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Effect of Harvesting Stage on Yield and Nutritive Value of Buffel Grass (*Cenchrus ciliaris linn)* Under Irrigation at Gewane District, North Eastern Ethiopia

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Abstract

A study was carryout to determine the biomass yield, chemical composition and in-vitro dry matter digestibility of irrigated Cenchrus Ciliaris. The treatments had three harvesting days (60, 90 and 120) in randomized complete block design (RCBD). Stage of harvesting days had significant influence ($p< 0.05$) on the biomass and chemical composition of Cenchrus Ciliaris. With longer days of harvesting, there was a reduction in nutritive value of the grass; whereas at longer day of harvesting, there was the highest biomass yield. DMY, NDF, ADF and ADL and plant height were positively correlated to each other but negatively correlated to LSR, CP, total ash, and IVDMD. Biomass yield of Cenchrus Ciliaris was positively correlated with delaying stage of harvesting but nutritive value in Cenchrus Ciliaris, were negatively correlate with increasing stage of harvesting. Eventually, harvesting of Cenchrus ciliaris at 90 days had good nutritive (10.62 % CP and 12.3t/ha DM) value and biomass yield. So that, this finding creates an opportunity for the pastoralists and agro-pastoral community along the Awash River to resolve the scarcity of feed and increase the livestock productivity in the study area.

Keywords: Stage of harvesting, biomass yield, nutritive value, *Cenchrus ciliaris.*

1. INTRODUCTION

In Ethiopia agriculture is the major economic sector, then livestock production is among the major of agricultural activities throughout the country (Funk *et al.,* 2012) [11]. The world's land uses surface dominantly covered (45%) by livestock production, and most of this area found in variable and unsuitable for other agricultural activities (L. H. Baumgard *et al*., 2015) [14]. In most of the rural house hold especially pastoralists considered livestock as a mobile bank that could be hired, and inherited. In Ethiopia the main livestock feed resources is based on natural pastures, fallow grazing, stubble grazing and crop residues (Tilahun *et al.,* 2005) [30]. As research finding Cahill *et al.* (2014) [8] on Switch grass indicate that, at grass's its early stage of harvesting, the biomass yield constantly increase until its optimum stage and gradually decrease in later season harvesting. Furthermore, longer harvesting time have negative impact on the quality of any hay providing to animals (Gashaw *et al*., 1991; Teshome *et al.,* 1994) [12, 25]. The forage nutritive value and biomass yield are influenced by situations. Among them, time interval cutting, forage composition, time of maturity, climatic condition, soil condition (fertility), and preservation method. Moreover, if forage stay for long period of time, it was characterized by high ingestible plant part, and low in forage quality.

According to practical experience among the promising forage grass adaptable for the low land of Ethiopia, the under-research grass *will have a significant role to maximize the yield and quality for animal producer in the research area.* However, in the study area the lack documents (know how) related to impact of stage of harvesting of forage on the dry matter yield and nutritive value. Therefore, to ensure an adequate supply of animal products for the ever-growing human population, sufficient and quality forage production is required. Specifically, the semi-arid and arid nature of the study area, where grazing land is almost becomes degraded due to chronic shortage of rainfall and continuous overgrazing, introduction of improved forage along proper management systems are suitable for the area and would be the best options for boosts and sustainable productivity of the livestock sector in the region along Awash River basis. One means of enhancing yield and quality of forage is following optimum stage of harvesting. Accordingly, a study was planned with objectives of find out the impact of stage of harvesting on agronomic traits, biomass yield and nutritive value of *Cenchrus ciliaris* (Buffel grass).

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2. RESEARCH DESIGN

2.1 Back Ground Justification (Study Area)

The experiment was conducted from January to May 2016 at Gewane Agricultural Technical Vocational and Educational Training (ATVET) College demonstration site; Afar regional state, located in Gewane district, Ethiopia. The research (experimental area) was found in arid and semi-arid climatic zone with about 400 mm an average annual rainfall. The mean annual temperature of the experimental area was about 32 ^{0}C with ranges of 44 ^{0}C maximum and 17 ^{0}C minimum. The soil texture of the experimental area is silt sandy loam with pH 8.44.

2.2 Treatments and Experimental Design

The study was conducted using 3 different harvesting (60, 90 and 120) days and have 15 treatments and total 45 plots and 3 blocks. Area of one plot was 3-meter length x 4 meter width (12 m^2), spacing between plots to plot was 1 m and blocks to block 1.5 m. The exact net single size plot was 3.20 m x 2.20 m (7.04 m^2), because 40 cm from both sides was used as border effect.

Figure 1: Land preparation

Figure 2: Cenchrus after 7 days emergency

Figure 4: Cenchrus ciliaris during tinning

Figure 5: Cenchrus ciliaris after 60 days

Table 1: Treatment arrangement layout

Block 1	90 DH	60 DH	120DH	60DH	60DH	120DH	90DH	120DH	90DH	120DH	60DH	120DH	60DH	90DH	90DH
Block 2	120DH	90DH	120DH	120DH	90DH	90DH	120DH	90DH	60 DH	120DH	90DH	60DH	60DH	60DH	60DH
Block 3	120DH	60DH	90DH	120DH	60DH	60DH	90DH	120DH	60 DH	60DH	120DH	90DH	90DH	120DH	60DH

DH= Day of harvesting

2.3 Land Preparation and Planting

The land was ploughed and prepared using tractor and leveled manually. The recommended amount seed rate of *Cenchrus ciliaris* is 8kg per hectare, due to this, 432g *Cenchrus ciliaris* seed for 540m^2, 9.6g seed per plot were used. The seeds were drilled at a depth of about 1-2.5cm, and lightly covered with soil to ensure adequate emergence, since the seed of *Cenchrus ciliaris* are too light in weight.

2.4 Establishment and Management Practices of *Cenchrus ciliaris*

Plots of *Cenchrus ciliaris* were weeded manually at different times during the experimental period and furrows were made to prevent water logging. Irrigation, water management practices was carried out uniformly for each plot, watering once every 7 days at 4:00 PM to minimize water evaporation.

2.5 Sampling and Data Collection Procedures

Plant morphological traits were calculated average by taken from ten plants that were randomly selected from each plot on 1m^2 quadrant. The ration leaf and stem were obtained by cutting plants from randomly selected two consecutive rows, separating into leaf and stem portions. About 500 gram of fresh sample weight was taken from each plot at a time of harvesting. A total of fifteen plots were harvested at each of the three harvesting stages. From each randomly selected plant, three representative samples were taken per parameter for morphological and chemical analysis. Forage samples within the quadrant area were harvested and weighed immediately and each treatment (sample) was dried at 60^{0}c for 72h in the oven dry until constant weight was attained.

Figure 6: Cenchrus ciliaris during morphology sampling

2.6 Chemical Analysis

The chemical analyses for determination of CP and total ash content of *Cenchrus ciliaris* were carried out according to Association of analytical chemist (1990). Crude protein of any forage grass is compute through multiplying the nitrogen content by constant number 6.25. This is based on the fact that, plant protein contains on an average 16 % N (Prasad, 1996) [19]. Research sample was putting in oven dry until it gets its constant weight at 100 ± 5 ^{0}C for 24 h to determine percent dry weight prior to chemical analysis. Finally, all results were calculated on a DM basis.

2.7 Statistical Analysis

All the collected data were analyzed with ANOVA using the general linear model (GLM) procedure of the Statistical Analysis System by using SAS computer software version 9.0 (2008). Least significance difference (LSD) was taken to account to separate the means. Finally, the effect of stage of harvesting days on morphological characteristics, yield, chemical composition and digestibility were determined using the following model.

1. The designed model for this research was:

$$Yjk = \mu + Cb + Qp + EbpR$$

Assume, Y_{ik}= Number of the jth harvesting phase

μ = Overall mean

Cb = Result of the bth cutting phase

Qp= Result of the pth replication

EbpR= Random error (residuals)

3. RESULTS AND DISCUSSION

3.1 Agronomic Performance and Biomass Yield of *Cenchrus ciliaris*

3.1.1 Plant height

Plants harvested at 120 days gave the highest height (131. 68 cm), which was followed by plant harvested at 90 days (114.68 cm), but the plant height was low (102 cm) when grass was cut at 60 days of growth. The largest increment in mean plant height and tiller number was recorded in the time from the 90 days to the last 120 days of harvesting. This change could be due to the effect of additional days gives chance to enhance massive root development and efficient nutrient uptake, and allowing the plant to continue increase in height. Generally, plant height and number of tiller growth were consistent with plant maturity until the optimum stage. This research finding also similar with results been reported by Berihun (2005) [5] and Simachew (2016) [21].

3.1.2 Number of tiller

Cenchrus ciliaris harvested at 120 days gave the highest tiller number per plant (29), which was followed by harvesting at 90 days (27.22). The highest tillers density per plant observed at late stages of harvesting which was significantly different from the number of tillers harvested at early days growth of plant indicated that, number of tillers per plant increased with an increase in stage of harvesting days. The current result was confirmed by reported Mehiret (2008) [17] for elephant grass explained that, there were significantly higher differences in number of tillers due to defoliation days.

3.1.3 Dry matter yield

The total DMY of the late harvesting stage (120 days) was the highest (21.44 t/ha), while the lowest DMY (7.82 t/ha) was recorded for plots harvested at days (60). The increasing trend in DMY with advance in stage of maturity was due to increase in the structural carbohydrate and reducing the moisture content of the grass. The present study was in line with the finding of Mehiret (2008) [17] who explained that the increment in DMY was due to longer time on the growing season before harvest and amount of cell wall materials (hemicelluloses, cellulose and lignin) deposited as a result of the addition of days

3.1.4 Leaf to stem ratio (LSR)

There was a significant effect observed in leaf to stem ratio of *Cenchrus ciliaris* due to the different harvesting day. 60 days of harvesting had significantly higher leaf to stem ratio as compared to the 90 and 120 days. As the stages of growth of *Cenchrus ciliaris* increased, LSR become reduced, this indicated that, there was an inverse relationship between the growths of plant to leaf to stem ratio. This could be due to the reason that old leaves fall down when a plant gets older and older, thereby reducing the number of leaves. The present finding agreed with the finding of Malede (2006) [15] and Berihun (2005) [5]. Moreover, according to Agza *et al.* (2013) [7], there was an inverse relationship between LSR and DMY of natural pasture in Pawe, which is as the harvesting time increase the DMY trend was increasing from 172 to 397 g/kg. The highest (1.64) LSR in blue panic grass was recorded in the treatments harvested at 60 days

whereas the lowest (0.58) was recorded in the treatments harvested at 120 days (Simachew, 2016) [21].

3.1.5 Number of leaves and inter nodes per plant

The number of leaf per plant (NLPP), which determines the photosynthetic capacity of the plants showed highly significant ($p < 0.01$) variation due to the effect of harvesting stage. The number of leaves per plant significantly increased ($p < 0.01$) with an increase in stage of harvesting served at 90 (49.76 cm) and 120 (53.15 cm) days. The increasing tendency in number of leaves per plant with advanced in stage of harvesting indicated that, time of harvesting had high influence on number of leaves per *Cenchrus ciliaris*. This might be due to the extended growth; there was increment in plant height, number of tillers, and the larger number of nodes that produce comparable number of leaves. The results of this study were in agreement with Mehiret (2008) [17], Simachew (2016) [21] and Berihun (2005) [5]. As the time of harvesting advanced, the number internodes per plant increased significantly. This indicated that, increased harvesting days also increased the internodes number through extending the growth of plants until its optimum stage of maturity. The results of this study were also similar with the results of Berihun (2005) [5] for bana grass, who reported that, the highest numbers of internodes per plant were recorded at 120 days.

3.1.6 Length leaf and inter node per plant

The length of leaf per plant (43.96 cm) observed at 60 days of harvesting was significantly lower as compare with 120 day. Late harvesting of *Cenchrus ciliaris* notably observed longer internodes as compared to early and intermediate days of harvestings. The highest length of internodes per plant (11.71 cm) and the lowest length of internodes per plant (11.34 cm) were recorded at 120 and 60 days of harvesting, respectively. This result was similar with finding of Mehiret (2008) [17]. Malede **(**2006) [15] also found that, leaf length of *triticale* grass was highly affected by the different stages of plant growth; when the growth stages of plant advanced the leaf length was raised. According to Berihun (2005) [5] experiment on bana grass, the highest mean length internodes (16.40 cm) and the lowest (10.30 cm) length of internodes were recorded harvested at 120 and 60 days, respectively. The reason for differences in the length of internodes would probably be to longer physiological and anatomical growth of the plants during late harvest.

Table 2: Effect of stage of harvesting on agronomic traits and biomass yield of C*enchrus ciliaris* (Mean ±SE)

Stage of harvesting (day)	Parameter							
	Ph(cm)	**NT(No.)**	**NLPP(No.)**	**NIPP(No.)**	**LLPP (cm)**	**LIPP(cm)**	**DMY(t/ha)**	**LSR**
60	102.4 ± 1.9^{c}	24.88 ± 2^{b}	94.80 ± 5.18^{c}	74.45 ± 4.6^{c}	43.96 ± 2^{c}	11.34 ± 0.6^{c}	7.82 ± 0.7^{c}	1.27 ± 0.1^{a}
90	114.7 ± 2.7^{b}	27.22 ± 2^{ba}	114.26 ± 3.93^{b}	94.9 ± 4.4^{b}	49.76 ± 1^{b}	11.64 ± 0.4^{b}	12.3 ± 1.4^{b}	0.77 ± 0.03^{b}
120	131.7 ± 2.6^{a}	29 ± 2^{a}	125.37 ± 4.13^{a}	115 ± 5.5^{a}	53.2 ± 0.3^{a}	11.71 ± 0.2^{a}	21.4 ± 1.8^{a}	0.62 ± 0.1^{c}
P-Value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.04	<0.0001	<0.0001
LSD(0.05)	5.90	2	9.37	9.37	1.04	0.7	2.58	0.11

Treatments means with different superscripts within a column and row are significantly different ($P < 0.01$) for all harvesting days, Ph= plant height, NT= number of tiller, NLPP= number of leaves per plant, NIPP= number internodes per plant, LLPP= leave length per plant, LIPP= length internodes per plant, DMY= dry matter yield, LSR= leave to stem ratio, cm=centimeter.

3.2 Chemical Composition

3.2.1 Crude protein content (CP)

The highest CP (13.57%) was observed from plant samples harvested at 60 days, while the lowest CP (6.72%) was from the 120 days of harvest. The decline in CP content with advancing maturity might be due to an increase in structural carbohydrate content and lignin content of forage materials and reducing leaf to stem ratio. The finding of this study agreed with finding of Bilal *et al*. (2001) and Muhammad (2010) who reported that, as the stage of harvesting increased, CP content decreased due to the maturation of the grass. The highest CP (14.78%) content in blue panic was observed at the 60 days of harvesting, whereas, the lowest CP (7.46%) content was observed in the 120 days of harvesting (Simachew, 2016) [21].

3.2. 2 Total Ash content, calcium and phosphorus

The higher total ash content (14.34%) was obtained in plants which were harvested at 60 days, while the lowest value (10.62%) was recorded at 120 days of harvesting. Treatments harvested at their early (60 days) stage produced significantly higher calcium content. The mean highest content of (0.55%) and lowest content of (0.377%) Ca was obtained at 60 and 120 days of harvesting, respectively. The mean highest (0.63) and lowest (0.41) percentage of P was recorded at 60 and 120 day of harvesting, respectively. Total ash content was considerably influenced by stage of harvesting. The highest total ash content observed in plants harvested at 60 days indicated that, total ash content decreased as the harvesting days of grass advanced. This might be due to natural dilution and translocation of nutrients, the agro-ecology of the area, poor soil fertility during the growth and development of plant tissue resulting in a decline in mineral concentration in the grass. McDonald *et al. (*2002) [16] who reported that, as grasses gets mature, the mineral content changed and this was reflected on the Ca content that declined in a similar pattern to that of total ash due to a natural dilution process and translocation of minerals to the roots. The minimum P which is daily expected for grazing ruminants as mentioned by McDowell (1985) was 0.17%, likewise, this idea was supported by ARC (1980) [3], P requirement for calves and other grower farm animals' ranges from 0.11 to 0.34% of forage dry matter basis. Therefore, P (0.63) percentage found in *Cenchrus ciliaris* in the study was higher than the minimum and maximum daily P rations of the ruminant animal. So, allowing only *Cenchrus ciliaris* could adequate to demand P for lactating and ruminant animals.

3.2.3 Neutral detergent fiber (NDF), Acid detergent fiber (ADF) and Acid detergent lignin (ADL)

Plants harvested at 60 day had the lowest NDF, ADF and ADL content whereas, the higher NDF, ADF and ADL content was recorded in the plots harvested at 120 days. Fiber content of the grass was highly influenced by stage of harvesting. This was due to an increasing structural carbohydrate and lignin and reducing moister content. Similarly, as the plant becomes older and older the stem to leaf ratio increases, but the leaf to stem ratio was decreasing. The present study agrees with finding of Berihun (2005) [5], Simachew (2016) [21] and Ashagire (2008) [4].

Table 3: Chemical composition of *Cenchrus ciliaris* as affected by harvesting day (Mean ±SE)

Stage of harvesting (day)	Chemical composition (% DM)							
	DM%	CP	TA	Ca	P	NDF	ADF	ADL
60	28.04±1[c]	13.57±0.6[a]	14.34±0.4[a]	0.55±0.03[a]	0.63±0.04[a]	51.61±1[c]	32.98±1.8[c]	7.63±0.5[c]
90	34.33±1[b]	10.60±0.4[b]	13.04±0.6[b]	0.46±0.03[b]	0.49±0.04[b]	54.52±1.4[b]	36.73±1.7[b]	9.26±0.6[b]
120	46.96±2.5[a]	6.72±0.5[c]	10.62±0.5[c]	0.37±0.03[c]	0.41± 0.03[c]	62.97±1.6[a]	42.24±1.3[a]	10.17±0.6[a]
P-Value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
LSD(0.05)	4.22	1.03	0.89	0.031	0.02	2.48	2.67	0.50

Treatments means with different superscripts within a column are significantly different (P < 0.001) for all harvesting days. DM= dry matter, CP= crude protein, TA = total ash, Ca= calcium, P= phosphorus, NDF= neutral detergent fiber, ADF=acid detergent fiber, ADL= acid detergent lignin.

3.3 *In-Vitro* Dry Matter Digestibility (IVDMD), Digestible Dry Matter Yield (DDMY) and Metabolized Energy (ME)

In-Vitro Dry Matter Digestibility decline when the grass get old (prolong harvesting time). The highest (64.88%) and lowest (56.82%) IVDMD in the study grass was obtained when the grass harvested at early (60 days) and later (120 days) respectively. The decrease of IVDMD as forage advanced might be due to an increase in proportion of cell wall and its constituent fractions. In other words, as the plant get mature; the stem comprises an increasing proportion from the whole plant than the leaf at later days of harvesting. The present results agreed with the results of Taye *et al*. (2007) [22] and Mehiret (2008) [17]. Similarly, the finding of Simachew (2016) [21] showed that, as the stage of harvesting day increase, the IVDMD percentage of blue panic grass reduced constantly. The basic determinant in forage digestibility is the plant anatomy, plant cell contents, being mainly soluble carbohydrates and proteins are almost completely digestible but cell wall vary in digestibility according to their degree of reinforcement with lignin and it also influenced by the proportion of leaf to stem ratio (McDonald *et al.,* 2002) [16]. As Owen and Jayasuriya (1989) explained that, 50% IVDMD for feeds is critical and acceptable threshold level. Therefore, the percentage of IVDMD obtained in *Cenchrus ciliaris in the current study is* acceptable. The lowest DDMY (4.97 t/ha) was recorded at 60 days of harvesting. Harvesting day has shown significant influence on DDMY of the *Cenchrus ciliaris.* That means when the grass was harvested at its early (60 days) stage of maturity, the DDMY was lower, where as the highest DDMY was at the delayed stage of harvesting, this was due to an increased trend in digestible DMY as the age of plant advanced. This result was in line with finding of previous scholars (e.g. Tessema *et al*., 2002; Simachew, 2016) [26, 21], who reported that, there was an increasing trend in digestible DDMY of grasses with extended days of harvesting. This experiment also revealed that, the highest values of ME were recorded from the considerably highest ME (9.02MJ kg DM) and lowest ME (7.65 MJ kg DM) were recorded at 60 and 120 days of harvesting, respectively. The results indicated that, energy content decreased as the days of harvesting increased. The finding of this study was agreed with the results of Berihun (2005) [5] who reported that, energy content decreased as the days of harvesting became longer. It was explained by McDonald *et al.* (2002) [16] that, the later the cutting date, the larger will be the DMY was due to higher indigestible plant part (cell wall components), then this leads to a reducing digestibility of the pasture, which was also reflected in the lower ME value of grasses.

Table 4: *In- vitro* dry matter digestibility (IVDMD); metabolized energy (ME) and digestible dry matter yield (DDMY) *Cenchrus ciliaris* as influenced by harvesting stage (Mean± SE).

Stage of harvesting (day)	Parameter		
	IVDMD (%)	ME(MJ /kg DM)	DDMY (t/ha)
60	64.88±2.1[a]	9.02±0.3[a]	4.97± 0.5[c]
90	61.20±2.1[b]	8.40±0.3[b]	7.49±1.0[b]
120	56.82±1.7[c]	7.65±0.2[c]	10.86±1.1[a]
P-Value	<0.0001	<0.0001	<0.0001
LSD(0.05)	0.91	0.154	0.98

Treatments means with different superscripts within a column are significantly different (P < 0.001), IVDMD = *in vitro* dry matter digestibility; ME= metabolized energy, DDMY =digestibility dry matter yield

4. CONCLUSSION AND RECOMMENDATION

Recognizing the appropriate biomass yield and quality due to the exact stage of harvesting of the grass was among the most important concern of the current days' pastoralist and other farmers to improve and maximize yield and improve quality of pastures. Due to effect of harvesting day on morphological traits, biomass yield and chemical composition parameters were highly significant. The highest DMY was recorded in the grasses harvested at get matured. Crude protein, Calcium, Phosphorus, total ash, structural carbohydrate were significantly different due to stage of harvesting. The phosphorus percent found in the *Cenchrus ciliaris* in the study area was above P requirements of ruminant animal which set from 0.11 to 0.34% of the forage dry matter content. Therefore, feeding this grass did not need any additional phosphorus supplementation feed and indeed it is sufficiently an adequate for higher producing and farm animals. Harvesting grasses at 90 days to get optimum level of forage productivity in terms of both quantity (12.3 ton) and quality (10.60% CP). Generally, now a day, due to the impact of climatic variability, desertification, soil erosion, land degradation, bush encroachment, erratic rain fall and chronic drought have a negative impact on livestock producer who rely on range land or natural grass land. Therefore, to resolve the problem, government organizations and other stakeholders should practice forage development through exact stage of harvesting for optimum animal productivity.

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