एवं गुणवत्ता के लिए प्रयोग हेतु उपयुक्त है।

(केवलानंद)
परामर्शदाता

(ब्रजकिशोर प्रजापति)
लेखक