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Research Article

Effect of Harvesting Stage and Cutting Interval on Herbage Yield and Quality of Desho Grass Under Irrigation at Adami Tulu Agricultural Research Center

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Abstract

The experiment was conducted at Adami Tulu Agricultural Research Center (on station) for two consecutive years (2021-2022) with the objective to evaluate the effect of harvesting stage and cutting intervals on herbage dry matter yield, other agronomic performances, nutritive value and economic advantages of Desho grass variety (KK1-DZF # 591) produced under irrigation. The treatment contained three levels of harvesting stages (60, 75, and 90) and three cutting times (30, 45 and 60 days). The experiment was laid out in randomized complete block design in factorial arrangement with three replications. The data collected from the current study were herbage dry matter yield, yield related agronomic parameters, and chemical composition of the grass. The analysis of variance indicated that plant height, leave length, leaf to stem ratio and herbage dry matter yield were showed significance ($P<0.001$) variations among the treatments. The highest plant height was recorded from advanced age at cutting interval 60 days and the lowest was from the early harvesting at 30 days. The highest herbage dry matter yield was recorded from treatment harvested every 45 days of cutting interval, after a maximum age of 75, this was due to high number of tillers recorded. The lowest values were recorded long stages of harvesting (90 and 75 days) with long cutting interval (60 days). The highest cutting frequencies were recorded from early harvesting stage (60 days) of cutting interval after every month (30 days) and the lowest was from late harvesting stage (90 days) of cutting interval after two months (60 days). CP, ash NDF and, ADF contents of Desho grass was affected by harvesting stage and cutting interval. The highest mean values of CP and ash contents were recorded from early harvested forage at 30 and 45 days than 60 days of cutting intervals and the lowest was recorded from late of cutting interval. The highest returns were obtained from forage harvested at every 45 days after reach maximum age of 75 days at both seasons. 75x45 treatment combination was good in total dry biomass yield, chemical compositions and high return. Therefore, Desho grass established under irrigation condition harvested after the harvesting stage of 75 days with cutting interval 45 days was recommended for the end user of the study area and similar agro ecology.

Keywords

Cutting Interval, Desho, Harvesting Stage, Herbage, Quality

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1. Introduction

Low quality and insufficient feed supply are major factors contributing to cattle productivity declines [1]. Animals are kept on poor-quality natural pastures, roadsides, pathways, and spaces between cropped plots. An alternative solution to overcome feed shortage and improve livestock productivity through introduction of improved and adapted forage technologies into the farming systems.

Desho grass is one of the adapted perennial forage grass in the study area. The grass provides high yields green herbage ranging between 30-109 t/ha [2, 3]. Morphological characteristics and chemical composition of the grass is affected by harvesting stages and altitude [4]. The stage of harvesting as well as the frequency of harvesting is important to determine the quality and quantity of forage species for animal feed. Desho grass serves as a business opportunity for farmers in Ethiopia [5, 6]. However, there is no adequate information on the agronomic characteristics, economic importance, management practices, chemical composition and productivity of the grass under irrigation management in the study area. Therefore, this study was conducted with the objectives of characterizing Desho grass for its agronomic performance, yield and chemical composition at different levels of harvesting stages with different cutting intervals under irrigation.

2. Materials and Methods Description of Study Site

The experiment was conducted at Adami Tulu agricultural Research Center (ATARC) on station from for two consecutive years (2021-2022) under irrigation conditions. ATARC is located in the mid rift valley of Oromia region, 167 km south of Addis Ababa on Hawassa road. It lies at latitude of 7 ዐ'N and 38 ዎ'E longitude. Its altitude is about 1650 meters above sea level. It has an average annual rain fall of 760mm. It has a bimodal rainfall from March to April (short rain) and July to September (long rains) with a dry period in May to June which separates short rains from long rains. The average annual minimum and maximum temperature of the area at the study year were 11.8 ℃ and 28.3 ℃ (Metrology station of Adami Tulu Agricultural Research Center). The soil is loam with sand, silt and clay in a proportion of 44%, 34% and 22% respectively and the PH of the soil is 7.88.

2.1. Experimental Design and Treatments

The experiment was conducted in a randomized complete block design with three replications by using a 3×3 factorial arrangement in randomized complete block design with three replications. with three levels of harvesting stages after the maximum age limit (60, 75, and 90) and 3 cutting intervals of (30, 45, and 60 days) by using KK1-DZF # 591 variety. The roots of Desho were row planted on each plot of (3 × 3) m2 area and the spacing between rows and plants was 50 and 10 cm, respectively and 1m between each plot and replication. An irrigation water management practice was carried out uniformly for each plot, watering twice every 7 days at 11:00 AM to minimize water evaporation. NPS fertilizer was applied at planting at the rate of 100 kg per ha. 50 kg/ha of urea was applied after each cutting. Weeding and related management practices were applied according to the grass's requirements.

2.2. Forage Sampling Procedures

The first harvested data was not included and discarded from all treatments; because the first harvesting was taken as an establishment period. Total forage biomass yield was determined by harvesting from the two middle rows of each plot at each cutting interval, at a height of 5 cm near the ground. After cutting, the total fresh weight of the forage sample from each plot was measured immediately for total biomass yield determination by using a sensitive balance at field, and 250 g subsample per plot was brought to ATARC Animal feed laboratory and chopped into pieces for further chemical analysis.

2.3. Partial Budget Analysis

A partial budget analysis was performed to determine the economic importance of improved forage production under irrigation conditions in the study area. Selling of native pasture harvested from protected grazing land, pastures grown on the borderline and in the papaya of farmland were well practiced in the study area. Two seasons were taken into consideration for partial budget analyses: the dry seasons, when feed resources are scarce, and the wet seasons, when feed resources are somewhat available. In the study area grass is sold by kuntals and in the form of bundles.

A partial budget analysis was undertaken by using the procedure of [7] to determine the profitability of established grass under irrigation conditions. The cost of grass was estimated from native pasture sold at Maki, Batu, and Tullu Markets. The total variable costs involved were transport cost, labor cost (wage, plowing), harvesting cost, rent of land, input cost (fertilizer NPS and urea and fuel cost. The net return was calculated as: NR = TR-TVC Where: - NR = Net Return, TR = Total Return, and TVC = Total Variable Cost.

2.4. Collected Data

The morphological data such as plant height, number of tillers per plant, leaves length was recorded from five randomly selected plants from the middle rows of each plot,

leaf to stem and total variable costs.

2.5. Total Forage Biomass Yields Determination

The representative subsample was dried in oven dry at 105 ℃ for overnight for total dry matter determination. Accordingly, DM yield (t/ha) estimation was calculated by using the recommended formula by the research [8]. The final total dry matter yields were reported in tons per hectare and calculated as 10 x TFW x (DWss /HA x FWss) Where, TFW = Total fresh weight, DWss = oven-dried subsample, FWss = Fresh weight subsamples and HA = Harvesting area.

2.6. Chemical Analysis

Samples were dried in an oven set at a temperature of 60 ℃ for 72 hours, and ground to pass through a 1 mm sieve screen. Ash, Dry mater (DM), and Crude Protein (CP) were determined according to the [9]. The Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) were determined following the procedures of [10]. Fiber and DM contents of the collected samples were analyzed at Adami Tullu Agricultural Research center Animal feed laboratory.

2.7. Statistical Analysis

The collected data were analyzed using the General Linear Model (GLM) of SAS 9.1 [11]. The difference among treatment means was determined by using Tukey's at 5% level of significance. The profit of Dasho grass established under irrigation was analyzed by using Excel Program Microsoft Cope.

3. Result and Discussions

The harvesting stage of Desho grass with three cutting intervals for total dry matter yield showed a significant difference ($P<0.05$) among the combined treatments in the case of total dry biomass yield production under irrigation condition.

Table 1. *Mean squares of ANOVA for total dry matter yield of harvesting days after maximum age limit with 3 cutting intervals.*

Source of variation	DF	PH	NTPP	LL	LSR	DMY
Rep	2	1.40ns	0.25ns	0.77ns	0.28ns	0.37ns
Age	2	0.25*	3.39*	1.73**	1.10ns	1.91ns
Intervals	2	45.09**	5.64*	20.00**	2.57*	5.43***
Age * intervals	4	2.48***	0.61*	2.12***	0.71***	0.117**
Error	37					

Where: - DF- Degree freedom.

3.1. Agronomic Performances of Desho Grass at Different Harvesting Stage and Cutting Intervals

The effect of the harvesting stage after the maximum age limit with different cutting intervals on agronomic parameters of Desho grass is presented in Table 2. The combined mean value of plant height indicated that there was significant ($P<0.001$) variation among the treatments. The highest mean value of plant height 90.80 was recorded from 90 x 60 treatment combination followed by 75 x 60 and 60 x 60 treatments combinations, respectively, while the lowest was recorded from 60 x 30 treatment combination followed by 90 x 30. The current finding was similar with the finding of [4], who reported plant height increased as the harvesting stage and cutting interval increased. The current result was similar to the report of [3] from the same site. The overall mean value of the current report was lower than the finding of [12] who reported 98.5 cm, from the research work at the high land of Holeta. This difference might be due to variations in soil types and cutting intervals. Plant height of the Desho grass varieties could be attributed to cutting frequencies, level of soil fertility, agronomic practices, and climatic zones of study areas [4].

The number of tillers per plant varied significantly ($P<0.05$) among the combined treatments. The highest average mean value was recorded from 75x45 and the lowest value was recorded from 90 x 60. The present finding was in line with the idea of [13] who stated that the number of tillers per plant increased as harvesting time increased. The overall mean value of the present report was similar to previous reports of [14] which is (88.4) and higher than the finding of [15] which reported 49.17-69.83 and [13] which reported 43.33 number of tillers per plant. This difference might be due to harvesting

intervals and agro ecology, the former research was conducted at high land of North Western Ethiopia under irrigation conditions with 75, 105, and 135 harvesting intervals.

Leaf length per plant showed significant (P<0.001) variation between the treatments. The longest leaf length was measured from late harvesting days 75x60 treatment followed by 60x60 and 90x60 treatments, respectively, and the lowest value was from early harvesting interval 60x30. These results indicated as the harvesting age increased the length of leaf increased. The current result was lower than the report of [16, 3], which reported 43.65cm and 47.67cm, respectively. However, the current value was higher than the finding of [17, 13], which recorded 18.3cm and 24.44cm lengths, respectively. These variations might be due to age of harvesting and cutting interval.

Cutting frequency after reaching the maximum age limit had a significant effect (P<0.001) on leaf to steam ratio (LST). The maximum leaf to steam ratio was gained from 75x45 followed by 60 x 45 treatment combination. The minimum average mean value was recorded from late harvesting stage and cutting interval (90x60). The average mean of the current result was higher than the finding [13] at harvesting ages of 90, 120, and 150 days (1.24, 1.17, and 0.82, respectively). This might have been due to a reduction in leaf proportion and an increase in the stem fraction of the grass at the advanced stage of harvesting [18].

The total dry matter yield of Desho grass was significantly (P<0.01) affected by cutting frequencies or intervals. The highest average mean value of total dry biomass yield (23.61 t/ha) was recorded from 75 x 45 and this value was due to a high number of tillers recoded from this treatment combination. As the number of tillers per plant increases total dry biomass yield also increased. The lowest total dry matter yield (17.13 t/ha) values were recorded from 90 x 60 and 75 x 60 treatments. The overall average mean values of the current work were similar to the reports of [4], who reported 20.72 t/ha, and higher than the finding of [17], which reported 16.1t/ha. This difference might be due to different cutting intervals; the former research was harvested by the frequencies of 75, 105, and 135 days under irrigation conditions.

Table 2. *Agronomic performance of Desho grass harvesting after maximum age limit with 3 cutting intervals.*

Treatments (age*interval)	Parameters				
	PH	NTPP	LL	LSR	TDMY (t/ha)
60x30	52.56^{c}	90.49^{ab}	31.98^{c}	4.39^{a}	19.40^{ab}
60x45	63.78^{bc}	80.33^{ab}	39.65^{ab}	4.09^{a}	18.67^{ab}
60x60	85.27^{a}	81.36^{ab}	42.78 ^{a}	2.11^{c}	17.89^{ab}
75x30	74.15^{ab}	91.81^{ab}	41.30^{a}	3.94^{a}	17.61^{ab}
75x45	76.15^{ab}	109.66^{a}	37.98^{abc}	3.79^{ab}	23.61^{a}
75x60	86.51^{a}	72.13^{b}	40.64^{ab}	2.71^{bc}	17.13^{b}
90x30	53.73^{c}	93.96^{ab}	33.31^{bc}	3.54^{ab}	19.04^{ab}
90x45	62.12^{bc}	82.70^{ab}	37.60^{abc}	3.76^{ab}	18.02^{ab}
90x60	90.80^{a}	68.93^{b}	44.16^{a}	0.64^{d}	17.13^{b}
Overall Mean	68.07	88.17	37.83	3.40	19.15
CV (%)	27.1	21.5	20	26	27.9
LSD (0.05%)	11.32	21.64	4.65	0.76	6.81
P-value	***	*	***	***	**

Where:- $^{a, b, c, d}$ =Means in a column within the same category having different superscripts differ (from P<0.05 to P<0.001), *= (p<0.05), **= (p<0.01), *** = (p<0.001), CV= Coefficient variation, LSD = Least Significant difference, PH- Plant Height, NTPP- Number of tiller per plant, LL- Leaf Length, LSR- Leaf to Steam Ratio and TDMY- Dry Matter Yield.

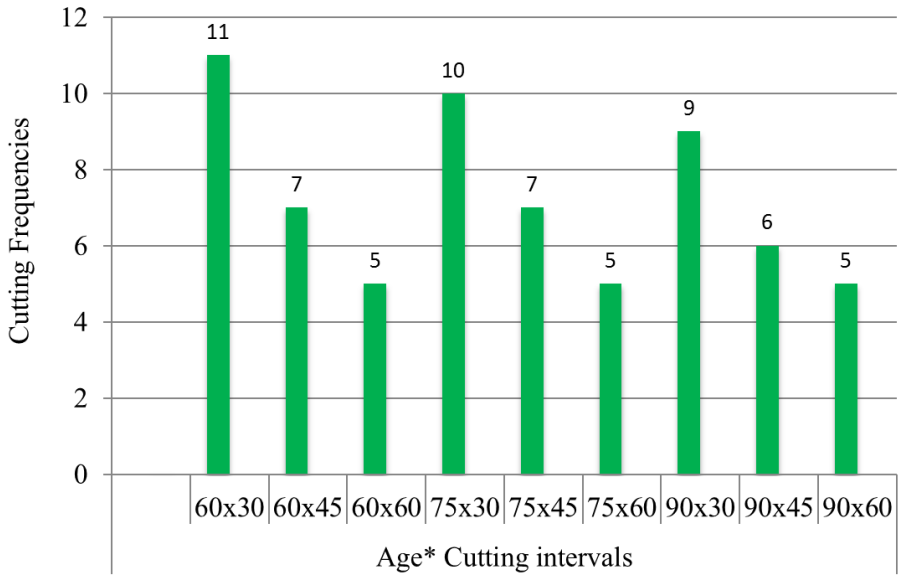

Figure 1. *Cuttings frequency of Desho grass in a year.*

3.2. Cutting Frequency of Desho Grass

Annually cutting frequency of Desho grass is presented in Figure 1. Established Desho grass under irrigation conditions was harvested after forage reached the maximum age limit of 60, 75, and 90 days. After this age, established forage was harvested every 30, 45, and 60 days. The highest cutting frequencies were recorded from treatment combination of 60 x 30 and followed by treatment 75 x 30. This was due to the 30 days being the shortest days than the 45 and 60 days of cutting intervals. The forage in this treatment combination was harvested once a month, while the other treatments were harvested after 45 to 60 days. Treatment combinations with long cutting intervals (60 days) such as 90 x 60, 75 x 60, and 60 x 60 showed the lowest cutting frequencies.

3.3. Chemical Quality of Desho Grass

Chemical qualities of the combined treatments are presented in Table 3. Among the analyzed quality parameters DM and LDF contents showed none significance ($P>0.05$) and the rest were showed significant ($P<0.05$) differences between the set treatments. The highest average mean value of ash content was recorded from the treatment with shorter cutting intervals (30 and 45 days), while the treatments with 60 days of cutting intervals had the lowest value. The overall average mean value of the current finding was higher than the finding of [17], who reported 8.00% in Farta District and lower than [16] who recorded 13.2%, from the work done at high land of Guje Zone. The ash content of Desho grass varied with location and harvesting stage [19]. The forage harvested at the early growth stage has better ash content as compared with the late-harvested forage. The ash concentration of different grasses declined significantly with advancing age [20, 21].

The crude protein contents of the current result ranged from 9.23- 14.88% in which the highest value was observed for the earlier harvested date (at 30 days of cutting interval with 60 days of harvesting age) and the lowest value was obtained from advanced age of harvesting 90 days with late cutting interval (60 days). The CP content in the current study is higher than values reported by different scholars who conducted research under different agro-ecology [13, 22-24] and lower than the finding of [16]. This difference might be due to location, harvesting age, soil factors, weather conditions, and management provided. The mean value of the CP content of Desho grass in the current study was higher than the critical value of 7% required for normal rumen microbial function [25]. Pasture and other roughage feeds are classified as high, medium, and low quality according to their CP contents. Accordingly, roughage feeds with CP content of 9.92 to 15.2%, 6.6 to 9.1% and 3 to 6.5% were classified as high, medium, and low-quality roughage feeds, respectively [26]. Based on this information, the average mean value of CP contents of the current result can be classified as high.

NDF and ADF were significantly affected by harvesting stage and cutting interval. The highest value of NDF of the current finding was recorded from treatment combination with late harvesting stage (75 and 90) with late cutting interval of 60 days and the lowest were from the early harvesting stage (60) with the early cutting intervals at 30 and 45 days. As the stage of harvesting is increased, reduction in quality, especially reduced in CP concentrations and increased in NDF and ADF concentrations [19].

The ADL fraction was not significantly affected by harvesting stage and cutting intervals; the current finding was similar to the finding of [19] reported that, the ADL fraction was not significantly affected by altitude and harvesting date. The current result of ADL increased from 2.82% to 7.09% from cutting intervals of 30 to 60 days.

Table 3. Combined Chemical composition (%) of 3 levels of harvesting stage after maximum age limit with 3 cutting intervals.

Treatments combination (age*intervals)	Parameters					
	DM	Ash	CP	NDF	ADF	LDF
60x30	85.07	15.39^{a}	14.88^{a}	35.63^{b}	16.54^{ab}	2.82
60x45	97.43	13.69^{ab}	12.00^{ab}	37.36^{b}	16.91^{ab}	4.89
60x60	84.23	12.51^{ab}	10.71^{ab}	39.18^{b}	17.31^{ab}	6.66
75x30	90.00	12.96^{ab}	13.17^{ab}	35.69^{b}	16.48^{ab}	4.24
75x45	84.56	13.24^{ab}	12.83^{ab}	36.68^{b}	16.78^{ab}	5.12
75x60	88.70	12.15^{b}	10.07^{ab}	48.19^{a}	17.85^{a}	7.05
90x30	89.20	12.27^{ab}	11.85^{ab}	34.84^{b}	15.86^{ab}	4.35
90x45	97.43	11.8^{5b}	10.73^{ab}	37.72^{b}	16.99^{ab}	5.17
90x60	84.10	11.5^{b}	9.23^{b}	51.09^{a}	17.14^{ab}	7.09
Overall Mean	88.97	12.84	11.72	39.60	16.87	5.27
CV (%)	12.37	14.02	24.1	9.92	6.2	14.2
LSD (0.05%)	19.05	3.12	4.89	6.78	1.81	4.65
P-value	NS	*	*	**	*	NS

Where: $^{a, b,}$ =Means in a column within the same category having different superscripts NS- None significance, *= ($p<0.05$), CV= Coefficient variation, LSD = Least Significant difference DM- Dry Matter, OM- Organic Matter and CP- Crude Protein.

3.4. Partial Budget Analysis

Variable costs and growth revenue of the total fresh yield of Desho grass established under irrigation conditions are presented in Table 4. The highest net return was obtained from treatment 75x45 followed by 60x60 at both seasons; this was due to the highest production biomass yield. The lowest return was recorded from 75x30 treatments in both seasons; this was due to low total biomass yield production. The highest return was recorded at the dry season than the wet season; this was due to the demand for forage increased, other feed shortages and the costs also raised in this season. The forage producers more benefited when they sold forage in form of fresh at dry season.

Table 4. Variable costs and Return in ETB of total fresh biomass yield of Desho grass established annually under irrigation condition.

Treatment (age*inter)	TDM Kg/ha	TVC	Total revenue	Growth revenue at Wet season	MRR	Total revenue	Growth revenue at Dry season	MRR
60x30	24100	294560	361500	66940	1.23	482000	187440	1.64
60x45	23005	264560	345075	80515	1.30	460100	195540	1.74
60x60	21835	249560	327525	77965	1.31	436700	187140	1.75
75x30	21415	287060	321225	34165	1.12	428300	141240	1.49
75x45	30415	257060	456225	199165	1.77	608300	351240	2.37
75x60	20695	249560	310425	60865	1.24	413900	164340	1.66
90x30	23560	279560	353400	73840	1.26	471200	191640	1.69
90x45	22030	257060	330450	73390	1.29	440600	183540	1.71

Treatment (age*inter)	TDM Kg/ha	TVC	Total revenue	Growth revenue at Wet season	MRR	Total revenue	Growth revenue at Dry season	MRR
90x60	20695	249560	310425	60865	1.24	413900	164340	1.66

The Total variable costs involved were transport, labors (wage, ploughing, harvesting, land cost, input (fertilizer NPS and urea) and fuel cost, TDM- Total Dry Matter, TVC-Total Variable Cost, MRR-Marginal Rate of Return.

4. Conclusions and Recommendations

The results of the current study showed that there were significance variations in plant height, leave length, number of tillers per plant, leaf-to-stem ratio, and total forage biomass yield. Plant height was affected by cutting stages, the highest value was recorded from which had an advanced age of cutting interval (60 days), and the lowest were recorded from the early days of cutting interval (30 days).

The highest average mean value of total dry matter yield was recorded from Desho grass harvested every 45 days of cutting interval, after a maximum age of 75 days. This value was due to the high number of tillers recorded from this cutting interval with better grass performance than those harvested every 30 and 60 days of cutting intervals. The lowest values were recorded from Desho grass harvested after long stages of harvesting (90 and 75 days) with long cutting intervals (60 days). The highest cutting frequencies were recorded from the treatment combination of 60 x 30 followed by treatment 75x30 and the lowest cutting frequencies were recorded from treatment combination 90 x 60, 75 x 60, and 60 x 60.

CP, ash NDF, and, ADF contents of Desho grass were affected by the harvesting stage and cutting interval. The highest average mean values of CP and ash contents were recorded from early harvested forage at 30 and 45 days rather than 60 days of cutting intervals. NDF and ADF were significantly affected by the harvesting stage and cutting interval. The highest value was recorded from the late cutting interval. As stages of harvesting and cutting intervals are increased, reduction in quality especially reduced CP and increased NDF and ADF concentrations.

The highest returns 1.77 and 2.37 were obtained from forage harvested at every 45 days after reaching the maximum age limit of 75 days at wet and dry seasons, respectively. The highest forage return was recorded in the dry season than wet season. Forage producers under irrigation conditions in the study area are more benefited when is produced at dry season and sold during dry period.

75 x 45 treatment combination was better in total dry biomass yield production, chemical compositions, and high return at both seasons than other treatments. Therefore, Desho grass established under irrigation conditions harvested after the harvesting stage of 75 days with a cutting interval of 45 days was recommended for the end user of the study area and similar agro-ecology.

Abbreviations

ADF	Acid Detergent Fiber
ADL	Acid Detergent Lignin
CP	Crude Protein
DM	Dry Matter
NDF	Neutral Detergent Fiber
NR	Net Return
TR	Total Return
TVC	Total Variable Cost

Conflicts of Interest

The authors declare no conflicts of interest.

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