CUTTING INTERVALS AND ADDITIVES FOR QUALITY SILAGE PRODUCTION

by

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(2014-11-137)

THESIS

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DECLARATION

I, hereby declare that this thesis, entitled **"CUTTING INTERVALS AND ADDITIVES FOR QUALITY SILAGE PRODUCTION"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled **"CUTTING INTERVALS AND ADDITIVES FOR QUALITY SILAGE PRODUCTION"** is a record of bonafide research work done independently by **Ms. Ishrath, P. K. (2014-11-137)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Ishrath, P. K.

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LIST OF ABBREVIATIONS AND SYMBOLS USED

et al.	And other co workers
@	At the rate of
cm	Centimetre
CRD	Completely Randomised Block Design
CD	Critical difference
°C	Degree Celsius
°E	Degree East
°N	Degree North
DM	Dry matter
dSm^{-1}	Deci Siemens per metre
FYM	Farmyard manure
Fig.	Figure
g	Gram
g kg^{-1}	Gram per kilogram
ha	Hectare
kg	Kilogram
kg $acre^{-1}$	Kilogram per acre
kg ha^{-1}	Kilogram per hectare
m	Metre
mL	Milli litre
mm	Millimetre
m ha	Million hectare
viz.	Namely
N	Nitrogen
NS	Non significant
No.	Number
POP	Package of practices

%	Per cent
Cut^{-1}	Per cut
ha^{-1}	Per hectare
$Year^{-1}$	Per year
P_2O_5	Phosphate
K_2O	Potash
K	Potassium
RBD	Randomised Block Design
RH	Relative humidity
Sl.	Serial
sp.	Species
SE	Standard error
i.e.	That is
$t\ ha^{-1}$	Tonnes per hectare

APPENDIX

INTRODUCTION

1. INTRODUCTION

India is the leading country in livestock population. India accommodates nearly 20 per cent of the world livestock and 16.8 per cent human population on a land area of only 2.3 per cent. The livestock sector plays a major role in the rural economy as well as it provides employment for India's majority of the rural people.

Among the livestock products, milk is the most important one and in milk production, India leads in the world. Although India has a very large population of livestock, the productivity of milk and other livestock products per animal is very low compared to many other countries in the world. Lack of availability of good quality green fodder throughout the year is the major constraint for low productivity of animals.

Future development and growth of livestock are highly associated with the scope of availability of fodder from cultivable land, forest, pastures and grazing lands and also preservation of green fodder for lean season to ensure the year round availability (Shah *et al.*, 2011).

The National Commission on Agriculture in 1976 recommended that a minimum 10 per cent of the arable area in the country (about 16.5 m ha) should be under improved forage crops to meet the green forage needs of the ever growing livestock population (Singh *et al.*, 2011). Now the area under fodder cultivation is only 8.3 m ha (4 per cent of total cropped area). At present, the country faces a net deficit of 61.1 per cent in green fodder and also recent population trends of India is not matching with the livestock growth rate, signifying that India have to import milk by 2021, if the milk production does not increase at the rate of 5.5 per cent (Datta, 2013).

In India, Kerala state has the highest percentage of cross bred animals with higher genetic potential for milk production. But the average yield of cow per day is only 7.508 kg milk and the total milk production does not meet the requirement of the state (Anita, 2014). In Kerala also the main reason for low productivity is lack of good quality fodder. The cultivated area under fodder in Kerala is only 4890 ha. The fodder requirement in the state is 232 m t where as the availability is only 94.5 m t, a deficit of nearly 60 per cent (137.5 m t) (FIB, 2015).

Although the per capita land availability is very less in Kerala, high yielding varieties will help to tackle the problem of fodder shortage. Among the fodder crops hybrid napier is the most popular fodder crop in Kerala. Compared to other fodder grasses it has good nutritional quality as well as high yield potential. Suguna is a popular hybrid napier variety having an yield potential of 280-300 t ha^{-1}. It has better quality with crude protein content of 9.4 % and crude fibre content of 24.0 %. The grass is nutritious, palatable and free from oxalates (Abraham and Thomas, 2015).

The oxalate content of napier grass can be manipulated by varying the harvesting interval. Rahman *et al.* (2010) reported a decline in oxalate content with increase in harvest interval. Appropriate cutting management is essential for high production and quality of napier grass (Jorgensen *et al.*, 2010; Tessema *et al.*, 2010). The commonly adopted cutting interval of hybrid napier is 45 to 60 days (KAU, 2011). High cutting frequency reduces growth and development, whereas long intervals between harvests leads to accumulation of fibre and reduction in quality (Tessema *et al.*, 2010).

To overcome the acute shortage of fodder during summer, fodder preservation is the alternative suggested. It ensures supply of quality fodder throughout the year, though the method is not much popular in the rural areas of the state. Hay and silage are the common preserved products of fodder crops. Compared to hay, silage is more nutritious as the deterioration of nutrients from the green fodder is less in silage than hay.

As silage bags are commercialised, which are reusable, makes the process of ensiling easy, rather than in pit silos. It also enables the farmer to prepare silage even in very small quantities according to his requirement.

To improve the quality of silage, additives can be used. Silage additives are any substances that will either promote rapid fermentation or increase the nutritional value of silage (Kaiser. 1999). Molasses is the common water soluble carbohydrate additive used in making fodder grass silage in India. However, increased use and price of molasses and its inability to reduce effluent in succulent fodder grasses bring an urge to find alternative locally available additives. In the light of the above facts, the present study was undertaken with the following objectives.

1. To assess the effect of cutting intervals on quality fodder production for ensiling

2. To study the effect of additives and cutting intervals for quality silage production.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

An experiment entitled "Cutting intervals and additives for quality silage production" has been conducted at Kerala Livestock Development Board farm, Palakkad during May 2015 to April 2016. The main reason for low productivity of milk in Kerala is non availability of good quality feed. The acute shortage will occur during summer months. In rural areas the farmers are unaware about the preservation of fodder. To improve the availability during summer months also, preserved products like hay and silage can be used. As silage studies in Kerala were less, the available studies that are directly or indirectly related to the topic of research from various sources are reviewed in this chapter.

2.1 HYBRID NAPIER

Due to tallness and vigorous vegetative growth of napier grass, it is also called as elephant grass. Under favourable climatic and soil conditions it produces nearly 50 tillers. But the napier grass is coarse-textured in nature, the leaf blade and leaf sheaths are hairy, leaf margins are sharply toothed and stems are fibrous and less juicy. In 1953, a cross was made in India with bajra, the resulted progenies were more succulent, leafy, fine textured, palatable, fast growing and drought resistant than napier. Hybrid napier produces more number of tillers compared to napier grass. Even though its stems are harder and the plant is persistent, it grows faster and produces more herbage (KAU, 2011).

2.2 EFFECT OF CUTTING INTERVALS ON FODDER QUALITY

The first cut of hybrid napier can be taken 9-10 weeks after planting under Kerala condition. Subsequent cuts can be taken up after four to six weeks or when the plant attains a height of 1.5 m. At least six to eight cuts are possible annually. Stubbles of 10-15 cm are left out at harvest, in order to encourage quicker regeneration from the basal buds. The oxalate content of some of the varieties may be high and it can be mitigated if harvested at longer intervals *i.e.* 45 to 60 days (KAU, 2011).

2.2.1 Green Fodder Yield

Walmsley *et al.* (1978) reported that in general, a crop of common napier grass removes 463 kg of nitrogen, 96 kg of phosphorus and 594 kg of potassium per hectare per year. They also suggested that highest yields could be expected from applying nitrogen after every cut. It has been observed that basal application of recommended NPK fertilizer has given higher establishment percentage and a higher yield of 359.7 t ha^{-1} $year^{-1}$.

From a study on maize and cowpea intercropping, Azim *et al.* (2000) reported green fodder yield of maize harvested at 75 days after planting as 43 t ha^{-1}, 85:15 ratio of maize and cowpea intercropping as 47 t ha^{-1} and 70:30 ratio of maize and cowpea intercropping as 52 t ha^{-1}.

According to Hussain *et al.* (2002), green forage yield and dry matter yield in oat cultivar *fatua* increased with maturity. Here maximum green forage and dry matter yield was obtained at fifty per cent of flowering. Singh *et al.* (2002) indicated that the green fodder yield of napier bajra hybrid increased with increased cutting interval. The yield of 3 grass species *i.e.*, ruzi grass (*Brachiaria ruziziensis*), dwarf napier and Taiwan A25 (both *Pennisetum purpureum*) increased with increasing cutting intervals (Tudsri *et al.*, 2002).

Premaratne and Premalal (2006) observed that for efficient management and utilization of the hybrid napier, harvesting pattern is important. In a well established crop, the first cut was ready in 60 days and subsequent cuttings were taken approximately at an interval of 30 – 45 days.

Significant effects of days for cutting in hybrid napier was observed by Bayble *et al.* (2007) and digestible organic matter yield (DOMY) was maximum at 120 days of cutting than 60 days and 90 days of cutting after planting. This increasing trend in DOMY of the forages is due to proportional increment of dry matter yield with advance in cutting days. Highest green fodder yield was obtained with longest cutting interval of 3 months in napier grass (Rengsirikul *et al.*, 2011).

From a study conducted by Bandeswaran *et al.* (2013) on yield and nutrient content of napier-bajra hybrid grass with different manures and fertilizers, reported that the fodder harvested at 86^{th} day gave a higher biomass yield of 24 kg $acre^{-1}$ when organic manures were used in combination with 60 kg $acre^{-1}$ of inorganic nitrogen application.

Subhalakshmi *et al.* (2013) reported that the total bio-mass yield was highest at 120 days of harvest in hybrid napier varieties CO-2 and CO-3, when compared with 60 and 90 days of harvest. Cutting at 5 weekly interval recorded maximum green fodder yield in guinea grass with an acceptable leaf to stem ratio compared to other 2 cutting intervals, *i.e.* 3 week and 4 week (Jusoh *et al.*, 2014).

2.2.2 Dry Fodder Yield

The studies of Mohammed *et al.* (1988) indicated that dry forage yield of napier grass was significantly increased as harvesting interval was increased from 30 to 60 days. The highest DM (3.2 to 3.3 t ha^{-1}) was recorded by clipping the crop at 60 days interval.

Tsegahun *et al.* (1992) observed an increase in dry matter yield as the cutting interval was increased from 2 weeks to 8 weeks in four cultivated grasses (*Chloris gayana, Panicum maximum, Panicum cloratum* and *Cenchrus ciliaris*).

Total dry matter yield in 3 grass species ruzi (*Brachiaria ruziziensis*), dwarf napier and Taiwan A25 (both *Pennisetum purpureum*) increased progressively with increase in cutting interval ranging from 32.3 t ha^{-1} at 20 day cutting to 40.4 t ha^{-1} at 40 day cutting (Tudsri *et al.*, 2002).

DM production in elephant grass (*Pennisetum purpureum* cv. King grass) and two guinea grass (*Panicum maximum*) increased as length of harvesting interval increased (Man and Wiktorsson, 2003).

Baybale *et al.* (2004) reported that, as the harvesting dates advanced the DM yield was also increased in *Pennissetum purpureum* sole or intercropped with *Demodium intortum* or *Lablab purpureus*.

Melakie *et al.* (2005) noticed that DM yield was highly influenced by harvesting interval in bana grass. The highest DM yield was obtained from 120 days of harvesting interval compared to 60 and 90 days.

The study conducted by Ansah *et al.* (2010) noticed that the dry matter in napier grass increased with an increase in harvest interval from 60 days to 120 days.

According to Jusoh *et al.* (2014) the highest yield per harvest of guinea grass was at 5 week cutting interval (1527.7 kg ha^{-1}), followed by 4 week cutting interval (923.7 kg ha^{-1}) and 3 week cutting interval (738.4 kg ha^{-1}).

2.2.2 Crude Protein Percentage

Determination of crude protein in the feed stuff is important since mostly they are classified according to the protein content. The proteins are mainly used for the production of lean meat and for replacing the physiological losses of protein from the body. The raw protein is required to supply the proteins in milk, wool and egg production in the animals (Ranjhan, 1991).

Protein content of a feed stuff also gives indirect information about the digestible energy of the feeds. When the protein content is high, the crude fibre content is usually low and in turn the digestibility of the fodder will be higher. Higher digestible fodder would give more digestible energy (Ranjhan, 1977).

Shenkoru *et al.* (1987) noticed highest value for crude protein content of native pastures at early stage of growth of 30 and 60 days of harvest than 90 days

In a report given by Mohammed *et al.* (1988) revealed that crude protein content in napier grass was significantly decreased (9.8 %, 8.1 % and 6.4 %) with longer harvest intervals (30 days, 45 days and 60 days respectively).

Azim *et al.* (2000) observed the crude protein content of maize harvested 75 days after planting as 8.32 %, 85:15 ratio of maize and cowpea intercropping as 9.75 % and 70:30 ratio of maize and cowpea intercropping as 14.43 %.

Hussain *et al.* (2002) confirmed that oat cultivar with higher crude protein content was estimated when the crop was harvested after 70 and 85 days of planting. The crude protein concentration in both leaf and stem of 3 grass species *i.e.*, ruzi (*Brachiaria ruziziensis*), dwarf napier and Taiwan A25 (both *Pennisetum purpureum*) decreased as the cutting interval increased (Tudsri *et al.*, 2002).

As the cutting interval increased (4, 6 and 8 weeks) the forage quality in terms of crude protein and cell wall concentrations, decreased in elephant grass (*Pennisetum purpureum* cv. King grass) and two guinea grass (*Panicum maximum*) (Man and Wiktorsson, 2003).

Baybale *et al.* (2004) observed an increase in crude protein content in *Pennisetum purpureum* sole or intercropped with *Demodium intortum* or *Lablab purpureus* with advanced harvesting dates (60, 90 and 120 days from planting).

The studies of Melakie *et al.* (2005) indicated that crude protein content was highly influenced by harvesting days in bana grass. The highest crude protein content was obtained from the lowest harvesting interval of 60 days than 90 and 120 days.

Aganga *et al.* (2005) reported that the crude protein content of hybrid napier harvested at different heights of 50 cm, 75 cm, 1 m, 1.25 m and 1.5 m were 13.29 %, 10.33 %, 8.85 %, 6.67 % and 4.79 % respectively.

In a study conducted in Sri Lanka on hybrid napier variety CO-3, the crude protein content was in the range of 15 % –16 % when the cutting interval was 30-45 days (Premaratne and Premalal, 2006). According to Bayble *et al.* (2007), days at cutting showed a significant difference in crude protein content of napier grass. That was 14.13 %, 10.4 % and 7.77 % for the days at cutting 60, 90 and 120 days respectively.

Tauqir *et al.* (2009) reported that the crude protein content of jumbo grass harvested at full bloom stage was 12.7 %. Ansah *et al.* (2010) noticed that the crude protein decreased with an increase in harvest day from 60 days to 120 days. The crude protein content of hybrid napier harvested at 86^{th} day was found to be 9.19 % with the addition of poultry manure and nitrogen 60 kg $acre^{-1}$ (Bandeswaran *et al.*, 2013).

Subhalakshmi *et al.* (2013) reported that maximum nutrients in hybrid napier varieties CO-2 and CO-3 were available at 60 days of harvest in hybrid napier than 90 and 120 days. In their study the crude protein content ranged from 7.28 % to 10.60 % on dry matter basis.

According to Antony and Thomas (2014), crude protein in leaves of hybrid napier was found higher in the cultivars IGFRI-3, CO-3 and DHN-6 (14.2 %, 14.1 %. and 13.5 % respectively) when the fodder was harvested at 45 days interval. In this study the crude protein content in stem was higher in CO-3, IGFRI-3 and PBN 16 (9.58 %, 9.17 % and 8.54 % respectively).

Pathan *et al.* (2014) concluded that, increase in cutting interval in bajra-napier hybrid decreases the crude protein content. The crude protein content of three cutting intervals 45 days, 60 days and 75 days were 6.75 %, 6.58 % and 6.50 % respectively.

The crude protein content of fodder sorghum, hybrid napier and maize harvested at fifty per cent flower initiation stage was 11.6 %, 13.3 % and 8.7 % respectively (Bandara *et al.*, 2014). Jusoh *et al.* (2014) observed that, 3 week old guinea grass recorded the highest crude protein content of 15.3 %, followed by 4 week interval (12.8 %) and 5 week interval (11.1 %).

2.2.3 Crude Fibre Percentage

Crude fibre is that fraction of the total carbohydrates which is not digested after successive boiling with dilute acid and dilute alkali. Crude fibre consists of cellulose, hemicelluloses, pentosans and small fractions of lignin (Ranjhan, 1977).

Studies of Mohammed *et al.* (1988) revealed that crude fibre content in napier grass was significantly increased with lengthening of harvest intervals from 30 days to 60 days.

In a study conducted by Azim *et al.* (2000) on maize and cowpea intercropping , the crude fibre content of maize harvested 75 days after planting was 23.29 %, 85:15 ratio of maize and cowpea intercropping was 20.90 % and 70:30 ratio of maize and cowpea intercropping was 20.95 %.

Hussain *et al.* (2002) confirmed that the crude fibre content in oat cultivar *fatua* increased with maturity and the lower content was observed at 75 and 85 days after planting. Premaratne and Premalal (2006) confirmed that the crude fibre percentage of hybrid napier variety CO-3 was in the range of 34 % - 37 %. In a study conducted by Bandeswaran *et al.* (2013), the crude fibre content of fodder harvested at 86th day was higher *i.e.* 33.99 % with the addition of poultry manure and N at the rate of 60 kg acre^{-1}.

Pathan *et al.* (2014) reported that the crude fibre content in bajra- napier hybrid increased with increase in cutting interval *i.e.* 30.2 %, 31.5 % and 32.6 % in 45, 60 and 75 days intervals, respectively.

Antony and Thomas (2014) analysed the crude fibre content in leaves and stems of hybrid napier varieties and it was high in IGFRI-7 when the fodder was harvested at 45 days interval. According to Bandara *et al.* (2014) the crude fibre content of fodder sorghum, hybrid napier and maize harvested at fifty per cent flower initiation were 36.8 %, 37.8 % and 34.7 % respectively.

2.3 SILAGE

Silage is the product formed by the fermentation of green fodder under anaerobic conditions (Reddy and Reddy, 2010). According to Tauqir (2004), to preserve as much of the nutrients of the original crop as possible is the important goal of silage making. Stewart (2011) also reported that the main goal of silage making is to improve the preservation of original nutrients in the forage crop for feeding of livestock under forage shortage times.

2.3.1 Principles of Ensiling

According to Stewart (2011). ensilage or ensiling is a process of preserving forage for feed shortage times. The principles of ensilage are well known. The first major objective is to achieve anaerobic conditions under which natural fermentation can take place (Yitbarek and Tamir, 2014). In practice, this is achieved by consolidating and compacting the material and sealing of the silo to prevent re-entry of air. Air that is trapped in the herbage is rapidly removed by respiratory enzymes (Mc Donald *et al.*, 1991). Meeske (2005) confirmed that finer chopping of the forage will improve the compaction and fermentation of silage. This will improve the palatability and intake of silage.

The second objective is to reduce the activities of undesirable microorganisms such as clostridia and enterobacteria. Growth of clostridia and enterobacteria can be inhibited by lactic acid fermentation (Mc Donald *et al.*, 1991).

During ensiling, the microorganisms capable of anaerobic growth namely, lactic acid bacteria, enterobacteria, clostridia, some *Bacillus* spp. and yeasts begin to grow and compete for available nutrients in the chopped fodder.

Under favourable conditions lactic acid bacteria will quickly acidify the environment to such an extent that the competing organisms will not be able to survive and the end result will be stable, low pH silage. If, however, the pH is not lowered quickly enough, the undesirable microorganisms mainly enterobacteria, clostridia and yeasts will be able to compete for nutrients. This will reduce the chances of obtaining good quality silage (Mc Donald *et al.*, 1991).

2.3.2 Silage Additives

Silage additives are any substances that will either promote rapid fermentation or increase the nutritional value of silage (Kaiser, 1999). Henderson (1993) reported that research on silage and silage additives has been conducted for many years to maximize the nutritive value of silage and to reduce the risks during the ensiling process.

According to Merensalmi and Virkki (1991), silage additive should be safe to handle and should reduce dry matter losses. Silage additives are added to the forage or crop at ensiling, may improve the ensiling (fermentation) process, reduce losses, reduce aerobic deterioration at feed out, improve the hygienic quality of the silage, limit secondary fermentation, improve aerobic stability, increase the nutritive value of the silage and as a result increases animal production and give the farmer a return greater than the cost of the additive.

Tropical grasses have been successfully ensiled when supplemented with cassava meal (Panditharane *et al.*, 1986), maize meal (Van Onselen and Lopez, 1988) and sorghum grain (Alberto *et al.*, 1993).

In the early cut tropical grasses, urea or molasses is possibly the best additive (Bolsen, 1999). Applying urea or anhydrous ammonia to silage has an adverse effect on fermentation and nutrient quality of silage, particularly high-moisture forage sorghums (Bolsen *et al.*, 1995), although Sarwatt (1995) obtained good quality silage by ensiling with 0.5 % urea for maize, sorghum and rhodes grass in Tanzania.

There are five types of additives used in ensiling such as fermentation stimulants, fermentation inhibitors, aerobic spoilage inhibitors, nutrients and absorbents (Kaiser, 1999).

Commonly used additives come under fermentation stimulants, nutrients and absorbents. Silage additives will not produce poor quality forage into good quality silage but they can help to make good quality forage into excellent quality silage (Kenilworth and Warwickshire, 2012).

2.4 EFFECT OF ADDITIVES ON SILAGE QUALITY

2.4.1 Colour

In a study conducted by Naik *et al.* (2013) on napier bajra hybrid silage prepared without any additives in bunker silo was well accepted by dairy animals. The colour of the silage was greenish yellow to brownish with vinegar smell and pleasing taste.

The colour of maize silage harvested at 75 days maturity and prepared in synthetic nylon bag silos was greenish yellow (Khandaker and Uddin, 2013).

In a study conducted by Delena and Fulpagare (2015), the colour of hybrid napier silage was light green to brown with the addition of molasses.

2.4.2 pH

Miller *et al.* (1963) observed a lower pH of 4.1 and 4.2 in maize and maize and cowpea mixed silage respectively. Boin (1975) reported that when sugarcane molasses was added at the rate of 3 % to napier grass, silage had good fermentation quality. The fermentation in silage can be improved by the addition of an inoculum of lactic acid bacteria and carbohydrate rich materials like molasses. pH of hybrid napier silage was decreased from 6.3 of the fresh herbage to 3.5-4.0 with the addition of molasses and inoculums (Singh and Neelakantan, 1981).

Guinea grass with 4 weeks (18.6 % DM) and 8 weeks (26.5 % DM) of growth was ensiled untreated or with 4 % molasses in 400 g laboratory silos. The pH varied from 4.4 to 5.4 and from 4.0 to 4.7 and ammonia-N ranged from 23.5 to 35.3 and from 15 to 39 respectively, for untreated and molasses treated silage (Esperance *et al.*, 1985).

Addition of 0.2 % urea and 2 % molasses decreased pH in mature grass silage while in young grass silage it did not have any effect. This may be because of the higher water soluble carbohydrate content in young grass than mature grass (Mc Donald *et al.*, 1991; Davis *et al.*, 1997)

Dwarf elephant grass cut at 72 days re growth was mixed with 4 % molasses and ensiled in 4 kg polythene bags and the resulting silage showed lower pH and ammonia-N than the control silage (Tosi *et al.*, 1995).

Keady (1996) observed that molasses treatment improved silage preservation, but did not significantly alter the silage digestibility or animal performance although silage dry matter intake was improved.

Molasses addition benefitted unwilted crops with low water soluble carbohydrates and high buffering capacity by reducing final pH and the reduced clostridia spoilage (Leibensperger and Pitt, 1988; Mc Donald *et al.*, 1991; Scudamore and Livesy, 1998).

Concentration of fermentable carbohydrates in the forage, its buffering capacity, dry matter content and the number and type of bacteria present on the forage is the main factors that could affect the rate of pH decline and final pH of the silage (Bolsen *et al.*, 1996; Higginbotham *et al.*, 1998).

In a study conducted by Azim *et al.* (2000), the pH of maize silage harvested 75 days after planting was 4.1, 85:15 ratio of maize and cowpea mixed silage was 4.00, 70:30 ratio of maize and cowpea mixed silage was 3.8 and 2.5 %

urea mixed maize silage was 5.4. The pH values of molasses added silage were significantly lower compared to control silage (Man and Wiktorsson, 2001).

Tauqir (2004) reported that during ensiling, the preservation is achieved by acidity and by maintaining anaerobic environment. Acids produced by bacteria convert fermentable carbohydrates into lactic and acetic acids. As fermentation progresses, more acids are produced, pH drops and eventually the acidity level is sufficient to inhibit or kill the growth of most bacteria and other microorganisms. At this pH, if protected from exposure to air and water seepage from rain, silage can be preserved for a long period.

Mtengeti and Urio (2006) reported that the pH values of molasses treated maize fodder (of 75 days maturity) silage from the earthern pit remained more than 5 up to the fourth day of feeding out. Mtengeti and Urio (2006) also reported that the elephant grass silage in plastic bag silos, without any additives shows a higher pH of more than 5, for both the silage stored in barn and earthern pit.

In a study conducted by Naik *et al.* (2013) on napier bajra hybrid silage prepared without any additives in bunker silo, the silage was firm in texture, without mould growth and acidic (pH 4.0) in nature. According to Bandara *et al.* (2014), the pH of 1 silage from hybrid napier, maize and sorghum harvested at fifty per cent flowering was below the level of 4.7.

The pH of maize silage harvested at 75 days maturity and prepared in synthetic nylon bag silos was 7.49 (Khandaker and Uddin, 2013).

Cane molasses (75 % DM) has been widely used at the rate of 10 % to provide fast fermentable carbohydrate for the ensilage of tropical herbages. Molasses in many silage experiments has been proven to be an effective silage additive in terms of promoting lactic fermentation, reducing silage pH, discouraging clostridial fermentation and proteolysis and generally decreasing organic matter losses. It is of particular benefit when applied to forage crops low in fermentable carbohydrates for lactobacilli (Yitbarek and Tamir, 2014).

According to Delena and Fulpagare (2015), pH of silage decreased which are made from hybrid napier, maize and lucerne with the addition of molasses 3%. They found out the best silage as hybrid napier sole or in combination with maize and lucerne.

2.4.3 Total Ash Percentage

Ash is the inorganic residue which is estimated after the sample is burnt at 600°C. The total ash does not give any information about the amount of minerals present in sample. However, it helps in estimating the nitrogen free extract. The part of the ash which is soluble in hydrochloric acid is called soluble ash (Ranjhan, 1977).

Tauqir (2004) reported that the additives, their levels and fermentation periods did not affect the ash content of jumbo grass silage and the ash content was within 9.3 to 9.7 %. Additives, their levels and fermentation periods did not affect the ash content of mott grass silage and ash content ranged from 10.8 to 11.5 %.

In a study conducted by Elgersma *et al.* (2004) to evaluate the effects on milk composition of transition from a fresh grass diet on pasture to a winter diet of mixed grass/maize silage, the total ash content observed for grass silage, maize silage and mixed silage (50 per cent grass silage + 50 per cent maize silage) was 53.5 g kg^{-1} DM, 11.5 g kg^{-1} DM and 30.9 g kg^{-1} DM.

Aganga *et al.* (2005) observed that the ash content of silage prepared using hybrid napier harvested at different heights with molasses 5 % as additive were 7.1 %, 9.11 %, 9.02 %, 13.02 % and 12.15 % for the cutting heights of 50 cm, 75 cm, 1 m, 1.25 m and 1.5 m respectively. With the addition of molasses 5 % and urea 1 %, the ash content were 7.2 %, 9.23 %, 9.81 %, 13.12 % and 12.27 % respectively.

Tauqir *et al.* (2009) reported that the total ash content of jumbo grass silage with molasses 2 %, harvested at full bloom stage was 9.50 %. Hamza *et al.* (2009) observed that the ash content in whole corn silage with 2 % urea was 6.33 %.

According to Naik *et al.* (2013), there was an increase in total ash content during ensiling of napier bajra hybrid silage in bunker silo without any additives. The total ash content in the silage was 10.21 %. The total ash content of maize silage harvested at 75 days maturity and prepared in synthetic nylon bag silos was 11.3 % (Khandaker and Uddin, 2013).

2.4.4 Acid Insoluble Ash Percentage

The acid insoluble ash indicates the amount of silica present in the sample and is not available to the animal. Higher acid insoluble ash indicates poor quality of feed and sometimes shows the adulteration of feed (Ranjhan, 1977).

In a study conducted by Naik *et al.* (2013) on napier bajra hybrid silage prepared in bunker silo without any additives, the acid insoluble ash content in the silage was 2.28 %.

2.4.5 Crude Protein Percentage

Urea and ammonia can improve the aerobic stability of silage (Glewen and Young, 1982; Mc Donald *et al.*, 1991; Yunus *et al.*, 2000). Such additives when added to high dry matter, low buffering forages (maize or sorghum grain), will increase crude protein content and are claimed to improve aerobic stability of silage at feed out.

Miller *et al.* (1963) observed a lower crude protein content of 5.2 % and 7.3 % in maize and maize and cowpea mixed silage respectively. They also observed a crude protein content of 5.7 % in napier grass silage, 4.3 % in guinea grass silage ordinary, 5.7 % in pre- wilted guinea grass silage and 5.2 % in pre-wilted deenanath grass silage.

Patel *et al.* (1968) reported that sorghum silage has a crude protein content of 5.2 %. According to Ranjhan *et al.* (1969) the crude protein content of Pusa giant napier silage was 5.23 %.

The report given by Glewen and Young (1982) indicated the use of urea as a silage additive for elephant grass, it was concluded that with low dry matter forage and in the absence of additives rich in water soluble carbohydrate such type of product should not be recommended when aiming an improvement of fermentation.

Garcia *et al.* (1989) reported that during ensiling process crude protein content of fodder had undergone extensive degradation and significant amount of ammonia was liberated.

The study conducted by Ruiz *et al.* (1992), the crude protein concentration of freshly harvested elephant grass was 12.4 % compared to only 10.7 % in its silage. The reduction in crude protein concentration can be attributed to crude protein loss during the ensiling process.

De Visser *et al.* (1998) reported that silage from early- cut grass contained more N and sugar than did the silage from late- cut grass. Barley silage at boot stage had less dry matter and more crude protein as compared to soft dough stage silage. Acosta *et al.* (1991) reported that the reason for low crude protein content of soft dough stage was that with increasing maturity, cell content decreases and cell wall contents increases. Increased cell wall components and decreased cell contents of forages with maturity was also reported by Givens *et al.* (1989).

The studies of Azim *et al.* (2000) on maize and cowpea intercropping showed the crude protein content of maize silage harvested 75 days after planting as 8.52 %, 85:15 ratio of maize and cowpea mixed silage as 9.82 %, 70:30 ratio of maize and cowpea mixed silage as 14.90 % and 2.5 % and urea mixed maize silage as 13.86 %.

Man and Wiktorsson (2001) noticed the reduced crude protein content when grass was ensiled with additives. The reduction in crude protein content was attributed to the extensive proteolysis during the ensiling process (Ruiz *et al.*, 1992)

Tauqir (2004) observed non-significant impact on the crude protein content of jumbo grass ensiled with molasses or corn for all fermentation periods.

Aganga *et al.* (2005) studied about the nutrient content of silage prepared using hybrid napier harvested at different heights with different additives. While using molasses 5 % as additive, the crude protein values were obtained as 13.9 %, 11.16 %, 8.35 %, 7.16 % and 4.93 % for the cutting heights of 50 cm, 75 cm, 1 m, 1.25 m and 1.5 m respectively. With the addition of molasses 5 % and urea 1 %, the crude protein content was observed as 16.54 %, 13.74 %, 12.91 %, 9.58 % and 6.92 % for the cutting heights of 50 cm, 75 cm, 1 m, 1.25 m and 1.5 m respectively. They observed an increase in crude protein content while ensiling.

According to Mtengeti and Urio (2006) the crude protein values of molasses treated maize fodder (of 75 days maturity) silage were 10.06 % and 11.18 % respectively in barn and earthern pit stored silage, also the elephant grass silage in plastic bag silos, without any additives showed a lower crude protein content of less than 10 % in both the silage stored in barn and earthern pit.

Hamza *et al.* (2009) observed that the crude protein content in whole corn silage with 2 % urea was 14.05 %. Tauqir *et al.* (2009) reported that the total ash content of jumbo grass silage with molasses 2 %, harvested at full bloom stage as 12.7 %.

According to Naik *et al.* (2013) there was a decrease in crude protein content during ensiling of napier bajra hybrid silage prepared without using any additives in bunker silo. The crude protein content was 8.05 %. The crude protein content of maize silage harvested at 75 days maturity and prepared in synthetic nylon bag silos was 5.92 % (Khandaker and Uddin, 2013).

The studies of Dantas *et al.* (2014) on *Brachiaria decumbens* grass silage with different levels of soybean hulls as additives, the crude protein values were 5.48 %, 6.79 %, 8.10 %, 9.42 % and 10.73 % for different levels of soybean hulls *i.e.* 0 %, 10 %, 20 %, 30 % and 40 % respectively. The control silage recorded low crude protein content in this study.

2.4.6 Crude Fibre Percentage

Miller *et al.* (1963) recorded the crude fibre content of 41.8 % and 30.7 % in maize and maize and cowpea mixed silage respectively. They also observed a crude fibre content of 40.8 % in napier grass silage, 37.7 % in guinea grass silage ordinary, 40.8 % in pre- wilted guinea grass silage and 25.5 % in pre- wilted deenanath grass silage.

Silage of sorghum has lower crude fibre content of 34.8 % (Patel *et al.*, 1968). According to Ranjhan *et al.* (1969) the crude fibre content of Pusa giant napier silage was 38.49 %.

Hamza *et al.* (2009) indicated that the crude fibre content in whole corn silage with 2 % urea was 27.90 %. In a study conducted by Naik *et al.* (2013) on napier bajra hybrid silage prepared in bunker silo without any additives, the crude fibre content in the silage was 40.7 %. The crude fibre content of maize silage harvested at 75 days maturity and prepared in synthetic nylon bag silos was 30.4 % (Khandaker and Uddin. 2013).

2.4.7 Ether Extract Fat Percentage

The ether extract is that fraction of the feed stuffs which is obtained when the feed stuff is subjected to continuous extraction with petroleum ether. This includes fats, cholesterol, free fatty acids, lecithin, chlorophyll, resins, volatile oils and alkali substances (Ranjhan, 1977). Ether extract is the only source of essential fatty acids (Banerjee, 1970).

Elgersma *et al.* (2004) conducted an experiment to evaluate the milk composition of cattle undergoing transition from a fresh grass diet on pasture to a winter diet of mixed grass or maize silage. They reported that, the crude fat content of milk was 15.8 g kg^{-1} DM in those cattle fed on grass silage, 8.7 g kg^{-1} DM for those fed with maize silage and 12 g kg^{-1} DM for those fed with mixed silage (50 per cent grass silage + 50 per cent maize silage).

Arvidsson *et al.* (2008) conducted a study to investigate effects of wilting and additives (Proens TM (formic acid and propionic acid, 60–66 g $100g^{-1}$ and 25–30 g $100g^{-1}$, respectively), the bacterial inoculant Siloferm® Plus (*Pediococcus acidilactici* and *Lactobacillus plantarum*) and water (control)) on the fatty acid (FA) composition of timothy grass silage, the different additives and wilting strategies tested in this study did not affect the proportions of FAs in silage to a major extent.

According to Hamza *et al.* (2009), the ether extract content in whole corn silage with 2 % urea was 2.03 %. The ether extract content of maize silage harvested at 75 days maturity and prepared in synthetic nylon bag silos was 0.23 % (Khandaker and Uddin, 2013).

Naik *et al.* (2013) conducted a study on napier bajra hybrid silage prepared in bunker silo without any additives, the ether extract content in the silage was 1.1 %.

According to Dantas *et al.* (2014) the ether extract fat values in *Brachiaria decumbens* grass silage with different levels of soybean hulls as additives as 2.08 %, 3.18 %, 3.67 %, 4.61 % and 5.91 % for different levels of soybean hulls *i.e.* 0 %, 10 %, 20 %, 30 % and 40 % respectively.

2.4.8 Nitrogen Free Extract Percentage

Nitrogen free extract is that fraction of the total carbohydrates which is obtained when a sum total of crude protein, ether extract, crude fibre and ash is subtracted from 100. It includes monosaccharides, disaccharides, trisaccharides and some of the soluble polysaccharides (Ranjhan, 1977).

Patel *et al.* (1968) reported that sorghum silage has a nitrogen free extract content of 47.9 %. The nitrogen free extract content of Pusa giant napier silage was 41.49 % (Ranjhan *et al.*, 1969).

According to Hamza *et al.* (2009), the nitrogen free extract content in whole corn silage with 2 % urea was 49.69 %. The nitrogen free extract content of maize silage harvested at 75 days maturity and prepared in synthetic nylon bag silos was 52.2 % (Khandaker and Uddin, 2013). In a study conducted by Naik *et al.* (2013) on napier bajra hybrid silage prepared in bunker silo without any additives, the nitrogen free extract content in the silage was 39.93 %.

2.4.9 Recovery Percentage

Leahy *et al.* (1988) observed that the dry matter recovery of corn silage (control), corn with culbac, corn with silabac and corn with crop cure was 85.4 %, 92.5 %, 87.3 % and 86.4 % respectively.

Dantas *et al.* (2014) reported that with the addition of each percent of improved soybean hulls, there was an increase of 0.26 per cent units in the dry matter recovery of *Brachiaria decumbens* grass silage. The level of 20 % soybean hulls increased the dry matter recovery to 79.77 %, while in the control treatment this value was 74.49 %; at this intermediate level (20 %) there was a dry matter recovery of 5.28 per cent points. The lower values of losses and the greater dry matter recovery indicate that there was inhibition of hetero fermentative bacteria, responsible for the elevation of the losses, probably as a consequence of the decrease in the pH of the silage. The dry matter recovery values were 72.10 %, 80.89 %, 81.02 %, 83.12 % and 84.18 % for different levels of soybean hulls *i.e.* 0 %, 10 %, 20 %, 30 % and 40 % respectively.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

An experiment entitled "Cutting intervals and additives for quality silage production" was conducted at Kerala Livestock Development Board (KLDB) farm, Dhoni, Palakkad during May 2015 to April 2016. The objectives of the study were to assess the effect of cutting intervals on quality fodder production for ensiling and to study the effect of additives and cutting intervals for quality silage production. The details of the experimental materials and methods are described below.

3.1 EXPERIMENTAL SITE

The experiment was conducted at Kerala Livestock Development Board farm, Dhoni, Palakkad, Kerala, located at 11^0 N latitude and 67^0 7" E longitude and at an altitude of 150 m above mean sea level.

3.1.1 Soil

Soil of the experimental site was gravelly clay loam under Malampuzha I class III series. Before starting the field experiment, the initial soil nutrient status was assessed. For this, a composite soil sample was collected from a depth of 0-15 cm and the chemical properties were analysed. The data on chemical properties of the soil are presented in Table 1. Chemical properties of the soil were rated as per the package of practices recommendations of Kerala Agricultural University (KAU, 2011).

The soil of the experimental site was extremely acidic in reaction, normal in electrical conductivity, high in organic carbon, low in available nitrogen and medium in available phosphorus and potassium.

3.1.2 Climate

Data on monthly average of maximum and minimum temperature, relative humidity and total rainfall during the cropping period were collected from the meteorological observatory situated at KLDB farm, Dhoni. The data are presented in Appendix 1 and graphically illustrated in Fig.1.

The mean maximum temperature ranged between 28.19^{0}C – 35.41^{0}C and mean minimum temperature ranged between 20^{0}C – 23.55^{0}C during the crop growing period. The mean relative humidity was in the range 52.13 % to 79.58 %. During the crop growing period, the total rainfall was 1779.5 mm, with a peak during the month of June 2015.

Table 1. Chemical properties of soil of the experimental site

Parameter	Content	Rating	Method used
Soil reaction (pH)	4.20	Extremely acidic	1:2.5 soil solution ratio using pH meter with glass electrode (Jackson, 1973)
Electrical Conductivity (dSm^{-1})	0.30	Normal	Digital conductivity meter (Jackson, 1973)
Organic carbon (%)	1.56	High	Walkley and Black rapid titration method (Jackson, 1973)
Available Nitrogen (kg ha^{-1})	188.16	Low	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	15.79	Medium	Bray colorimetric method (Jackson, 1973)
Available K_2O (kg ha^{-1})	161.84	Medium	Ammonium acetate method (Jackson, 1973)

3.1.3 Season

The crop was planted during *Kharif* season (June 2015) and was maintained for one year for the study.

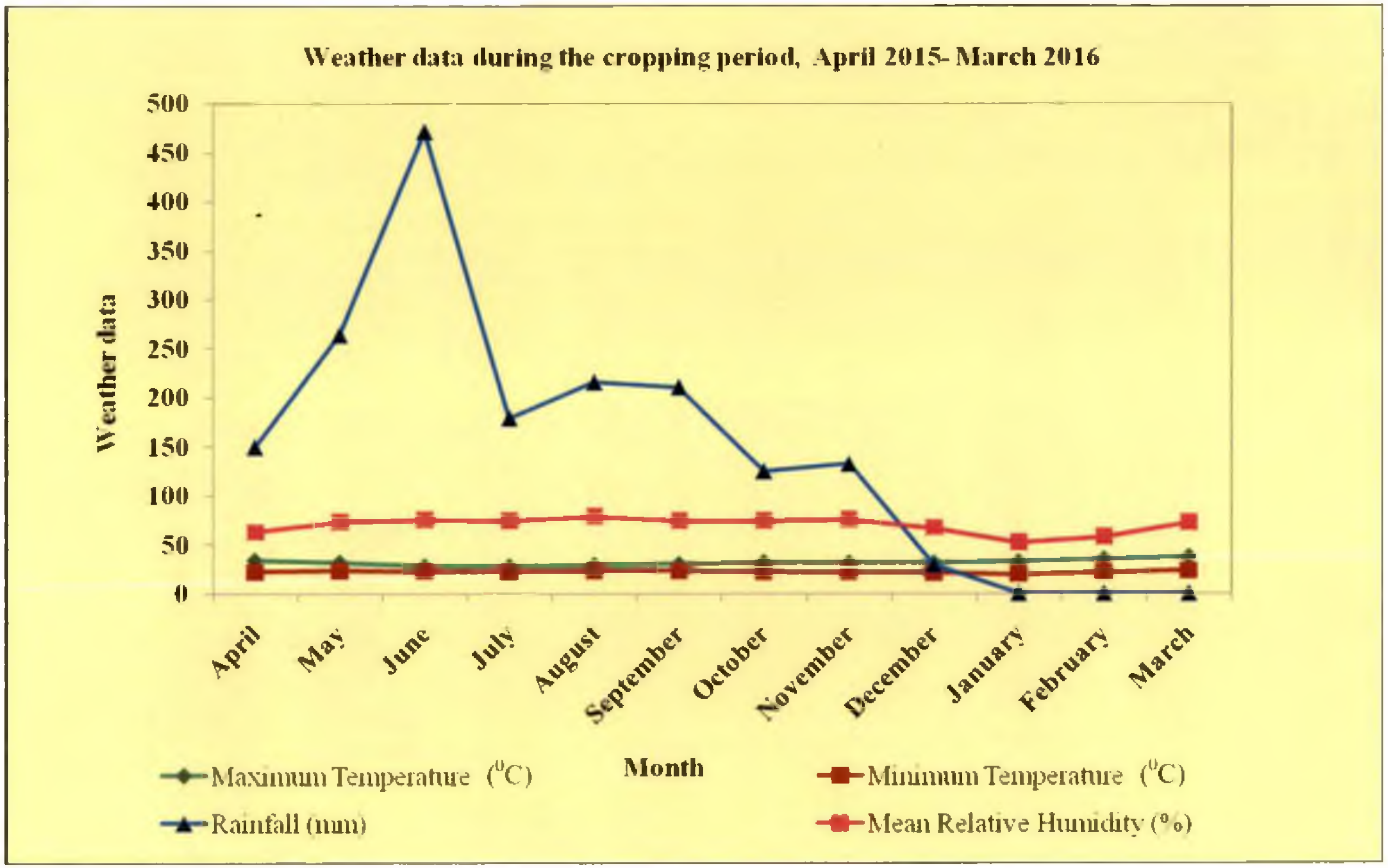


Fig. 1. Weather parameters during the cropping period, April 2015- March 2016

3.2 MATERIALS

3.2.1 Crop and Variety

The hybrid napier variety Suguna (Plate 1) released from Kerala Agricultural University was used in the study.

Suguna is a bajra-napier hybrid developed by crossing Composite 9 and FD 431. It has high tillering capacity (40 tillers plant^{-1}) with long broad leaves. The leaf sheath is pale green in colour with purple pigmentation, with serrated leaf margin. The average inter nodal length is 6.5 cm and leaf stem ratio is 0.82. It has better quality with crude protein content of 9.4 % and crude fibre content of 24.0 %. The grass is nutritious, palatable and free from oxalates. The production potential of the variety is 280-300 t ha^{-1}. The variety is free from pests and diseases. It is suited for uplands, homesteads and rice fallows of Kerala (Abraham and Thomas, 2015).

3.2.2 Manures and Fertilizers

Well decomposed farm yard manure (0.93 per cent N, 0.46 per cent P_2O_5 and 1.02 per cent K_2O) of 25 t ha^{-1} was used as organic source. For the chemical sources of nitrogen, phosphorus and potassium, fertilizers like urea (46 per cent N), rajphos (20 per cent P_2O_5) and muriate of potash (60 per cent K_2O) were used.

3.3 METHODS

3.3.1 Design and Layout

3.3.1.1 *Experiment 1: Effect of Cutting Intervals on Quality Fodder Production for Ensiling*

The layout of field experiment is depicted in Fig. 2.

Design	- RBD
Treatments	- 3
Number of replication	- 7

Plate 1. Hybrid napier variety Suguna

Plate 2. General view of the experimental plot

Gross plot size - 12 m x 6 m

Net plot size - 11.4 m x 5.4 m

Treatments - 3 cutting intervals

T_1 - 45 days
T_2 - 60 days
T_3 - 75 days

3.3.1.2 Experiment 2: Effect of Additives and Cutting Intervals on Quality Silage Production

Design - CRD

Number of replication - 3

Treatment combination - 15

Treatments

Ensiling material (E) -3

E_1 - Fodder harvested at 45 days interval

E_2 - Fodder harvested at 60 days interval

E_3 - Fodder harvested at 75 days interval

Additives (a) - 5

A_1 - Urea 2 %

A_2 - Jaggery 2 %

A_3 - Urea 1 % + Jaggery 1 %

A_4 - Molasses 2 %

A_5 - No additives

The treatment combinations were e_1a_1, e_1a_2, e_1a_3, e_1a_4, e_1a_5, e_2a_1, e_2a_2, e_2a_3, e_2a_4, e_2a_5, e_3a_1, e_3a_2, e_3a_3, e_3a_4 and e_3a_5.

3.3.2 Field Experiment

3.3.2.1 Land Preparation

The land was cleared by removing the weeds and stubbles and ploughed using tiller and leveled. According to the pH test result, lime was applied

@ 850 kg ha^{-1}, twenty one plots of 12 m x 6 m size were taken to accommodate the different treatments.

N

T_2R_3	T_3R_3	T_1R_3
T_1R_5	T_2R_5	T_3R_5
T_3R_2	T_1R_2	T_2R_2
T_2R_7	T_3R_7	T_1R_7
T_3R_1	T_1R_1	T_2R_1
T_1R_4	T_2R_4	T_3R_4
T_3R_6	T_2R_6	T_1R_6

T_1 - 45 days, T_2 - 60 days, T_3 - 75 days

Fig. 2. Layout of field experiment

3.3.2.2 Application of Manures and Fertilizers

After 14 days of land preparation FYM was applied @ 25 t ha^{-1}. Chemical fertilizers, urea, rajphos and muriate of potash were applied to supply NPK @ 200: 50: 50 kg ha^{-1}.

Full dose of phosphorous and potash were applied as basal. Nitrogen was applied in split doses after each harvest. The first dose was applied after two weeks of planting.

3.3.2.3 Planting

The stem cuttings with three nodes were used as planting material. The 3 budded cuttings were planted at a spacing of 60 cm x 60 cm in such a way that the cuttings were stuck into the soil with the basal end down, at an angle in such a depth that two nodes remain within the soil and one above the soil surface.

3.3.2.4 Other Management Practices

Irrigation was provided to the crop as and when required. After each harvest weeding was carried out, along with fertilizer application.

3.3.2.5 Harvesting

The first cutting was taken in all treatments 60 days after planting and subsequent cuttings were taken as per the Technical Programme (45, 60 and 75 days).

3.3.3 Silage Experiment

3.3.3.1 Selection of Silo

Plastic silo bags with a capacity of 25 kg were selected.

3.3.3.2 Ensiling

The crop was harvested at different cutting intervals. The harvested fodder was immediately chopped using chaff cutter. Then it was wilted under sun for 2-3 hours to reduce the moisture content to an optimum limit. The additives were prepared by mixing with water @ 30 m L kg^{-1} green fodder and thoroughly mixed with the wilted fodder as per the technical programme. After thorough mixing, it was filled compactly in silo bags and the bags were tightly tied (Plate 3, 4 and 5).

3.3.3.3 Storing

After the preparation of silage it was kept under cool, dry place, free from rodents and other pests.

A. Harvesting

B. Chopping

Plate 3. Steps in silage preparation

3.3.3.4 Ensiling Period

The prepared silage was opened after 60 days of ensiling. Samples for analysis were collected and quality was estimated.

3.3.4 Observations

Experiment 1

3.3.4.1 Green Fodder Yield

The crop was cut at each cutting interval, fresh weight was taken from net plot and it was expressed in t ha^{-1}. Total yield for one year also was calculated and expressed in t ha^{-1}.

3.3.4.2 Dry Fodder Yield

The crop samples collected from each net plot were sun dried and then oven dried to a constant weight at 60^0C. The dry matter content was computed and dry fodder yield was worked out. Total dry fodder yield for one year was calculated and expressed in t ha^{-1}.

3.3.4.3 Crude Protein Percentage

The nitrogen of protein and non-protein nitrogenous compounds in the feed was transformed into ammonium sulphate by digesting with concentrated H_2SO_4. The ammonium sulphate in the digest was split into free ammonia by adding excess of strong alkali (NaOH). The ammonia liberated was steam distilled into 4 % boric acid solution. Then the solution was titrated against 0.1N H_2SO_4. The crude protein content was calculated by multiplying the N_2 content by 6.25 (Simpson *et al.*, 1965).

3.3.4.4 Crude Fibre Percentage

Known quantities of dry fat free samples of dry fodder was refluxed with dilute sulphuric acid and dilute sodium hydroxide successively to remove all the digestible components. The residue containing crude fibre and mineral matter was

C. Wilting

D. Mixing with additives

Plate 4. Steps in silage preparation (continued...)

incinerated in a furnace. The loss in weight on ignition gives the crude fibre content and was expressed as percentage (Sadasivam and Manickam, 1996).

Experiment 2

3.3.4.5 Colour

Colour of silage in each treatment was assessed visually and variation in colour was recorded.

3.3.4.6 pH

The pH of silage was estimated after making an extract of silage. For the preparation of the extract, 20 g of the silage sample was taken and mixed well with 100 ml of distilled water. Allowed to stand for 30 minutes with occasional stirring and pH was estimated using a pH meter (AFIA, 2003).

3.3.4.7 Total Ash Percentage

Total ash is the non combustible fraction of the feed, represents the total mineral content in the feed. A weighed quantity of the sample was incinerated and ash left as residue was weighed and percentage was calculated (AOAC, 1990).

3.3.4.8 Acid Insoluble Ash Percentage

Total ash was digested with dilute HCl to dissolve the soluble fraction, which was separated from the insoluble residue by filtration. The filter paper containing the insoluble residue was incinerated and the residue was weighed (AOAC, 1990).

3.3.4.9 Crude Protein Percentage

The crude protein content was estimated as per the procedure in ***3.3.4.3.***

3.3.4.10 Crude Fibre Percentage

The crude protein content was estimated as per the procedure in ***3.3.4.4.***

E. Filling

F. Storing

Plate 5. Steps in silage preparation

3.3.4.11 Ether Extract Fat Percentage

The crude fat in the feed sample was extracted with organic solvents such as diethyl ether in a soxhlet fat extraction assembly for several hours. Afterwards the ether in the extraction flask was evaporated and the flask with the ether extract was dried and weighed. The ether extract was expressed in percentage (AOAC, 1990).

3.3.4.12 Nitrogen Free Extract Percentage (NFE)

NFE was calculated based on the following equation

NFE % (on dry matter basis) = 100 - (Crude protein % + Ether extract fat % + Crude fibre % + Total ash %) (AOAC, 1990).

3.3.4.13 Recovery Percentage

Dry matter recovery (DMR) percentage was calculated based on the following equation,

DMR (%) = [(GMfo × DMfo)/ (DMs × DMsi)] × 100,

Where, DMR (%) = dry matter recovery as percentage;

GMfo = green mass of the forage (kg) at the time of ensilage;

DMfo = dry matter of forage (%) at the time of ensilage;

DMs = dry matter of the silage (kg) at silo opening;

DMsi = dry matter of the silage (%) at silo opening (Dantas *et al.*, 2014).

3.3.5 Statistical Analysis

The data on various parameters were analysed statistically by using Analysis of Variance technique (ANOVA) techniques like RBD and factorial CRD (Panse and Sukhatme, 1985) and significance was tested by 'F' test (Snedecor and Cochran, 1967). In the cases where the effects were found to be significant, CD values were calculated at five per cent and one per cent probability levels. Means were compared by Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

RESULTS

4. RESULTS

An investigation was conducted at Kerala Livestock Development Board farm, Dhoni, Palakkad during May 2015 to April 2016 to assess the effect of cutting intervals on quality fodder production for ensiling and to study the effect of additives and cutting intervals for quality silage production. The data collected were statistically analysed and the results obtained from the present study are given under the following headings.

4.1 EXPERIMENT I- EFFECT OF CUTTING INTERVALS ON QUALITY FODDER PRODUCTION FOR ENSILING

4.1.1 Green Fodder Yield

Data on green fodder yield of hybrid napier cut^{-1} and green fodder yield $year^{-1}$ are presented in Table 2.

The data on green fodder yield cut^{-1} revealed that cutting intervals had significant effect on green fodder yield. Treatment T_3 (cutting interval of 75 days) recorded the highest green fodder yield (57.85 t ha^{-1}) and it was significantly superior to other two treatments. The lowest green fodder yield was 34.28 t ha^{-1} for the treatment T_1 (45 days).

The data on green fodder yield $year^{-1}$ showed that cutting intervals did not significantly influence the green fodder yield $year^{-1}$.

4.1.2 Dry Fodder Yield

The data given in Table 2 on dry fodder yield cut^{-1} and dry fodder yield $year^{-1}$ revealed that cutting intervals had significant effect on dry fodder yield cut^{-1} and dry fodder yield $year^{-1}$. The highest dry fodder yield cut^{-1} and dry fodder yield $year^{-1}$ (21.63 t ha^{-1} and 108.19 t ha^{-1}) were recorded from the treatment T_3 (cutting interval of 75 days) and it was significantly superior to other two treatments.

4.1.2 Crude Protein Percentage

The data presented in Table 4 showed that crude protein (%) was significantly influenced by the three cutting intervals tried in hybrid napier variety Suguna. The increase in cutting interval exhibited a decreasing trend in crude protein percentage. The highest crude protein content (10.56 %) was estimated in T_1 (45 days) and the lowest value of 7.61 % estimated from T_3 (75 days).

4.1.3 Crude Fibre Percentage

Values of crude fibre percentage are presented in Table 4.

The data revealed that cutting intervals had significant impact on crude fibre content of hybrid napier. Crude fibre percentage showed an increasing trend with increase in cutting interval.

T_1 (45 days) recorded the lowest crude fibre content (26.81 %) and the highest (40.56 %) was recorded by T_3 (75 days).

4.2 EXPERIMENT 2- EFFECT OF ADDITIVES AND CUTTING INTERVALS ON QUALITY SILAGE PRODUCTION

4.2.1 Quality Parameters

4.2.1.1 Colour

The colour of the hybrid napier silage were slightly different according to the additives used for ensiling. Cutting intervals didn't influence the colour of silage. Although there were slight differences in colour, the colour of all the silage were in acceptable range.

Colour of silage with urea as additive persists more greenish and it was yellowish green. While the silage with jaggery and molasses as additive was pale green in colour. In the case of urea and jaggery mixed silage the colour was same as that of urea silage. Yellowish green colour was also observed in silage without any additives.

Table 2. Effect of cutting intervals on green fodder yield cut^{-1} ($t\ ha^{-1}$) and green fodder yield $year^{-1}$ ($t\ ha^{-1}$)

Treatments	Green fodder yield cut^{-1}	Green fodder yield $year^{-1}$
Cutting intervals (T)		
T_1	34.28	274.29
T_2	45.83	275.03
T_3	57.85	289.25
SEm (±)	2.04	16.61
CD (P = 0.05)	6.307	NS

Table 3. Effect of cutting intervals on dry fodder yield cut^{-1} ($t\ ha^{-1}$) and dry fodder yield $year^{-1}$ ($t\ ha^{-1}$)

Treatments	Dry fodder yield cut^{-1}	Dry fodder yield $year^{-1}$
Cutting intervals (T)		
T_1	9.76	78.11
T_2	15.36	92.19
T_3	21.63	108.19
SEm (±)	0.71	4.08
CD (P = 0.05)	2.198	12.592

Table 4. Effect of cutting intervals on crude protein (%) and crude fibre (%) content of green fodder

Treatments	Crude protein	Crude fibre
Cutting intervals (T)		
T_1	10.56	26.81
T_2	9.16	35.28
T_3	7.61	40.56
SEm (±)	0.48	0.73
CD (0.05)	1.036	1.594

NS- Non Significant, T_1- 45 days, T_2 - 60 days, T_3- 75 days

4.2.1.2 pH

The pH values of different silage are given in Table 5.

No significant difference was noticed in pH of silage among the cutting intervals, additives and their interactions. The pH of all the silage was in acceptable range.

Although not significant, there was a slight increase in pH in silage prepared from E_3 (fodder harvested at 75 days interval) when compared to E_1 (fodder harvested at 45 days interval) and E_2 (fodder harvested at 60 days interval).

4.2.1.3 Total Ash Percentage

Data on total ash percentage is presented in Table 5.

Though the different additives tried in this experiment did not show any significant influence on the total ash content in silage but the cutting intervals and interaction between cutting intervals and additives significantly influenced the total ash content of silage.

The lowest ash content (6.67 %) was recorded in E_1 (fodder harvested at 45 days interval) and the highest total ash content (10.56%) was recorded in E_3 (fodder harvested at 75 days interval).

Among the treatment combinations, the lowest ash content (5.76 %) was recorded in e_1a_2 (45 days + jaggery 2 %) which was on par with e_1a_4 (45 days + molasses 2 %) and e_1a_5 (45 days + no additives). The highest ash content (11.42 %) was observed in e_3a_2 (75 days + jaggery 2 %) and it was on par with e_3a_4 (75 days + molasses 2%).

Table 5. Effect of cutting intervals, additives and interaction effects on pH and total ash (%) of silage

Treatments	pH	Total ash
Ensiling material (E)		
E_1	4.24	6.67
E_2	4.32	8.45
E_3	4.53	10.56
SEm (±)	0.13	0.24
CD (P = 0.05)	NS	0.49
Additives (A)		
A_1	4.28	8.25
A_2	4.46	8.25
A_3	4.46	8.86
A_4	4.10	8.72
A_5	4.50	8.72
SEm (±)	0.16	0.31
CD (P = 0.05)	NS	NS
Interaction (exa)		
e_1a_1	4.56	7.00
e_1a_2	4.06	5.76
e_1a_3	4.53	7.00
e_1a_4	3.76	6.73
e_1a_5	4.26	6.84
e_2a_1	4.16	7.63
e_2a_2	4.53	7.56
e_2a_3	4.23	9.52
e_2a_4	4.10	8.05
e_2a_5	4.56	9.50
e_3a_1	4.13	10.13
e_3a_2	4.80	11.42
e_3a_3	4.63	10.05
e_3a_4	4.43	11.39
e_3a_5	4.66	9.81
SEm (±)	0.28	0.53
CD (P = 0.05)	NS	1.09

NS: Not significant at 5 % level
E_1 - Fodder harvested at 45 days interval
E_2 - Fodder harvested at 60 days interval
E_3 - Fodder harvested at 75 days interval

A_1 - Urea 2 %
A_2 - Jaggery 2 %
A_3 - Urea 1 % + Jaggery 1 %
A_4 - Molasses 2 %
A_5 - No additives

4.2.1.4 Acid Insoluble Ash Percentage

Data on acid insoluble ash is presented in Table 6.

Result revealed that cutting interval alone had significantly affected acid insoluble ash content.

Lowest acid insoluble ash content (1.16%) was recorded with E_1 (fodder harvested at 45 days interval). Highest acid insoluble ash content (1.8 %) of silage was recorded with E_3 (fodder harvested at 75 days interval) which was on par with E_2 (fodder harvested at 60 days interval).

Additives and interaction between cutting intervals and additives didn't influence the acid insoluble ash content in silage.

4.2.1.5 Crude Protein Percentage

Data regarding crude protein percentage of hybrid napier silage (Table 6) revealed that cutting interval and additives significantly influenced the crude protein content in silage. Interaction effects were negligible in increasing the crude protein content of silage.

It was noticed from the data that there was a reduction in crude protein in silage when the cutting intervals were increased. The highest crude protein content (11.59 %) was obtained from E_1 (fodder harvested at 45 days interval). Crude protein content was lowest in E_3 (fodder harvested at 75 days interval).

Additives had also significant effect on crude protein. Among the additives tried in this experiment, the treatment A_1 (urea 2 %) recorded significantly higher crude protein content (10.55 %) which was on par with A_3 (urea 1 % + jaggery 1 %). Whereas A_5 (no additives) recorded the lowest crude protein content (8.93 %) which was on par with A_2 (jaggery 2 %) and A_4 (molasses 2 %).

Table 6. Effect of cutting intervals, additives and interaction effects on acid insoluble ash (%) and crude protein (%) of silage

Treatments	Acid insoluble ash	Crude protein
Ensiling material (E)		
E_1	1.16	11.59
E_2	1.63	9.67
E_3	1.80	8.09
SEm (±)	0.08	0.26
CD (P = 0.05)	0.18	0.54
Additives (A)		
A_1	1.45	10.55
A_2	1.57	9.45
A_3	1.65	10.52
A_4	1.49	9.46
A_5	1.48	8.93
SEm (±)	0.11	0.34
CD (P = 0.05)	NS	0.69
Interaction (exa)		
e_1a_1	1.05	13.29
e_1a_2	1.23	10.92
e_1a_3	1.29	12.75
e_1a_4	1.04	10.95
e_1a_5	1.18	10.04
e_2a_1	1.65	10.15
e_2a_2	1.53	9.71
e_2a_3	1.90	10.06
e_2a_4	1.28	9.32
e_2a_5	1.79	9.11
e_3a_1	1.65	8.23
e_3a_2	1.97	7.73
e_3a_3	1.78	8.77
e_3a_4	2.16	8.09
e_3a_5	1.46	7.65
SEm (±)	0.19	0.59
CD (P = 0.05)	NS	NS

NS: Not significant at 5 % level
E_1 - Fodder harvested at 45 days interval
E_2 - Fodder harvested at 60 days interval
E_3 - Fodder harvested at 75 days interval

A_1 - Urea 2 %
A_2 - Jaggery 2 %
A_3 - Urea 1 % + Jaggery 1 %
A_4 - Molasses 2 %,
A_5 - No additives

4.2.1.6 Crude Fibre Percentage

The data recorded on crude fibre percentage is presented in Table 7.

The data presented in table showed that cutting intervals significantly influenced crude fibre content of silage as in the case of green fodder. Additives and interaction effects had not significantly influenced crude fibre content. When harvest interval was increased, there was an increase in crude fibre content.

The lowest crude fibre content (29.01 %) was observed in E_1 (fodder harvested at 45 days interval) and the highest (42.90 %) was estimated in silage prepared using E_3 (fodder harvested at 75 days interval).

4.2.1.7 Ether Extract Fat Percentage

Data on ether extract fat percentage (Table 7) revealed that cutting intervals, additives and their interaction had significant influence on the ether extract fat of silage.

Highest ether extract fat content (2.07 %) was observed in E_2 (fodder harvested at 60 days interval) which was on par with E_3 (fodder harvested at 75 days interval). E_1 (fodder harvested at 45 days interval) recorded the lowest value (1.61 %).

Among the five additives tried, highest ether extract fat value (2.09 %) was observed in A_3 (urea 1% + jaggery 1%) which was on par with A_5 (no additives) and A_1 (urea 2%). The lowest value (1.45 %) was recorded in A_2 (jaggery 2%).

When interaction effect was analysed e_3a_1 (fodder harvested at 75 days interval+ urea 2 %) recorded highest value (2.60 %) for ether extract fat which was on par with e_3a_3 (fodder harvested at 75 days interval + urea 1 % + jaggery 1 %), e_2a_5 (fodder harvested at 60 days interval + no additives) and e_2a_3 (fodder harvested at 60 days interval+ urea 1 % + jaggery 1%).

Table 7. Effect of cutting intervals, additives and interaction effects on crude fibre (%) and ether extract fat (%) of silage

Treatments	Crude fibre	Ether extract fat
Ensiling material (E)		
E_1	29.01	1.61
E_2	39.15	2.07
E_3	42.90	1.91
SEm (±)	0.71	0.08
CD (P = 0.05)	1.45	0.17
Additives (A)		
A_1	37.27	1.99
A_2	36.70	1.45
A_3	36.87	2.09
A_4	36.69	1.79
A_5	37.57	2.02
SEm (±)	0.92	0.11
CD (P = 0.05)	NS	0.22
Interaction (exa)		
e_1a_1	30.81	1.31
e_1a_2	29.14	1.64
e_1a_3	28.62	1.45
e_1a_4	26.92	1.95
e_1a_5	29.55	1.73
e_2a_1	37.21	2.07
e_2a_2	38.81	1.51
e_2a_3	39.05	2.30
e_2a_4	39.11	2.07
e_2a_5	41.59	2.43
e_3a_1	43.79	2.60
e_3a_2	42.15	1.20
e_3a_3	42.95	2.53
e_3a_4	44.05	1.36
e_3a_5	41.56	1.90
SEm (±)	1.59	0.19
CD (P = 0.05)	NS	0.39

NS: Not significant at 5 % level
E_1 - Fodder harvested at 45 days interval
E_2 - Fodder harvested at 60 days interval
E_3 - Fodder harvested at 75 days interval

A_1 - Urea 2 %
A_2 - Jaggery 2 %
A_3 - Urea 1 % + Jaggery 1 %
A_4 - Molasses 2 %
A_5 - No additives

4.2.1.8 Nitrogen Free Extract Percentage

The calculated values on nitrogen free extract (%) are given in Table 8.

The data showed that cutting interval, additives and their interaction had significant effect on nitrogen free extract (%) of silage.

Treatment E_1 (fodder harvested at 45 days interval) recorded highest nitrogen free extract (51.11 %), this was significantly superior to the other two cutting intervals (60 and 75 days). Fodder harvested at 75 days interval (E_3) recorded lowest nitrogen free extract value (36.12 %).

Among the additives, A_2 (jaggery 2 %) recorded highest nitrogen free extract value (43.48 %) which was on par with A_4 (molasses 2 %) and A_5 (no additives). A_3 (urea 1 %+ jaggrey 1 %) recorded the lowest nitrogen free extract content (41.19 %).

The interaction of cutting intervals and additives significantly influenced the nitrogen free extract content in silage. e_1a_4 (45 days + molasses 2 %) showed highest nitrogen free extract (53.44 %), which was on par with e_1a_2 (45 days + jaggery 2 %) and e_1a_5 (45 days + no additives).

4.2.2 Recovery Percentage

The data on recovery percentage of silage is given in Table 8.

Recovery percentage in silage is in the range of 85-95 %. The data revealed that cutting intervals, additives and their interaction had no significant effect on the recovery percentage of silage.

Table 8. Effect of cutting intervals, additives and interaction effects on nitrogen free extract (%) and recovery percentage of silage

Treatments	Nitrogen free extract	Recovery percentage
Ensiling material (E)		
E_1	51.11	93.00 (9.66)
E_2	39.91	90.66 (9.54)
E_3	36.12	91.13 (9.57)
SEm (±)	0.57	0.09
CD (P = 0.05)	1.16	NS
Additives (A)		
A_1	41.47	91.89 (9.61)
A_2	43.48	89.33 (9.55)
A_3	41.19	92.44 (9.64)
A_4	43.22	91.22 (9.50)
A_5	42.53	93.11 (9.67)
SEm (±)	0.73	0.127
CD (P = 0.05)	1.50	NS
Interaction (exa)		
e_1a_1	47.58	93.33 (9.68)
e_1a_2	52.53	92.67 (9.65)
e_1a_3	50.17	95.00 (9.77)
e_1a_4	53.44	93.00 (9.67)
e_1a_5	51.83	91.00 (9.56)
e_2a_1	41.60	92.33 (9.63)
e_2a_2	41.74	85.00 (9.24)
e_2a_3	37.73	91.00 (9.56)
e_2a_4	40.12	90.67 (9.54)
e_2a_5	38.36	94.33 (9.73)
e_3a_1	35.24	90.00 (9.51)
e_3a_2	36.16	90.33 (9.77)
e_3a_3	35.69	91.33 (9.58)
e_3a_4	36.09	90.00 (9.31)
e_3a_5	41.56	1.90
SEm (±)	1.59	0.19
CD (P = 0.05)	NS	0.39

(The values in parenthesis represent square root transformed values)

NS: Not significant at 5 % level

E_1 - Fodder harvested at 45 days interval

E_2 - Fodder harvested at 60 days interval

E_3 - Fodder harvested at 75 days interval

A_1 - Urea 2 %

A_2 - Jaggery 2 %

A_3 - Urea 1 % + Jaggery 1 %

A_4. Molasses 2 %,

A_5 - No additives

DISCUSSION

5. DISCUSSION

An investigation entitled "Cutting intervals and additives for quality silage production" was conducted at Kerala Livestock Development Board farm, Dhoni, Palakkad during May 2015 to April 2016. The significant results obtained during the course of the present investigation are discussed below under separate heads.

5.1 CUTTING INTERVALS ON GREEN AND DRY FODDER YIELD

5.1.1 Green Fodder Yield

Scanning of the data presented in Table 2 revealed that cutting intervals had significant effect on green fodder yield of hybrid napier. An increasing trend in the green fodder yield was observed when the cutting interval was increased. Among the three cutting intervals, the highest green fodder yield cut^{-1} was obtained from 75 days cutting interval (T_3) and it was significantly superior to other two cutting intervals 60 and 45 days (Fig. 3). The increase in herbage yield with increase in harvesting days could be attributed to the increase in tiller number, leaf formation, leaf elongation as well as stem development (Robertson *et al.*, 1976). Lowest green fodder yield was reported at cutting interval 45 days. However harvesting at 45 days interval resulted in younger, leafier plants being harvested, but was reflected in the higher crude protein content (Table 4) and lower crude fibre content (Table 4) compared with harvesting at 60 and 75 days interval.

It was observed that when cutting interval was reduced from T_3 (75 days) to T_2 (60 days), there was 21.08 per cent reduction in yield and when the interval was reduced to 45 days, yield reduction was 41.35 per cent. This might be due to increase in dry matter content of the crop with increase in growth period. This could be well explained by the sigmoid growth curve, in which as the growth period increases, the accumulation of photosynthetic products also increase up to a limit, after which the growth might decrease (Reddy and Reddy, 2010). Singh *et al.* (2002) also reported higher green fodder yield in napier bajra hybrid with increased cutting interval. This result is also in agreement with the findings of Hussain *et al.* (2002), Bayble *et al.* (2007), Ansah *et al.* (2010) and Subhalakshmi *et al.* (2013).

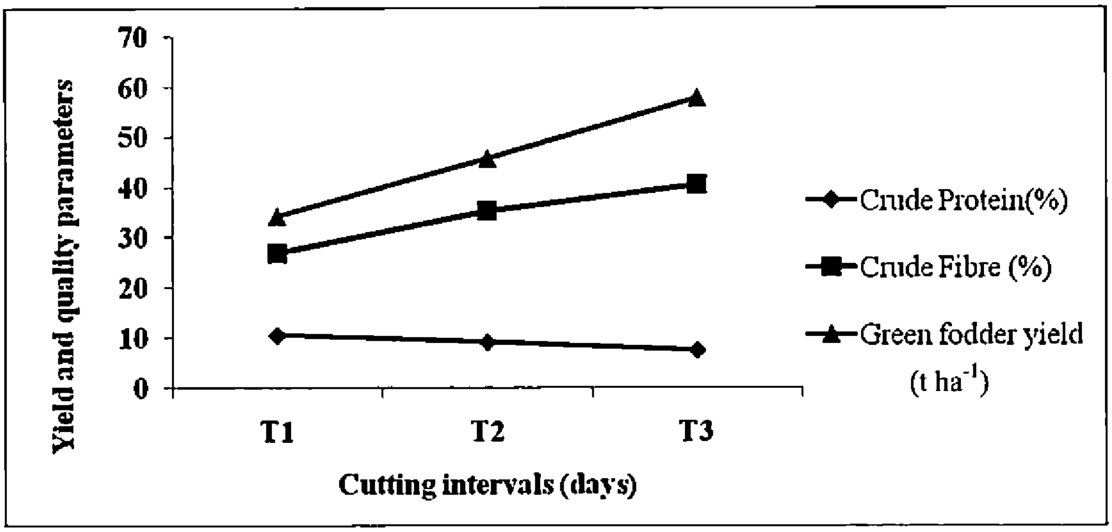
Though the cutting interval had significant effect on green fodder yield cut^{-1}, the cutting interval did not show any significant effect on total green fodder yield $year^{-1}$. There were eight harvests for 45 days interval, six harvests for 60 days interval and five harvests for 45 days interval. As the cutting interval increases, the number of harvest per year decreases and this lead to non significant variation on green fodder yield $year^{-1}$.

5.1.2 Dry Fodder Yield

Similar to green fodder yield dry fodder yield cut^{-1} increased significantly with increase in cutting interval. The highest dry fodder yield cut^{-1} was recorded by 75 days cutting interval (T_3). Dry fodder yield cut^{-1} of hybrid napier grass (Table 3) increased with increasing intervals between harvests, from 9.76 t ha^{-1} at 45 day interval to 21.63 t ha^{-1} at 75 days interval. Mc Donald *et al.* (2002) also reported an increase in dry matter at higher cutting intervals due to the increase in the fibrous tissues and carbohydrates at late season.

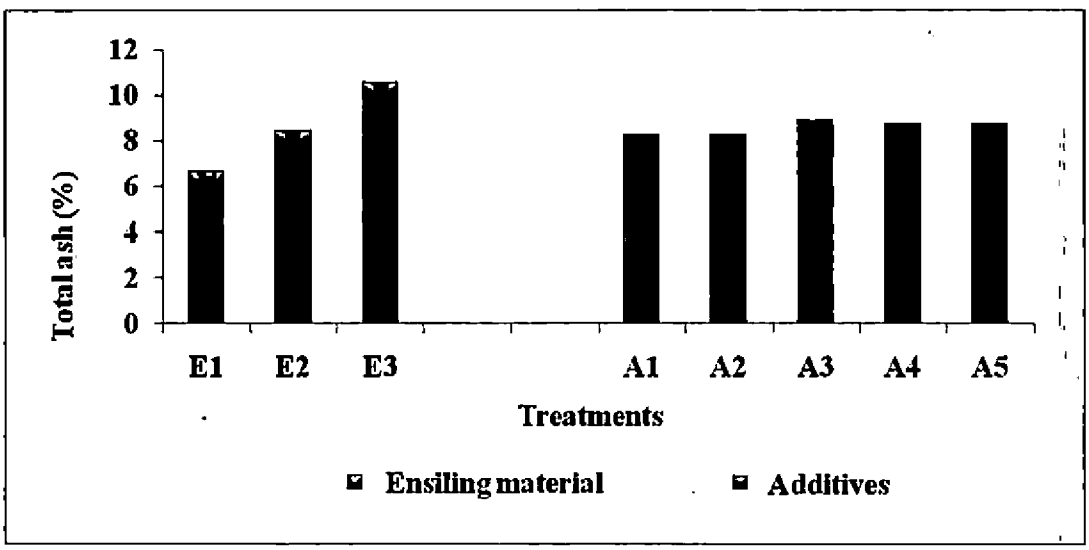
The results on dry fodder yield $year^{-1}$ also showed an increase in the dry fodder yield with increase in cutting interval. Here also, 75 days cutting interval (T_3) recorded the highest dry fodder yield $year^{-1}$. There was a 15.27 per cent increase in dry fodder yield when the cutting interval was increased from T_1 (45 days) to T_2 (60 days) and 27.80 per cent increase when the cutting interval was increased to T_3 (75 days). Increase in green fodder yield at 75 days cutting has resulted in corresponding increase in dry fodder yield.

Increase in dry fodder yield cut^{-1} with increase in cutting interval was also reported earlier by Hussain *et al.* (2002) in pearl millet, Tessema *et al.* (2002) and Tessema *et al.* (2003) in napier grass, Manyawu *et al.* (2003) in napier grass and Wangchuk *et al.* (2015) in napier hybrid grass.



T_1- 45 days, T_2 - 60 days, T_3- 75 days

Fig. 3. Effect of cutting intervals on yield and quality parameters of green fodder



E_1 - Fodder harvested at 45 days interval, E_2 - Fodder harvested at 60 days interval, E_3 - Fodder harvested at 75 days interval, A_1 - Urea 2 %, A_2 - Jaggery 2 %, A_3 - Urea 1% + Jaggery 1 %, A_4 - Molasses 2 %, A_5 - No additives

Fig. 4. Effect of ensiling material and additives on total ash content of silage

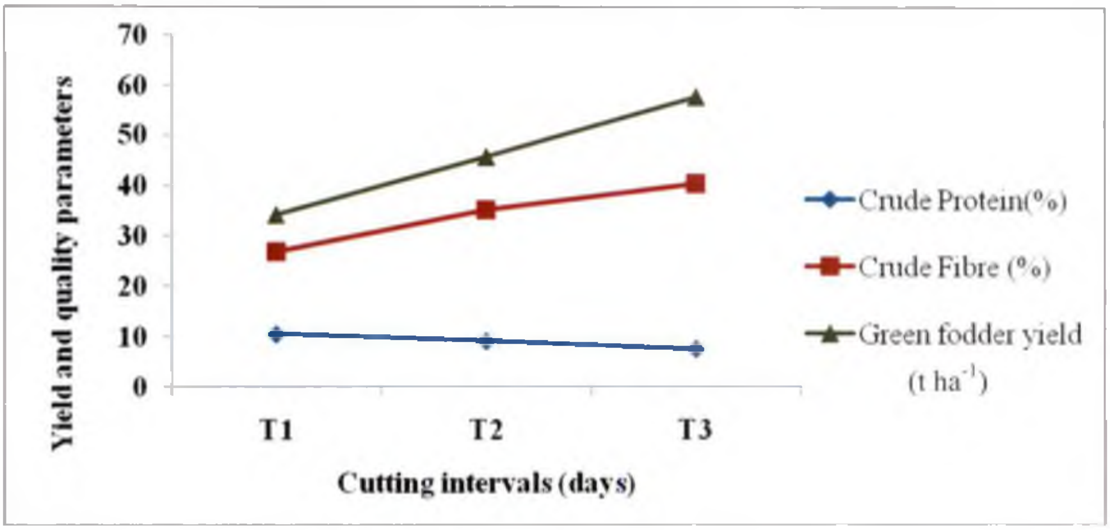
5.2 CUTTING INTERVALS ON FODDER QUALITY

5.2.1 Crude Protein Percentage

Crude protein is one of the important quality parameter of fodder crops. The crude protein content is directly related to the N content in fodder and is calculated by multiplying the N content with 6.25 (Simpson *et al.*, 1965). Mc Donald *et al.* (2002) reported that the crude protein might range from 3 % in very mature grass to over 30 % in very young grasses.

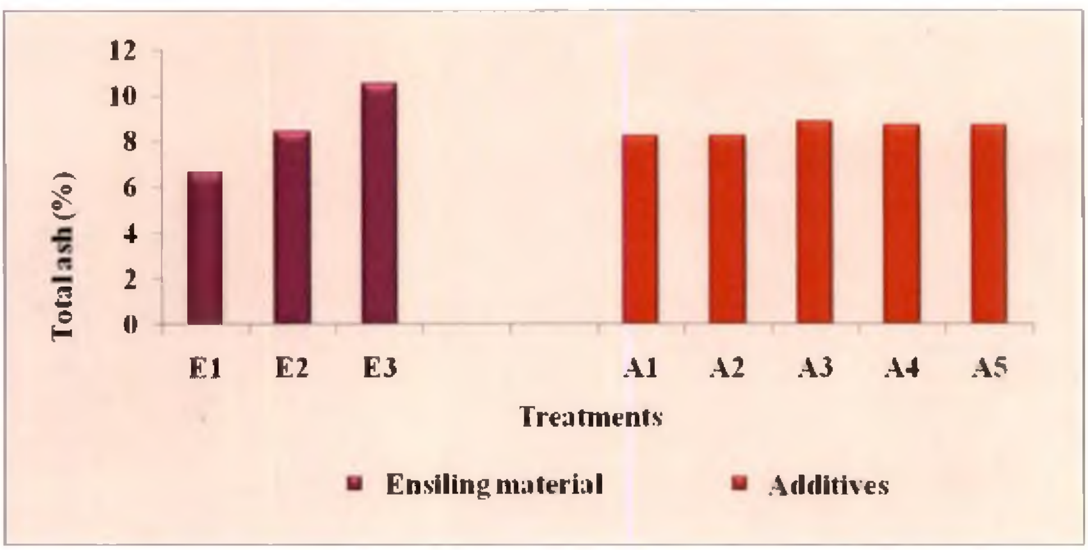
It could be deciphered from Table 4 (Fig. 3) that cutting intervals had significant effect on crude protein content of hybrid napier. The increase in cutting interval decreased the crude protein percentage. The highest crude protein content (10.56 %) was observed in T_1 (45 days interval) and the lowest value of 7.61 % in T_3 (75 days interval) (Fig. 3). The crude protein content was reduced by 13.25 per cent when the cutting interval was increased from 45 days to 60 days and by 27.99 per cent when cutting interval was increased from 45 days to 75 days. The decrease in crude protein with increase in maturity had already been documented. As explained by Van Soest (1994), with maturity there will be an immediate increase in the accumulation of carbohydrates in napier grass which can lead to the decrease in the concentration of crude protein concentration as well as digestibility. Ansah *et al.* (2010) also reported that the crude protein decreased with an increase in harvest day and it was observed that the crude protein levels decreased by 27 per cent from the 60 day harvest to the 120 days.

Similar results were also reported by Cleale and Bull (1986), Ammar *et al.* (1999) Mc Donald *et al.*, (2002), Bayble *et al.* (2007) Peiretti (2009), Ansah *et al.* (2010), Subhalakshmi *et al.* (2013) and Pathan *et al.* (2014) in different forage crops. Though green fodder yield at cutting interval of 45 days was low, the quality of the fodder is good as evident from higher crude protein content (Table 4) and lower crude fibre content (Table 4) in this treatment.



T_1- 45 days, T_2 - 60 days, T_3- 75 days

Fig. 3. Effect of cutting intervals on yield and quality parameters of green fodder



E_1 - Fodder harvested at 45 days interval, E_2 - Fodder harvested at 60 days interval, E_3 - Fodder harvested at 75 days interval, A_1 - Urea 2 %, A_2 - Jaggery 2 %, A_3 - Urea 1% + Jaggery 1 %, A_4 - Molasses 2 %, A_5 - No additives

Fig. 4. Effect of ensiling material and additives on total ash content of silage

5.2.2 Crude Fibre Percentage

Crude fibre is another important quality parameter of fodder. The good quality fodder should have low crude fibre content as this will help to reduce the wastage of feed as fibrous matter.

The present results on crude fibre percentage (Table 4 and Fig. 3) revealed that, cutting intervals significantly influenced the crude fibre percentage. The crude fibre percentage in hybrid napier showed an increasing trend with increase in cutting interval from 45 days to 75 days; the content being 26.81 %, 35.28 % and 40.56 % at 45 days, 60 days and 75 days respectively.

Increase in cutting interval from 45 days to 60 days, increased the crude fibre content by 31.57 per cent and increase in cutting interval to 75 days enhanced the crude fibre by 51.25 per cent. As reported by FAO (2005), for each and every plant the maturity stage differs, which is having a great influence on the fibre content, as the maturation process brings about a general decline in the digestibility of each of these plant component parts. This might be due to thickening and hardening because of the accumulation of extra carbohydrates on the cell wall of plant fibres. This is partly due to a non digestible component called lignin. As maturation takes place, the proportion of cell contents that are readily digestible parts of the plant, decline. In addition, as the plant matures the weight proportion of stem increases and the proportion of leaf declines. This might be the reason for increase in crude fibre content with increase in cutting interval.

A similar trend of increase in crude fibre percentage with increase in cutting interval was observed by Hussain *et al.* (2002) and Pathan *et al.* (2014). Pathan *et al.* (2014) noticed that the crude fibre content in hybrid napier was 30.2 %, 31.5 % and 32.6 % when the harvest was done at 45, 60 and 75 days.

These findings highlight the importance of optimum cutting interval and its varying effects on yield and quality. High cutting frequency reduces growth and yield and improves quality. Long intervals between harvests lead to accumulation of fiber and reduction in quality as reported by Tessema *et al.* (2010).

5.3 QUALITY PARAMETERS OF SILAGE AS INFLUENCED BY CUTTING INTERVALS AND ADDITIVES

5.3.1 Colour

Colour is one of the important quality parameter of silage. Based on colour itself the silage quality can be assessed by visual observations. Good quality silage should be green, fruity with pleasing taste and without sliminess and objectionable odour (Reddy and Reddy, 2010). FAO (2010), have reported the implications of colour of silage. According to them light green to greenish brown is ideal for silage prepared from grass and maize, pale green and straw yellow is ideal for wilted grass silage.

In the present study, the different additives tried for ensiling produced silage of pale green, light green, greenish brown and yellowish green (Plate 6). All these colours are in the acceptable range. The silage with urea as additive showed a more greenish colour compared to others. Research results on colour variations of silage from different fodder crops revealed that, the colour of maize silage harvested at 75 days maturity and prepared in synthetic nylon bag silos was greenish yellow (Khandaker and Uddin, 2013). The colour of napier bajra hybrid silage prepared in bunker silo without any additives was greenish yellow to brownish (Naik *et al.*, 2013) and the colour of hybrid napier silage was light green to brown with the addition of molasses (Delena and Fulpagare, 2015). All these indicate that the ideal colour range for silage is light green to greenish brown which is also evident from the present study.

5.3.2 pH

pH mainly represents the fermentation quality of silage, which reflects the changes occurred during ensiling. Moreover, it is a simple method to predict silage quality. Wilkinson *et al.* (1976), Etman *et al.* (1994), Sheperd and Kung

A. Urea 2 %

B. Jaggery 2 %

C. Urea 1 % + Jaggery 1 %

D. Molasses 2 %

E. No additives

Plate 6. Effect of additives on colour of silage

(1996), Yunus *et al.* (2000), Mc Donald *et al.* (2002) and EL-Shinnawy (2003) found that, quality silage has a pH value of less than or equal to 4.2.

The data presented in Table 5 indicated that the treatments couldn't significantly influence the pH of silage. The pH of silage in all treatments were in the range of 3.7- 4.8. Woodard and Prine (1991) had noticed that the pH values of napier grass silage were 3.8 to 4.4 and depended on harvest frequency and genotype of the forage. The result was supported by the findings of Yokota *et al.* (1992), who reported the pH of napier grass silage treated with 4 % molasses as 3.79. Otieno *et al.* (1999) also observed the pH within 3.0-4.0 for good silage using gunny bag ensiling technique. The present results were in conformity with the earlier findings, though a slight increase in pH above 4.4 was noticed in some samples.

Similar range in pH values were also observed by Singh and Neelakantan (1981) in hybrid napier silage; Esperance *et al.* (1985) in guinea grass silage; Yokota *et al.* (1992) in napier grass silage, Tosi *et al.* (1995) in dwarf elephant grass silage and Bandara *et al.* (2014) in hybrid napier, maize and sorghum silage. The pH of silage prepared without additives was also within the acceptable range. Similar results were also reported by Naik *et al.* (2013) in napier bajra hybrid silage prepared in bunker silo without using any additives.

Even though no significant difference was noticed in the pH of silage, there was a slight increase in pH according to the different ensiling materials. Fodder harvested at 45, 60 and 75 days interval registered pH values of 4.24, 4.32 and 4.53 respectively. The lower pH obtained at 45 days cutting interval might be due to the presence of more water soluble carbohydrates in the early stages of growth. Similar results were also observed by Thomson *et al.* (1992) in alfalfa and orchard grass silage. They have observed pH values of 4.1 and 4.19 from early and late cut alfalfa silage, while early and late cut orchard grass silage registered a pH of 4.27 and 4.57 respectively.

5.3.3 Total Ash Percentage

Ash content in silage gives information about the organic matter as well as the mineral content in the feed. Sometimes the highest ash content in feed might cause some kidney problems to the cattle. Results of studies conducted by Ranjhan (1977) indicated that the optimum ash content in feed is below 10 %.

Scanning of the data presented in Table 5 (Fig. 4) revealed that cutting intervals and interaction between cutting intervals and additives significantly influenced the total ash content of silage. Though there was an increasing trend in total ash content according to the increase in cutting interval, the ash content at 45 and 60 days cutting interval is within the optimum level of 10 %. The silage prepared from the fodder harvested at 75 days interval had values more than 10 %. This might be due to the presence of more minerals at longer maturity period or the possible contamination of fodder with soil due to lodging or more growth.

The different additives tried in this experiment did not show any significant influence on the total ash content in silage. This is in line with the findings of Tauqir (2004), who reported that the additives, their levels and fermentation periods did not affect the ash content of jumbo grass silage and mott grass silage and the ash content values ranged between 9.3 % to 9.7 % and 10.8 % to 11.5 % respectively. Tauqir *et al.* (2009) observed a total ash content of 9.5 % when jumbo grass was harvested at full bloom stage and ensiled with molasses 2 %. Naik *et al.* (2013) and Khandaker and Uddin (2013) also reported similar results in the total ash content.

Considering the interaction between cutting intervals and additives it was noticed that the different treatments registered lowest ash content, except in silage with fodder harvested at 75 days interval. The results obtained in the present study is in agreement with that of Aganga *et al.* (2005), who observed the total ash content of 7 % to 13.5 % in hybrid napier silage at different cutting heights with the addition of molasses 5 % as well as molasses 5 % and urea 1 %.

5.3.4 Acid Insoluble Ash Percentage

The acid insoluble ash content is directly related to the ash content because this is the acid insoluble portion of total ash content and indicates the amount of silica present in the sample. This fraction of total ash is not available to the animal. Higher acid insoluble ash indicates poor quality of feed and sometimes shows the adulteration of feed (Ranjhan, 1977).

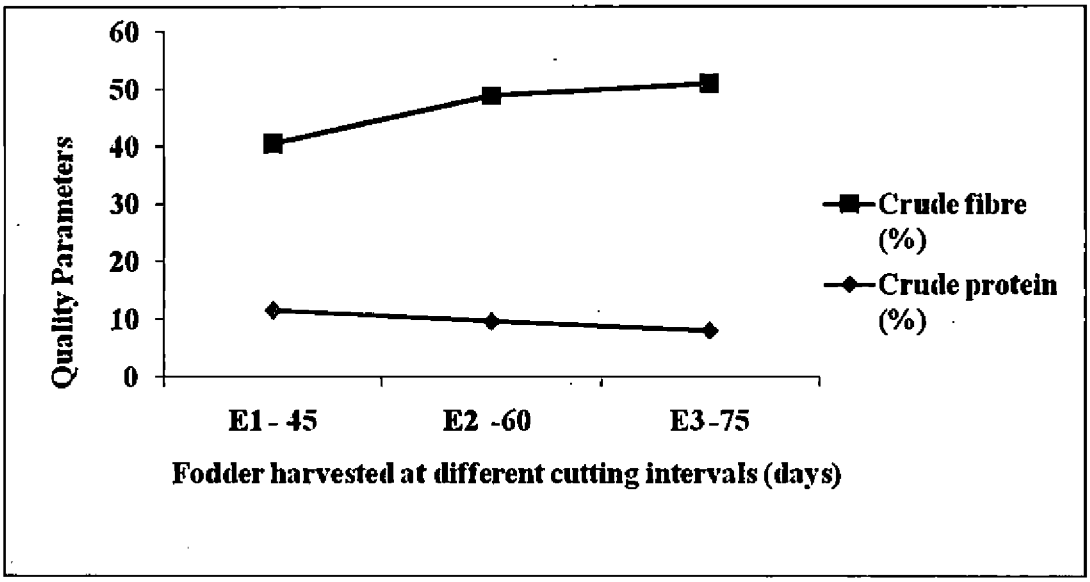
Cutting intervals had significant effect on acid insoluble ash content (Table 6). Highest acid insoluble ash content of silage was recorded from fodder harvested at 75 days interval (1.8 %) which was on par with fodder harvested at 60 days interval (1.63 %). These two cutting intervals also recorded highest ash content which is reflected in highest acid insoluble ash. More over these values are within the acceptable limit of 1.0 % to 2.5 %. Naik *et al.* (2013) also observed similar acid insoluble ash content in napier bajra hybrid silage prepared in bunker silo without using any additives. Additives and interaction between cutting intervals and additives couldn't influence the acid insoluble ash content in silage.

5.3.5 Crude Protein Percentage

As in the case of green fodder, crude protein is one of the major quality parameter of silage. To improve the crude protein content many nutrient additives like urea are commonly used. This will improve the N content, which in turn increase the crude protein content in silage.

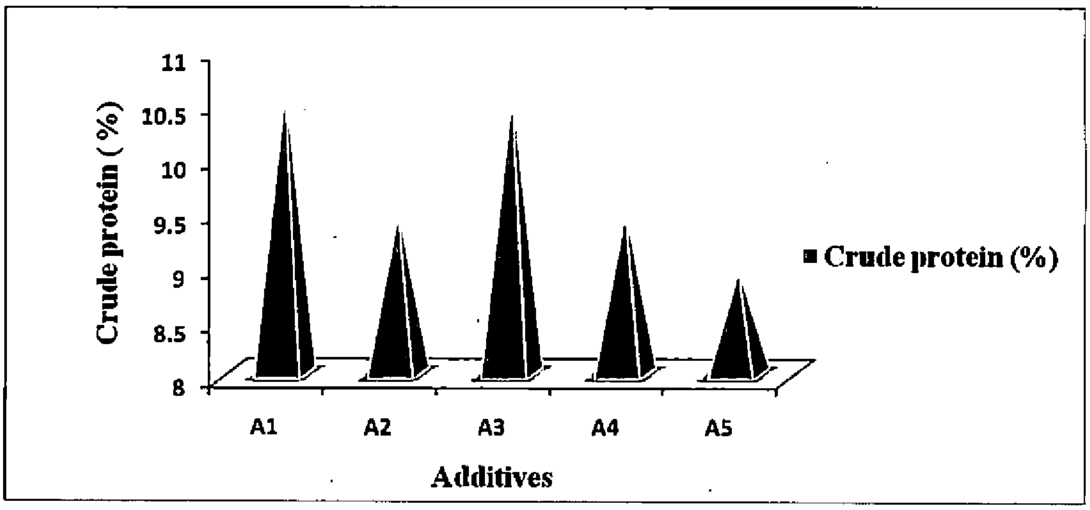
In general the crude protein content of silage obtained for this study is comparatively higher. Since the silage was prepared in bag silos the possibility of leaching loss of nutrients especially N during the ensiling process is less. This results in enhanced crude protein content.

The data on crude protein percentage of hybrid napier silage showed that cutting intervals and additives significantly influenced the crude protein content in silage (Table 6). The crude protein content was higher for silage prepared from



E_1 - Fodder harvested at 45 days interval, E_2 - Fodder harvested at 60 days interval
E_3 - Fodder harvested at 75 days interval

Fig. 5. Effect of ensiling material on crude protein and crude fibre content of silage



A_1 - Urea 2 %, A_2 - Jaggery 2 %, A_3 - Urea 1 % + Jaggery 1 %, A_4 - Molasses 2 %, A_5 - No additives

Fig. 6. Effect of additives on crude protein content of silage

45 days cutting interval. This high crude protein in silage could be attributed to the proportionate increase in crude protein content of green fodder harvested at 45 days interval. The crude protein content of younger grasses might be higher than mature grasses as the fibre content increases with maturity. As the cutting interval increased, the crude protein showed a decreasing trend. Khandaker and Uddin (2013) reported a lower crude protein content of 5.92 % from maize silage harvested at 75 days maturity and prepared in synthetic nylon bag silos. The low crude protein content in silage might be directly related to the decrease in crude protein content as the maturity increases or delays in cutting interval.

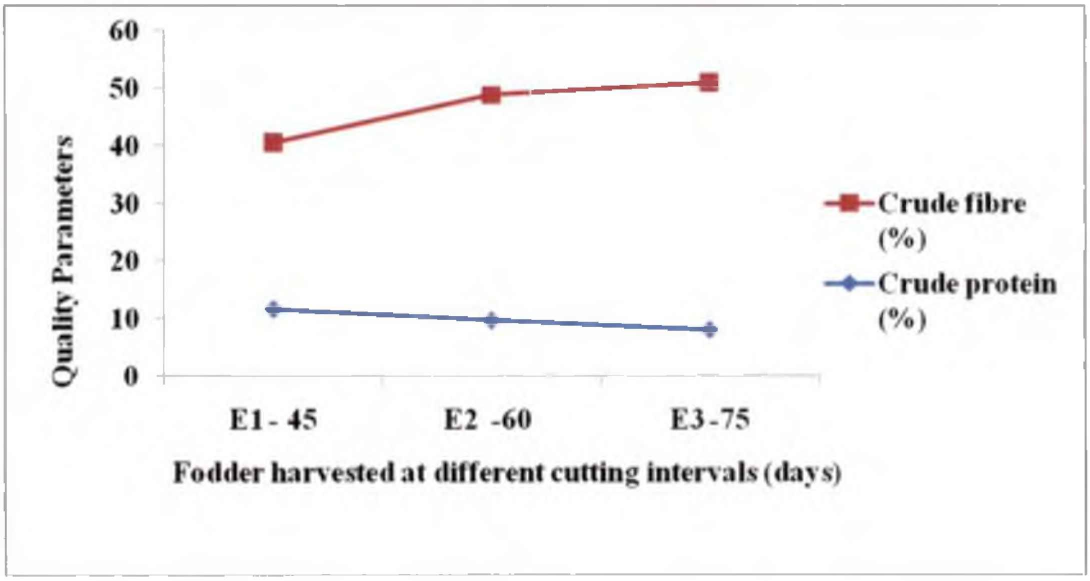
Among different additives tried, silage in which urea was used as additive showed the highest crude protein content than other additives. The high N content in urea (46 per cent) has contributed to the highest crude protein. The result of the present study is in agreement with the observations of Hamza *et al.* (2009) in whole corn silage prepared with urea (2 %) as additive. Interaction has no significant effect in the crude protein content of silage.

5.3.6 Crude Fibre Percentage

Crude fibre is another important index deciding silage quality. For good quality feed the crude fibre content should be low, this is mainly to avoid the wastage of feed.

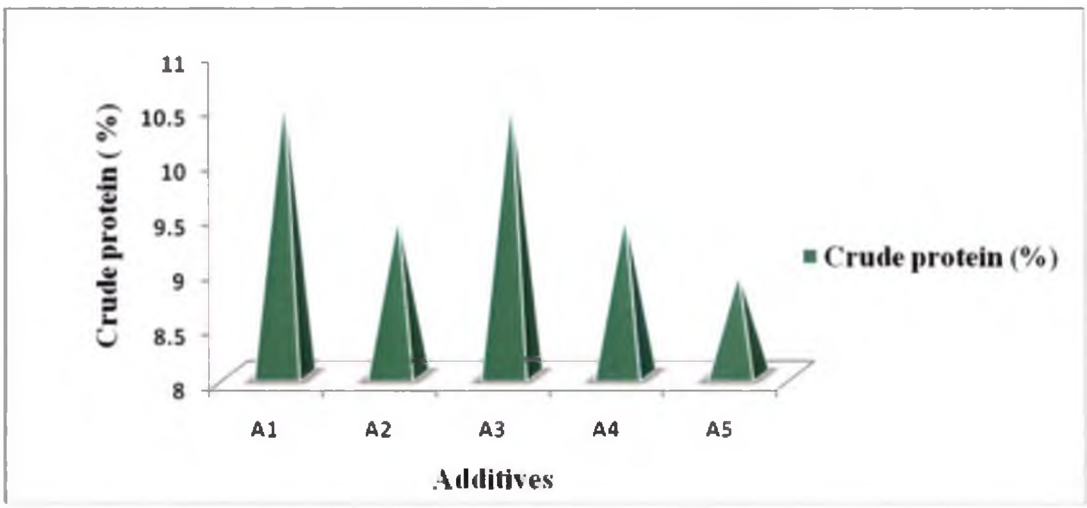
In the present study, the results revealed that crude fibre content increased significantly with longer cutting intervals, the value ranged from 29.01 to 42.90 (Table 7 and Fig. 5). In the present study the lowest crude fibre content of 29.01%, was observed from the fodder harvested at 45 days interval. A gradual increase in crude fibre content observed with longer cutting intervals. .

Present result is in agreement with Hamza *et al.* (2009), who observed a crude fibre content of 27.90 % in whole corn silage. From another study by Khandaker and Uddin (2013), lower crude fibre content (30.4 %) was observed in silage harvested at 75 days maturity and prepared in synthetic nylon bag silos. Naik *et al.* (2013) reported that the crude fibre content of napier bajra hybrid



E_1 - Fodder harvested at 45 days interval, E_2 - Fodder harvested at 60 days interval
E_3 - Fodder harvested at 75 days interval

Fig. 5. Effect of ensiling material on crude protein and crude fibre content of silage



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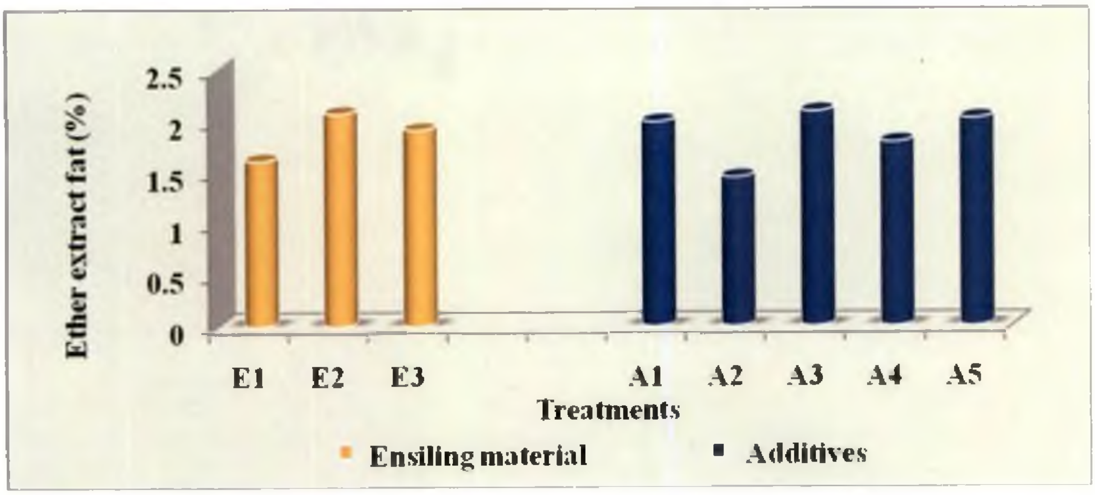
5.3.7 Ether Extract Fat Percentage

Ether extract is that fraction of the feed stuff which is obtained when the feed stuff is subjected to continuous extraction with petroleum ether. This includes fat, cholesterol, free fatty acids, lecithin, chlorophyll, resins, volatile oils and alkali substances (Ranjhan, 1977). Ether extract is the only source of essential fatty acids which supplies energy to the animal (Banerjee, 1970).

Results on ether extract fat percentage revealed that cutting intervals, additives and their interaction had significant influence on the ether extract fat of silage (Table 7). The ether extract fat content in the present study ranged within 1.3 % to 2.6 %. Hamza *et al.* (2009) observed similar values of ether extract fat in whole corn silage ensiled with 2 % urea.

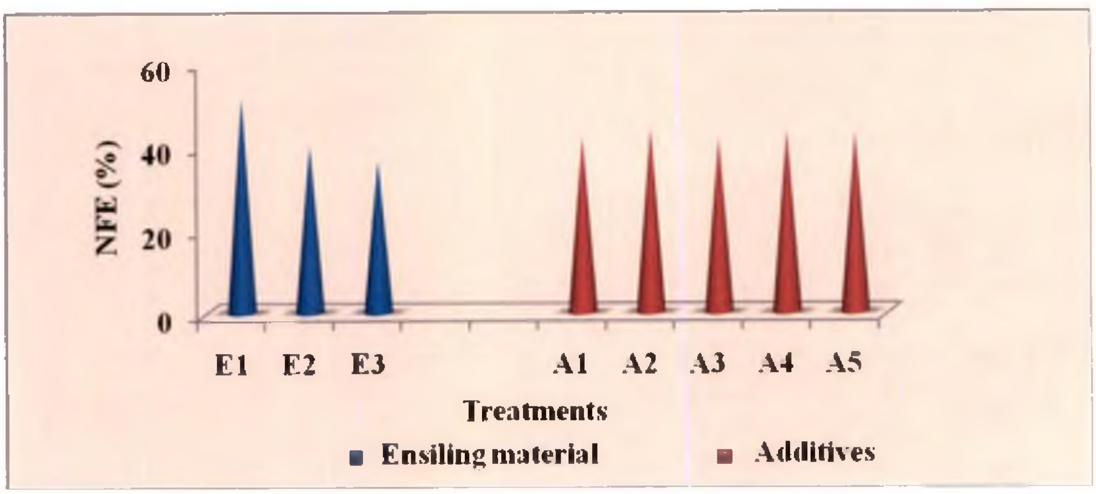
When cutting interval was increased from 45 days to 60 days, an increase in ether extract fat was observed. Though decreasing trend was noticed in silage prepared from75 days interval, it was on par with 60 days. Similar results were also reported by Khandaker and Uddin (2013), who reported fat content of 0.23 % from maize silage harvested at 75 days maturity and prepared in synthetic nylon bag silos.

Among the additives, urea 1 % + jaggery 1 % treated silage showed higher ether extract fat content. But in silage prepared without any additives also, ether extract was high, indicating that the additives have a comparatively lesser role in deciding the ether extract fat content. This is in conformity with the findings of Naik *et al.* (2013), who reported a lower ether extract fat content of 1.1 % from napier bajra hybrid silage prepared in bunker silo without using any additives.



E_1 - Fodder harvested at 45 days interval, E_2 - Fodder harvested at 60 days interval, E_3 - Fodder harvested at 75 days interval, A_1 - Urea 2 %, A_2 - Jaggery 2 %, A_3 - Urea 1% + Jaggery 1 %, A_4 - Molasses 2 %, A_5 - No additives

Fig. 7. Effect of ensiling material and additives on ether extract fat content of silage



E_1 - Fodder harvested at 45 days interval, E_2 - Fodder harvested at 60 days interval, E_3 - Fodder harvested at 75 days interval, A_1 - Urea 2 %, A_2 - Jaggery 2 %, A_3 - Urea 1% + Jaggery 1 %, A_4 - Molasses 2 %, A_5 - No additives

Fig. 8. Effect of ensiling material and additives on nitrogen free extract content of silage

5.3.7 Nitrogen Free Extract Percentage

Nitrogen free extract is that fraction of the total carbohydrates which is obtained when a sum total of crude protein, ether extract, crude fibre and ash is subtracted from 100. It includes monosaccharides, disaccharides, trisaccharides and some of the soluble polysaccharides (Ranjhan, 1977).

Scanning of the data presented in Table 8 on nitrogen free extract showed that cutting interval, additives and their interaction had significant effect on nitrogen free extract. The nitrogen free extract values were in the range of 35 % to 54 %.

There was an indirect relationship between cutting intervals and nitrogen free extract content. The highest nitrogen free extract (51.11 %) was observed from the fodder harvested at 45 days cutting interval. This might be due to the higher crude protein and lower crude fibre content in silage prepared from fodder harvested at 45 days cutting interval because the nitrogen free extract is a calculated value by subtracting crude fibre, crude protein, ether extract and ash from 100.

Silage with jaggery 2 % or molasses 2 % recorded highest nitrogen free extract content. Here also the lower values of other silage parameters results the higher nitrogen free extract content. Similar results were reported by Hamza *et al.* (2009) in whole corn silage with 2% urea. Naik *et al.* (2013) observed nitrogen free extract of 39.93 % from napier bajra hybrid silage prepared in bunker silo without using any additives.

5.4 RECOVERY PERCENTAGE OF SILAGE INFLUENCED BY CUTTING INTERVALS AND ADDITIVES

Neither cutting intervals nor additives influenced the recovery percentage of silage. The recovery percentage in different silage was in the range of 85-95 % (Table 8). The results from the present study revealed that cutting intervals, additives and their interaction had no significant effect on the recovery percentage of silage. The recovery percentage is directly related to the crude fibre content. The crude fibre content of green fodder was within the acceptable range of 26 % to 41 %. That might be the reason for high recovery percentage of silage.

SUMMARY

6. SUMMARY

An investigation was carried out at Kerala Livestock Development Board farm, Dhoni, Palakkad during May 2015 to April 2016 to assess the effect of cutting intervals on quality fodder production for ensiling and to study the effect of additives and cutting intervals for quality silage production. Summary of the results obtained are presented below under separate heads.

6.1 EXPERIMENT 1- EFFECT OF CUTTING INTERVALS ON QUALITY FODDER PRODUCTION FOR ENSILING

The first experiment was conducted to find out the effect of cutting intervals on quality fodder production for ensiling. The experiment was laid out in RBD with three treatments and seven replications. The treatments comprised of three cutting intervals - 45 days, 60 days and 75 days.

75 days cutting interval recorded highest green fodder yield from single cut. Lowest green fodder yield was recorded when the crop was harvested at 45 days cutting interval. The total green fodder yield from one year was not influenced by the cutting intervals.

Highest dry fodder yield from single cut was also recorded by 75 days cutting interval. As in the case of green fodder yield, lowest dry fodder yield from single cut was registered by 45 days cutting interval. Similar to dry fodder yield cut^{-1}, highest dry fodder yield from one year was recorded from 75 days cutting interval and the lowest from 45 days cutting interval.

Highest crude protein and lowest crude fibre content was estimated from 45 days cutting interval. Lowest crude protein and highest crude fibre were estimated in fodder harvested at 75 days cutting interval.

6.2 EXPERIMENT 2- EFFECT OF ADDITIVES AND CUTTING INTERVALS ON QUALITY SILAGE PRODUCTION

The second experiment was to find out the effect of additives and cutting intervals on quality silage production. The experiment was laid out as factorial experiment in CRD with two factors *i.e.* ensiling materials and additives and replicated thrice. Three types of ensiling materials tested were - E_1 (fodder harvested at 45 days interval), E_2 (fodder harvested at 60 days interval) and E_3 (fodder harvested at 75 days interval) and additives tested were - A_1 (Urea 2 %), A_2 (Jaggery 2 %), A_3 (Urea 1 % + Jaggery 1 %), A_4 (Molasses 2 %) and A_5 (no additives).

The colour of the hybrid napier silage were slightly different according to the additives used for ensiling. Cutting intervals couldn't influence the colour of silage. Silage with urea as additive had more greenish colour. Both cutting intervals, additives and their interactions did not exert any significant influence on silage pH. The pH of the silage was in the range 3.7- 4.8.

Fodder harvested at 45 days interval recorded lowest ash content and highest ash content was recorded by fodder harvested at 75 days interval. 45 days interval + jaggery 2 % recorded lowest ash content. The highest ash content was observed in 75 days interval + jaggery 2%. Additives tried in this experiment could not significantly influence the total ash content of silage.

Cutting interval alone had significant effect on acid insoluble ash content. Lowest acid insoluble ash content was registered by fodder harvested at 45 days interval and highest by fodder harvested at 75 days interval.

Highest crude protein content was obtained from fodder harvested at 45 days interval. Urea 2 % recorded highest crude protein content among the additives.

Cutting intervals alone had significant influence on crude fibre content of silage. Lowest crude fibre content was observed in silage prepared from fodder harvested at 45 days interval.

Highest ether extract fat content was estimated in fodder harvested at 60 days interval. Among the different additives, urea 1% + jaggery 1% recorded highest ether extract fat value. Among the treatment combinations, fodder harvested at 75 days interval+ urea 2% recorded highest value for ether extract fat.

Silage prepared from fodder harvested at 45 days interval recorded highest nitrogen free extract. Jaggery 2 % recorded highest nitrogen free extract value among the different additives and fodder harvested at 45 days interval + molasses 2% showed highest nitrogen free extract among different interactions.

Cutting intervals, additives and their interaction couldn't significantly influence the recovery percentage of silage.

Based on the study, it can be concluded that quality silage from hybrid napier can be prepared by ensiling the fodder harvested at 45 days interval and by adding urea 2 % or urea 1 % + jaggery 1 % as additive.

Future line of work

- The impact of cutting intervals and additives can be assessed in other fodder grasses like guinea grass and cereal fodders like fodder maize, fodder sorghum etc.

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CUTTING INTERVALS AND ADDITIVES FOR QUALITY SILAGE PRODUCTION

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ABSTRACT

The investigation entitled "Cutting intervals and additives for quality silage production" was conducted at Kerala Livestock Development Board farm, Dhoni, Palakkad during May 2015 to April 2016. The main objectives were to assess the effect of cutting intervals on quality fodder production for ensiling and to study the effect of additives and cutting intervals for quality silage production using hybrid napier variety Suguna.

The investigation comprised of two experiments. The first experiment was conducted in field and was laid out in RBD with three treatments and seven replications. The treatments comprised of three cutting intervals - 45 days, 60 days and 75 days. The results showed that, the highest fodder yield of 57.85 t ha^{-1} cut^{-1} was obtained in T_3 (75 days), but the fodder quality was better in T_1 (45 days) which registered high crude protein content (10.56 %) and low crude fibre content (26.81 %).

The second experiment on silage production was laid out as factorial experiment in CRD with two factors *i.e.* ensiling material and additives with three replications. Three types of ensiling materials tested were - E_1 (fodder harvested at 45 days interval), E_2 (fodder harvested at 60 days interval) and E_3 (fodder harvested at 75 days interval) and additives tested were - A_1 (Urea 2 %), A_2 (Jaggery 2 %), A_3 (Urea 1 % + Jaggery 1 %), A_4 (Molasses 2 %) and a no additive (A_5) treatment was also included.

The results indicated that among the different ensiling materials, fodder harvested at 45 days produced good quality silage. The silage was characterized by high crude protein content (11.59 %), low crude fibre content (29.01 %), ideal pH and other quality parameters like ash, ether extract fat (EEF) and nitrogen free extract (NFE) in safe limit.

Ensiling with urea 2 % or urea 1 % + jaggery 1 % produced good quality silage characterised by a crude protein content of 10.55 % and 10.52 % respectively and a crude fibre content of 37.27 % and 36.87 % respectively.

Crude protein, crude fibre, ash, EEF and NFE contents were significantly influenced by ensiling material. Additives significantly influenced the crude protein, EEF and NFE contents in silage and did not influence ash and crude fibre contents significantly. Interaction effect was found significant in ash, EEF and NFE contents of silage. Both ensiling materials and additives did not show any significant effect on pH of silage as well as recovery percentage.

Based on the study, it can be concluded that quality silage from hybrid napier can be prepared by ensiling the fodder harvested at 45 days interval and by adding urea 2 % or urea 1 % + jaggery 1 % as additives.

For the preparation of organic silage, molasses 2 % or jaggery 2 % can be recommended as additive depending upon availability.

സംഗ്രഹം

"വിളവെടുപ്പ് ഇടവേളകളും ചേരുവകളും സൈലേജിന്റെ ഗുണമേന്മയെ എങ്ങനെ ബാധിക്കുന്നു" എന്നതിനെ കുറിച്ച് കേരള കന്നുകാലി വികസന ബോർഡ് ഫാം, ധോണി, പാലക്കാട് 2015 മെയ് മുതൽ 2016 ഏപ്രിൽ വരെ ഒരു പരീക്ഷണം നടത്തുകയുണ്ടായി. ഈ പരീക്ഷണത്തിന്റെ പ്രധാന ലക്ഷ്യങ്ങൾ വിളവെടുപ്പ് ഇടവേളകൾ ഗുണമേന്മയുള്ള പുല്ലു നിർമ്മാണത്തെ എങ്ങനെ ബാധിക്കുന്നു, വിളവെടുപ്പ് ഇടവേളകളും ചേരുവകളും ഗുണമേന്മയുള്ള സൈലേജ് നിർമ്മാണത്തെ എങ്ങനെ സ്വാധീനിക്കുന്നു എന്നിവയായിരുന്നു. സങ്കരനേപ്പിയർ ഇനം സുഗുണയാണ് പരീക്ഷണത്തിനായി ഉപയോഗിച്ചത്.

പരീക്ഷണം രണ്ട് ഭാഗങ്ങളായാണ് നടത്തിയത്. ആദ്യത്തെ പരീക്ഷണത്തിൽ റാൻഡമൈസ്ഡ് ബ്ലോക്ക് ഡിസൈൻ എന്ന പരീക്ഷണ രീതിയിൽ മൂന്ന് വിളവെടുപ്പ് ഇടവേളകൾ (45 ദിവസം, 60 ദിവസം, 75 ദിവസം, യഥാക്രമം) ഏഴ് തവണ ആവർത്തിച്ചു. ഈ പരീക്ഷണത്തിൽ നിന്നും 75 ദിവസം ഇടവേളയിൽ ഒറ്റ വിളവെടുപ്പിൽ നിന്ന് കൂടുതൽ വിളവ് ലഭിച്ചു. എന്നിരുന്നാലും ഗുണമേന്മ കൂടുതലുള്ളത് 45 ദിവസം ഇടവേളയിൽ മുറിച്ചെടുത്ത പുല്ലിനായിരുന്നു. ഇതിൽ മാംസ്യം 10.56 ശതമാനവും കുറഞ്ഞ നാരിന്റെ അളവും കണ്ടെത്തി (26.8 %).

രണ്ടാമത്തെ ഭാഗത്തിന് കംപ്ലീറ്റ്ലി റാൻഡമൈസ്ഡ് ഡിസൈൻ ഫാക്ടോറിയൽ എന്ന പഠനരീതിയാണ് അവലംബിച്ചത്. ഇതിൽ മൂന്ന് വിളവെടുപ്പ് ഇടവേളകളിൽ നിന്നും ലഭിച്ച പുല്ലിനെ അഞ്ച് തരത്തിലുള്ള ചേരുവകൾ (യൂറിയ 2 %, ശർക്കര 2 %, യൂറിയ 1 % + ശർക്കര 1 %, മൊളാസ്സസ് 2 %, ചേരുവ ചേർക്കാത്തത്, യഥാക്രമം) ചേർത്ത് സൈലേജാക്കി. ഈ പഠനത്തിൽ നിന്നും 45 ദിവസം ഇടവേളയിൽ മുറിച്ചെടുത്ത പുല്ലിൽ നിന്നുള്ള സൈലേജിന് ഗുണമേന്മ കൂടുതലുള്ളതായി കണ്ടെത്തി. ഇതിൽ ഉയർന്ന മാംസ്യം (11.59 %), കുറഞ്ഞ നാര് (29.01 %), അനുയോജ്യമായ അമ്ലത്വം എന്നിവയും മറ്റു ഗുണമേന്മ നിർണയിക്കുന്ന ഘടകങ്ങളായ ചാരം, കൊഴുപ്പ്, നൈട്രജൻ ഫ്രീ എക്സ്ട്രാക്ട് എന്നിവയും അനുയോജ്യമായ അളവിലായിരുന്നു.

യൂറിയ 2 % അല്ലെങ്കിൽ യൂറിയ 1 % + ശർക്കര 1 % ചേർത്ത് നിർമ്മിച്ച സൈലേജിന് ഉയർന്ന മാംസ്യവും (10.55 %, 10.52 % യഥാക്രമം) നാരിന്റെ അളവായ 37.27 ശതമാനവും 36.87 ശതമാനവും യഥാക്രമം കണ്ടെത്തി. വിവിധ ഇടവേളകളിൽ മുറിച്ചെടുത്ത പുല്ലിന് സൈലേജിലെ മാംസ്യം, നാര്, ചാരം, കൊഴുപ്പ്, നൈട്രജൻ ഫ്രീ എക്സ്ട്രാക്ട് എന്നിവയുടെ തോതിൽ വളരെ വ്യക്തമായ മാറ്റങ്ങൾ വരുത്താൻ സാധിച്ചു. ചേരുവകൾ സൈലേജിലെ മാംസ്യം, കൊഴുപ്പ്, നൈട്രജൻ

ഫ്രീ എക്സ്ട്രാക്ട് എന്നിവയെ വളരെയധികം സ്വാധീനിച്ചു. എന്നാൽ നാര്, ചാരം എന്നിവയിൽ ചേരുവകൾക്ക് സ്വാധീനം ചെലുത്തൻ സ്വാധീനിച്ചില്ല.

വിളവെടുപ്പ് ഇടവേളകളും ചേരുവകളും തമ്മിലുള്ള പരസ്പര പ്രവർത്തനം ചാരം, കൊഴുപ്പ്, നൈട്രജൻ ഫ്രീ എക്സ്ട്രാക്ട് എന്നിവയുടെ തോതിൽ സ്വാധീനം ചെലുത്തി. വിളവെടുപ്പ് ഇടവേളകളും ചേരുവകളും സൈലേജിലെ അമ്ലത്വം, സൈലേജിന്റെ വീണ്ടെടുപ്പ് എന്നിവയിൽ സ്വാധീനം ചെലുത്തിയില്ല.

ഈ പരീക്ഷണത്തിൽ നിന്നും ഗുണമേന്മയുള്ള സൈലേജ്, 45 ദിവസം ഇടവേളയിൽ മുറിച്ചെടുത്ത പുല്ല്, യൂറിയ 2 % അല്ലെങ്കിൽ യൂറിയ 1 % + ശർക്കര 1 % ചേർത്ത് നിർമ്മിക്കാം എന്ന് കണ്ടെത്തി. ജൈവ സൈലേജ് നിർമ്മാണത്തിനായി മൊളാസ്സസ് 2 % അല്ലെങ്കിൽ ശർക്കര 2 % ചേരുവയായി ഉപയോഗിക്കാം.

APPENDIX

APPENDIX 1

Weather parameters during the cropping period, April 2015- March 2016

Month	Minimum Temperature (^{0}C)	Maximum Temperature (^{0}C)	Rainfall (mm)	Mean Relative Humidity (%)
April 2015	22.43	34.20	149.90	63.16
May 2015	23.58	32.19	264.20	73.55
June 2015	23.13	28.23	471.70	76.26
July 2015	22.80	28.19	179.50	74.70
August 2015	23.55	29.52	216.00	79.58
September 2015	23.16	30.33	211.00	75.13
October 2015	22.77	32.26	125.20	74.84
November 2015	22.00	31.60	132.60	75.90
December 2015	21.66	31.60	29.40	67.50
January 2016	20.00	32.45	0	52.13
February 2016	22.03	35.41	0	57.72
March 2016	23.25	37.58	0	72.77
Average/ Total	22.60	32.00	1779.50	70.30