

Effects of Cutting Date on Yield, Morphological and Quality Traits of Three Grass Species under Irrigation Conditions in North Mecha District, Ethiopia

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Abstract:

This study aimed to study the effects of cutting interval on yield, morphological and quality traits of three grass species under irrigated conditions in North Mecha district, Ethiopia. There were three kinds of grasses namely Para (*Brachiaria mutica* Stapf.), Napier (*Pennisetum purpureum*), and Desho (*Pennisetum pedicellatum*) at three cutting dates (60, 90, 120 day). The experimental design was a completely randomized block design with three replications and a total of nine plots. The grasses were first harvested after 60 days of regrowth; second and third harvests were done after consecutive 30 days of re-growth. Data were collected for plant height, tiller number, leaves number per plant and Leaf to Stem Ratio (LSR), Dry Matter (DM) yield and quality traits such as ash content, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL). All harvested data were laid open to GLM ANOVA procedures of SAS version 9.0. Result showed that harvesting age significantly affected all the traits except LSR in three grasses. DM yield, plant height, tiller number and the number of leaves per plant ADF, NDF ADL were increased with increasing harvesting age whereas ash content and CP decreased. It was concluded that Napier grass produces a higher forage yield among the three grasses and longer harvesting date results in increased forage DM yield and decreases the CP content in all the studied grasses. At 120 days cutting Napier grass recorded the highest DM yield (16 t/ha). Further research is needed to be conducted over much longer periods to determine to what extent these findings are related to performance over the life of a permanent pasture.

Keywords: Chemical composition; Cutting interval; Forage yield; Improved grass variety

1. Introduction

Livestock feed resources in Ethiopia are mainly obtained from natural and improved pastures, crop residues, agro-industrial by-products, and non-conventional feeds (Zereu and Lijalem, 2016). The contribution of these feed resources depends upon the agro-ecology, the type of crop produced, and the accessibility and production system. More than 90% of livestock feed are crop residues and natural pasture in Ethiopia. Both of which are either unavailable in suffi-

cient quantities due to fluctuating weather conditions or are accessible, but in poor quality, they do not provide adequate nutrition for sustainable animal production. Animal feed shortage remains the main constraint on herd size and productivity in both the lowlands and highlands of Ethiopia (Asmare et al., 2017).

The shortage of feed can be solved through the introduction and utilization of adaptable and high-yielding cultivated forage crops with better nutritional values than the current

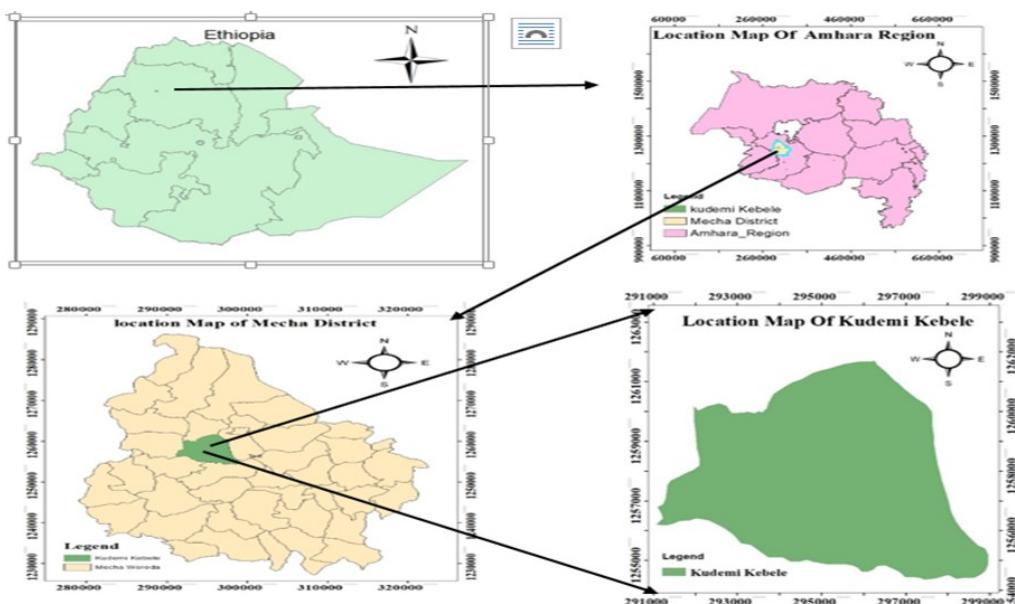


Figure 1. Map of study area adapted from MDOA, 2019.

feed resources in the country (Kefyalew et al., 2020). Using improved forages would decrease the burden on natural pastures; improve soil fertility and reduce erosion. Therefore, there is a need to evaluate suitable forage species or cultivars to address the feed shortage challenge. Among the improved forage grass species recommended in Ethiopia; Para, Napier and Desho grasses play a significant role (Kefyalew et al., 2020; Zemene et al., 2020).

For most forage grass species, cutting interval has been shown to influence the DM yield, morphological and quality traits of herbage (Ansaa and Garjila, 2019). According to the same source, cutting interval affects forage production, re-growth potential, and species survival; and shorter cutting intervals result in weak and thinner stands because of reduced carbohydrate reserves for regrowth.

Farmers do not have enough information on optimal management practices for Para grass (Zemene et al., 2020), Napier grass (Rambau et al., 2016) and Desho grass (Kefyalew et al., 2020). Although the potential of those grasses for increasing pasture and animal productivity is well known, it is important to understand the effects of re-growth cutting intervals on morphological traits, biomass yield, and chemical composition of Para, Napier and Desho grasses. Monçao et al., 2020 reported that Napier grass morphological and quality traits had been affected by four regrowth harvesting ages (30, 60, 90, 120 days). The optimization of productivity and nutritive value of grasses can be achieved by forage management (Mengistu et al., 2016). The previous study reported that cutting interval affected morphological traits, dry matter yield, and chemical composition of para and Napier grasses under rain-fed conditions (Tilahun et al., 2017; Zemene et al., 2020). On the other hand, Kefyalew et al., 2020 reported that cutting intervals affect morphological traits, dry matter yield, and chemical composition of Desho grass under irrigated condition. However, scientific evidence regarding DM yield, morphology and chemical composition of Para, Napier and

Desho grasses in response to different cutting intervals after regrowth and in irrigation condition is limited. Therefore, the present study was carried out to study the effect of cutting interval on yield, morphological and quality traits of three grass species (Para, Napier and Desho) under irrigated conditions in Mecha District, Ethiopia.

2. Materials and methods

2.1 Description of the study areas

The study was conducted at Koga irrigation site in Kudemi Kebele, Mecha Woreda of West Gojjam zone in Amhara Regional State (Fig. 1). It is located about 525 km northwest of Addis Ababa and 34 km southeast of Bahir Dar, the capital city of the Amhara Region. The district is in unimodal rainfall scheme. In Mecha Woreda, the climatic condition alternates between summer rainfall (June-September) and dry season with mean annual rainfall ranging between 1500 and 2200 mm. The mean temperature ranges between 24 and 27 °C and the altitude range from 1800 to 2500 m.a.s.l. Agriculture is the main economic activity in the study area. The main agricultural activities at present practiced include irrigation (modern and traditional) and mixed crop-livestock farming. The major crops grown in the area include maize, teff (*Eragrostis tef*) wheat and other legume groups. In this Woreda, there are 192,556 cattle, 148,971 ovine, 23,106 equine and 204,181 poultry (North Mecha Woreda Agriculture Office unpublished report).

3. Material and method

The experiment was performed under irrigation from November 2020 to February 2021 after two years of establishment. During the establishment year, the experimental land was first ploughed and cleared of weeds and then backhoed three times before subdividing it into blocks and plots; this was done before planting of grasses. After planting, Di-ammonium phosphate (DAP) and Urea fertilizers were

applied to each grass species based on the recommendation of (Cameron and Lemcke, 2008). Weeds were controlled by hand weeding to avoid intervention by interspecific competition. Weeding was done early and then twice a month until the final harvesting was accomplished to eliminate regrowth of undesirable plants and removal of the dry root to stimulate fodder re-growth by increasing soil exposure to air. The experiment was arranged using a randomized complete block design (RCBD) with three replications. The total area of the experiment was 108 m² (9×12 m). The plot size of each grass species was 12 m² (3×4 m) by excluding the outer row on both sides of each plot row length 0.25 m and 0.5 m row width were subtracted during planting on both ends of the rows to avoid probable border effects. With a 1 m path between blocks, a 0.5 m path was made between the plots and plants. There were three blocks resulting in 9 plots for each grass, each plot had six rows and in each row, there were eight plants. The experiment has a total of three grass species, namely Para, Napier and Desho grasses which were compared at three harvesting dates (60, 90 and 120 days). During the experimental periods, the field was irrigated with furrow two times per week throughout the growth period.

3.1 Data collection

Data on morphological traits and forage yield were recorded at each cutting interval. Six randomly selected plants in each species were randomly selected to record plant height, the number of tillers per plant, the total number of leaves per plant, and leaf to stem ratio (LSR). From the total of six rows within each plot, an entire of four rows was selected by eliminating the two border rows to avoid border effects.

Plant height: Plant height was measured on the primary bud from the soil surface to the base of the top-most leaf using a meter designated by (Rayburn et al., 2007). Measurement of plant height was undertaken immediately before the time of biomass harvest.

Number of tillers: The number of tillers per plant was counted from the sample of six plants in each cutting interval of the experimental plot area and the mean was calculated.

Leaves number: The leaves number per tiller was counted and then, the total number of leaves per plant was estimated from the tiller number per plant and leaf number per tiller.

Leaf to stem ratio: The fresh leaves and stems of each of the six harvested plants were separated by hand and weighed by sensitive balance to determine the dry matter. Then, average leaf to stem ratio (LSR) per plant was calculated.

The dry matter yield (DMY) was determined at the end of every harvesting day. Based on DM % and fresh biomass yield from the sample area of each plot were used to calculate total dry matter yields for each plot converted to metric tons per hectare (Gelavenew et al., 2019). DM Yield was calculated using the following formula:

$$\text{DM Yield} = \text{TFW} \times \left(\frac{\text{DW}}{\text{HA} \times \text{FW}} \right) \times 10$$

Where

TFW = total fresh weight kg/plot,

DW = dry sample weight in g

FW = fresh sample weight in g

HA = harvest plot area in m²

10 = is a constant for the conversion of yields in kg/m² to t/ha

During sampling, the four rows in the middle of each plot were cut at five cm above the ground from each block, excluding border rows and then, freshly harvesting plant samples were chopped into small pieces up to 1-2 cm to facilitate drying and weighed for their fresh weight right in the field. Samples taken from each harvesting stage were thoroughly mixed and 400 g sample was taken and dried under open air until the constant DM weight is attained. After drying, all samples were ground to pass a 1-mm Wiley mill screen and stored in an airtight container for different chemical analyses.

3.2 Analytical procedures

Samples of each treatment were subjected to chemical analysis for determination of dry matter, ash, and crude protein following the methods of (AOAC, 2004). Forage quality measurements such as determination of Kjeldhal nitrogen from which crude protein and calculated as total N×6.25. Fibers such as acid detergent fiber (ADF) and neutral detergent fiber (NDF) and acid detergent lignin (ADL) were analyzed using (Van Soest et al., 1991). Ash was determined by igniting at 550 °C overnight. All the chemical analyses were done in Bahir Dar University Animal Nutrition Laboratory.

3.3 Statistical analysis

The collected data were managed and organized with MS-Excel 2010. All data collected were statistically analyzed using General Linear Model (GLM) procedure of the Statistical Analysis System (SAS., 2004). Differences among treatment means were considered statistically significant at a 0.5% significance level using Duncan's Multiple Range Test (DMRT).

4. Results

4.1 The effect of cutting interval on morphological traits

In the present study, the effect of cutting interval on plant morphological traits of Para, Napier and Desho grasses is presented in Table 1. The finding indicated that cutting interval significantly affected all the traits except LSR in three grasses.

The overall results of the study show that maximum values of plant height, tiller number per plant and leaves number per plant were recorded for later cutting intervals (120 days) as compared to the shorter cutting interval (60 days and 90 days). Desho grass recorded generally higher tiller numbers than Para and Napier throughout the growth period. The highest mean tiller numbers were obtained for Para, Napier and Desho at 120 days. The highest tiller numbers were recorded for Desho (236 tillers/plant) at 120 days, followed by Para (181 tillers/plant). But the lowest number was recorded in Napier (46 tillers/plant). The Para grass recorded generally higher leaf numbers than Desho and Napier grasses throughout the growth period. Mean

Table 1. Effects of cutting date on morphological traits and DM yield of Para, Napier and Desho grasses.

grass variety	cutting interval (days)	plant height (cm)	tillers No. per plant	leaves No. per plant	leaf to stem ratio	DM yield (t/ha)
Para	60	43.15 ^c	148.8 ^b	1336.0 ^c	1.15 ^a	4.30 ^b
	90	60.40 ^b	153.2 ^b	1563.7 ^b	1.10 ^a	8.10 ^a
	120	75.00 ^a	183.0 ^a	2366.7 ^a	1.10 ^a	9.57 ^a
SEM		1.74	6.35	9.60	0.15	0.88
	Sig.	***	*	**	NS	*
Napier	60	101.99 ^b	40.5 ^b	267.5 ^b	2.40 ^a	12.50 ^b
	90	107.50 ^b	43.7 ^{ab}	325.0 ^{ab}	2.30 ^a	14.60 ^a
	120	151.90 ^a	45.8 ^a	414.8 ^a	2.30 ^a	16.20 ^a
SEM		6.49	1.32	3.81	0.27	0.18
	Sig.	**	*	*	NS	*
Desho	60	28.95 ^b	149.0 ^b	894.8 ^c	1.37 ^a	5.50 ^c
	90	39.20 ^{ab}	181.0 ^b	1199.4 ^b	1.20 ^a	6.60 ^b
	120	45.30 ^a	236.0 ^a	1588.4 ^a	1.20 ^a	8.60 ^a
SEM		4.42	10.35	3.50	0.22	0.37
	Sig.	**	**	**	NS	*

SEM = standard error of mean

NS, *, **= non significance and significance at 5% and 1%, probability levels, respectively

leaf numbers were higher for Para, Desho and Napier at 120 days of cutting interval. At 120 days Para grass recorded the highest leaf numbers (2366 leaf numbers) followed by Desho (1588 leaf numbers) but Napier (414 leaf numbers). The Napier grass recorded the higher DM yield and followed by Para grass throughout the growth period. At 120 days, Napier grass recorded the highest DM yield (16 t/ha).

4.2 Effects of cutting interval on quality traits

The chemical composition of three different harvesting days of Para, Napier and Desho grasses is shown in Table 2. In the current study, the DM yield, NDF, ADF and ADL increased with an increase in harvesting days ($60 < 90 < 120$ days) whereas the CP and total ash showed a decreasing trend and an increase in harvesting days ($60 > 90 > 120$ days). The CP content of Para, Napier and Desho grasses was 13.1%, 10.5%, 8.0%; 13.2%, 9.5%, 7.9% and 13.4%, 9.16%, 7.73% in the first, second and third cuttings, respectively. The average ash contents of Para, Napier and Desho grasses were 15.1, 15.24, 13.92% in the first cutting; 13.9, 13.2, 13% in the second cutting, and 12.8, 11.3 and 12.16% in the third cutting, respectively.

5. Discussion

5.1 The effect of cutting interval on morphological traits

Plant height increased progressively with enhanced age of harvesting days and this is supported with the finding of Rambau et al., 2016 on Napier grass. This is because plant height in grasses is greatly influenced by the developmental stage of the plant. An increase in plant height at 120 days of cutting is due to substantial root development and subsequent improvement in nutrient uptake to continued increase in plant height. The estimated boost in plant height at maturity is consistent with the research results of Tilahun et al.,

2017 who also reported similar results for Desho grass. The recorded plant heights for the three grasses indicated that Napier was with the highest (151.9 cm) followed by Para (75 cm) and the least was for Desho (45.3 cm) at 120 days of cutting interval. Mustaring et al., 2014 reported greater plant height for Brachiaria mutica followed by Brachiaria brizantha and Brachiaria Mulato at 8 weeks of harvesting. However, the results obtained from the current study were lower than that reported by Mustaring et al., 2014; Zemene et al., 2020 for Para grass. This variation may be attributed due to the difference in their species, soil fertility, maturity stage and weather condition of growing.

More tillers number was found in Desho (236) followed by Para (183) and the least were observed in Napier (46) at the latest harvesting age (120 days). It is supported by Rambau et al., 2016 who stated that as the plants approached maturity more tillers would develop. As studied by Rambau et al., 2016, the mean tiller number of Napier grass was lower than the current study. According to Zemene et al., 2020, the tiller number for Para grass was increased with increased harvesting days. Therefore, the results of the current study agree with the reports of Rambau et al., 2016; Mihret et al., 2018 and Zemene et al., 2020; for Napier, Desho and Para grasses, respectively. There was a significant effect on the total leaves number per plant of Para, Napier and Desho grasses in all harvesting day. Due to an increase in the tiller number of grasses, the first, second and third cutting intervals significantly increased the number of leaves per plant. Greater numbers of leaves per plant were recorded for Para, Napier and Desho grasses at a late stage of maturity (120 days) cutting interval. This result was higher than the values reported by Manyawu et al., 2003; Tilahun et al., 2017 and Zemene et al., 2020 for Napier, Desho and Para grasses, respectively. In the current study, the cutting interval had no significant ($P > 0.05$) effect on

Table 2. The effects of cutting interval on quality traits of Para, Napier and Desho grasses.

grass variety	cutting interval (days)	ash (%)	CP (%)	NDF (%)	ADF (%)	ADL (%)
Para	60	15.10 ^a	13.10 ^a	65.60 ^c	34.97 ^b	5.00 ^c
	90	13.90 ^{ab}	10.50 ^b	67.70 ^b	36.70 ^a	5.65 ^b
	120	12.80 ^c	8.00 ^c	69.00 ^a	37.10 ^a	5.97 ^a
Napier	SEM	0.45	0.30	0.23	0.19	0.09
	Sig.	*	***	***	**	**
	60	15.24 ^a	13.20 ^a	64.13 ^c	37.10 ^c	5.70 ^b
Desho	90	13.20 ^b	9.50 ^b	64.86 ^b	38.43 ^b	5.70 ^b
	120	11.30 ^c	7.90 ^c	65.36 ^a	40.00 ^a	6.50 ^a
	SEM	0.35	0.35	0.10	0.37	0.47
Desho	Sig.	**	***	**	*	*
	60	13.92 ^a	13.40 ^a	75.12 ^b	38.15 ^b	8.89 ^b
	90	13.00 ^b	9.16 ^b	77.21 ^a	39.30 ^{ab}	9.52 ^b
Desho	120	12.16 ^b	7.73 ^c	78.70 ^a	40.50 ^a	10.70 ^a
	SEM	0.30	0.26	0.44	0.57	0.24
	Sig.	*	***	**	*	*

CP= Crude protein; NDF= Neutral detergent fiber; ADF= Acid detergent fiber;

ADL= Acid detergent lignin; SEM= standard error of mean.

*, **, ***= significance at 5% and 1% and 0.01%, probability levels, respectively.

the leaf to stem ratio of the studied grasses. But cutting interval had a significant difference in leaf to stem ratio of the studied grasses numerically. Contrarily, Asmare et al., 2017 reported that harvesting dates affected LSR of Desho grass. The reason for this might be the accumulation of more cell wall components in plant tissues as a result of stem development with advancing maturity.

In the present study, the DM yield was increased as the grass aged, and a higher dry matter yield was observed at the late stage of maturity. This is when grass matures, forage yield is increased due to the rapid rise in the tissues of the plant, development of extra tillers and formation and elongation leaves, and stem development with increasing harvesting age. This idea is supported by Ansah et al., 2010 and Rambau et al., 2016, who reported that the DM yield increased as Napier grass maturity increased. Similarly, as reported by Zemene et al., 2020, the DM yield of Para grass was increased with increased cutting intervals. Tilahun et al., 2017 and Kefyalew et al., 2020 reported that the DM yield of Desho grass increased with increase cutting intervals. Therefore, the present study was in agreement with the report by Ansah et al., 2010; Rambau et al., 2016 for Napier; with Tilahun et al., 2017; Kefyalew et al., 2020 for Desho and with Zemene et al., 2020 for Para grasses.

5.2 Effects of cutting interval on quality traits

In the current study, there was a significant difference on the ash content of Para, Napier and Desho grasses in different cuttings. The ash content of the grasses in this study was reduced with an increase in the age of maturity which is in line with the report of Monçao et al., 2020 who reported that the ash content of Napier grass decreased as the regrowth harvesting age increased. This was when grasses mature, the mineral content drops due to dilution effect. Therefore,

the current result is in line with Ansah et al., 2010 for Napier grass; Tilahun et al., 2017; Kefyalew et al., 2020 for Desho and Zemene et al., 2020 for Para grass. Contrary to current findings, Rambau et al., 2016 found that plant maturity did not affect the ash content of Napier grass. Kitaba and Tamir, 2007 also reported that the ash content tended to increase as harvesting progressed. Therefore, the current study disagrees with the report by Kitaba and Tamir, 2007.

As expected, CP was the highest in the early stage compared with the intermediate and late stages of maturity. This was due to a growth reduction effect with an increase in the structural carbohydrate content of forage materials harvested at late maturity, reducing the percentage of protein in the forage since the nitrogen moves from the cell to cell wall content supported by study findings of Monçao et al., 2020. Grasses harvested at an early stage of maturity in this study had the best nutritional value, particularly the highest CP content. Even forage cut at 120 days interval had CP concentrations well above 7.0%, which is the level below which voluntary intake of ruminants might be depressed. However, harvesting at the early stage resulted in low DM yields. This result is in line with the results of Tudsri et al. (2002); Ansah et al., 2010 reported for Napier grass; Tilahun et al., 2017 and Kefyalew et al., 2020 reported for Desho grass and Zemene et al., 2020 reported for Para grass.

As would be expected, the NDF, ADF and ADL contents increased with forage maturity increases. The late-stage had the high lignin content; this implies that forages from later stages of growth in grasses are going to have lower quality as higher levels of lignification result in reduced digestibility. This result agrees with Rambau et al., 2016 for Napier grass, Zemene et al., 2020 for Para, Tilahun et al., 2017 and Kefyalew et al., 2020 for Desho grasses reporting that the NDF, ADF and ADL content increase progressively

as forage maturity increased. Similarly, the findings for ADL agree with the studies of Bayble et al., 2007 and Aganga and Omphile, 2005. They observed the increased ADL with the progressive stages of maturity. Therefore, forages with lower ADL concentrations are more desired for the healthy and functional rumen.

6. Conclusion

From the results of the current study, it has been concluded that Napier grass produces a higher forage yield among the three grasses and longer harvesting intervals result in increased forage yield in all the studied grasses. However, forage quality as expressed in terms of crude protein value progressively declines. Therefore, under conditions where protein is not a limiting nutrient in practical feeding, letting the grass stands to regrow for a longer period would guarantee increases in forage yield. Cutting at 90 days of the grass stands yields a reasonably good quantity and quality of fodder from the studied grass species. Further research is needed to be conducted over much longer periods to determine to what extent these findings are related to performance over the life of a permanent pasture.

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Ethical Approval

This manuscript does not report on or involve the use of any animal or human data or tissue. So the ethical approval does not applicable.

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Authors Contributions

All authors have contributed equally to prepare the paper.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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