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Effect of Plant Spacing and Harvesting Stage on Chemical Composition and *In-Vitro* Digestibility of Desho Grass (*Pennisetum Glaucifolium* L.) at Midland of Guji, Oromia Region

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ABSTRACT

The experiment was conducted to evaluate appropriate combination harvesting stage and plant spacing on chemical compositions, digestibility and its rumen degradability potentials of Desho grass. Three-by-three randomized complete block design was used to set up the experiment. factorial arrangements in three replications. The experiment employs three harvesting stages (75, 105 and 135 days) and three plant spacing (10, 30 and 50 cm). Prior to planting 100 kg/ha-1 combinations of Nitrogen, phosphate and sulfur fertilizer were applied to all plots. The chemical composition such as CP, DM, TA, NDF, ADF, ADL, cellulose and CPY and DMY yield parameters differed considerably ($p<0.01$). Hemi cellulose concentration, however, was not substantially ($p>0.05$) impacted. With the 30*105 combination, a higher dry matter yield (31.87 t/ha) was achieved. The treatment combination of 30*105 had the greatest CP content (12.37%). Treatment combinations have an impact on the properties of crude protein and dry matter in-sacco degradability. Thus, it is possible to conclude that, the treatment combination 30 cm*105 days has resulted in optimum yield and nutritive values of Desho grass under the current experiment around Adola. However, there is a need for further studies on different combinations of harvesting stage and plant spacing over years and locations to arrive at dependable conclusions

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INTRODUCTION

With over 70 million cattle, 42.9 million sheep, 52.5 million goats, 10.8 million donkeys, 2.15 million horses, 0.34 million mules, 8.1 million camels, 57 million poultry, and 6.99 million beehives, Ethiopia boasts the biggest livestock population in Africa (CSA, 2021). Livestock is an essential component of subsistence crop-livestock systems, providing rural people with draft power, cash income, assets, and nutrition (Sere et al., 2008). The primary factors influencing the livestock industry in Ethiopia ACDI (2017) are the quantity and quality of feed, as these factors have an impact on animal productivity and production (Malede, 2013). Anele et al. (2009) claim that native forages are accustomed to smallholder farmers, require little inputs to grow, and may be adjusted to a variety of agro-ecological circumstances. One Using native forages as the primary source of feed is one of the main areas to increase livestock productivity in the nation (Shapiro et al., 2015).

The most crucial input in livestock production is feed, and any significant and long-term increase in livestock productivity requires a year-round supply of it (Samuel et al., 2008). According to Firew and Getnet (2010), the main feed supplies that are available in Ethiopia include agro-industrial byproducts, crop leftovers, natural pasture, and aftermath grazing. Livestock productivity is strongly impacted by late harvesting of natural pasture and poor yield agricultural leftovers in terms of quantity and quality (Tessema et al., 2002; Tessema and Baars, 2004). Consequently, feeding animals appropriately remains a major issue for the nation's livestock producers, particularly during the dry season when pasture and cereal crop leftovers are restricting both quality and quantity (Muhammad, 2016). Low-quality feed sources might result indue to a low voluntary intake, which causes an inadequate supply of nutrients, low productivity, an animal's weight to drop significantly, and a decrease in animal maintenance requirements (Benin et al., 2003). Thus, it is imperative to consider methods for boosting the pasture's output and nutritional value. to improve livestock production and productivity (Ashagre, 2008).

Desho grass (Pennisetum glaucifolium L.) FAO (2010) is a forage with high yielding potential that can boost animal productivity. It is best suited for intensive management and performs well at altitudes between 1500 and 2800 m.a.s.l. (Leta et al., 2013). It can also easily adapt to tropical environments due to its drought tolerance. Additionally, because of its multi-cut nature, which guarantees a consistent supply of forage, it offers more forage per unit area, potentially addressing the issues associated with feed scarcity (Ecocrop, 2010). Given the grass's propensity to produce multi-cut forages, Brias and Tesfaye (2009) believe that it could be a viable feed source during the dry season, when feed availability in the tropics is crucial. Moreover, altitude, soil fertility, the biomass yield and nutritional value of Desho grass are primarily determined by morphological fractions, the maturation stage, environmental conditions, disease and pest, planting technique, and variety (Papachristou and Papanastasis, 1994). High productivity and quality of Desho grass depend on proper plant spacing and cutting control (Tessema et al., 2010). There is a limit to how much these factors influence the nutritional value and productivity of Desho grass in Ethiopia.

To fully grasp the potential value of Desho grass, it is necessary to examine its production status, agronomic practices, morphological traits, chemical composition, and use under various agro-ecological circumstances (Bimrew et al., 2016; Genet et al., 2017). However, there is currently little data on the effects of proper plant spacing and harvesting age on the productivity of Desho grasses in the Bore Agricultural Research Center's Adola district. In order to ascertain the proper plant spacing and harvesting age in relation to the chemical composition, in-sacco degradability, and in-vitro digestibility of Desho grass in the Adola sub-site of the Bore Agricultural Research Center, the current study was carried out.

LITRATURE REVIEW

Desho grass is a leafy plant with several branches that can reach a height of one meter or more (Leta et al., 2013). The leaves are flat, glabrous, and measure 15–25 cm in length and 4–10 mm in width. The culms are upright and branched. The 4 mm long spikelets are typically solitary (FAO, 2010). Desho grass is a highly palatable plant for cattle and is used as fodder (FAO, 2010). High green herbage yields, ranging from 30 to 109 t/ha, are produced by the grass (Ecocrop, 2010). In addition, previous interventions have demonstrated that the best way to apply Desho-based grazing land management strategies is to redistribute community grazing land into tiny plots (less than 0.5 ha) that are easily managed, developed, and used for individual purposes (Danano, 2007).

As feed for animals From a resource standpoint, Desho grass is utilized in cut-and-carry systems or temporary pastures since it yields sufficient amounts of high-quality green fodder, can withstand many cuttings annually, and can be used to prepare hay and silage (Ecocrop, 2010). The grass is primarily found on recently cleared areas, road edges, and disturbed ground with an average annual rainfall of between 600 and 1500 mm, a wet season lasting four to six months, and average daily temperatures between thirty and thirty-five degrees Celsius. Desho grass grows well in a variety of soil types as long as it has adequate drainage, even in degraded sandy or ferruginous soils. Desho grass grows well at elevations between 1500 and 2800 m.a.s.l. and is suited for intensive treatment (Leta (2013), et al. The optimal growing conditions for desho grass are found above 1700 meters above sea level (Welle et al., 2006). Even in extreme drought circumstances, the grass can efficiently regulate water loss and bounces back quickly from irrigation (Welle et al., 2006).

METHODOLOGY

Description of Study Area

Located in Adola town in Darartu's "Kebele," on the west side of the main road leading to Negele town, is the Adola sub-site of the Bore Agricultural Research Center (BoARC) Guji zone, southern Oromia, where the study was carried out. At a height of 1721 meters above sea level, the region is located between 55°36'31"N latitude and 38°58'91"E longitude. The region experiences bimodal rainfall, with the first and most significant rainy season being between April and August and the second rainy season falling between September and November. According to the Adola district (2011), the district is divided into three agro ecologies: highland (11%), midland (29%), and lowland (60%). It has 1084 mm of rainfall annually. The study site's mean annual minimum and maximum temperatures are, respectively, 15.93 °C and 9.89 °C. Orthic aerosols and basaltic soil (Nitisols) are the two main soil types in the region (Etefa and Dibaba, 2011).

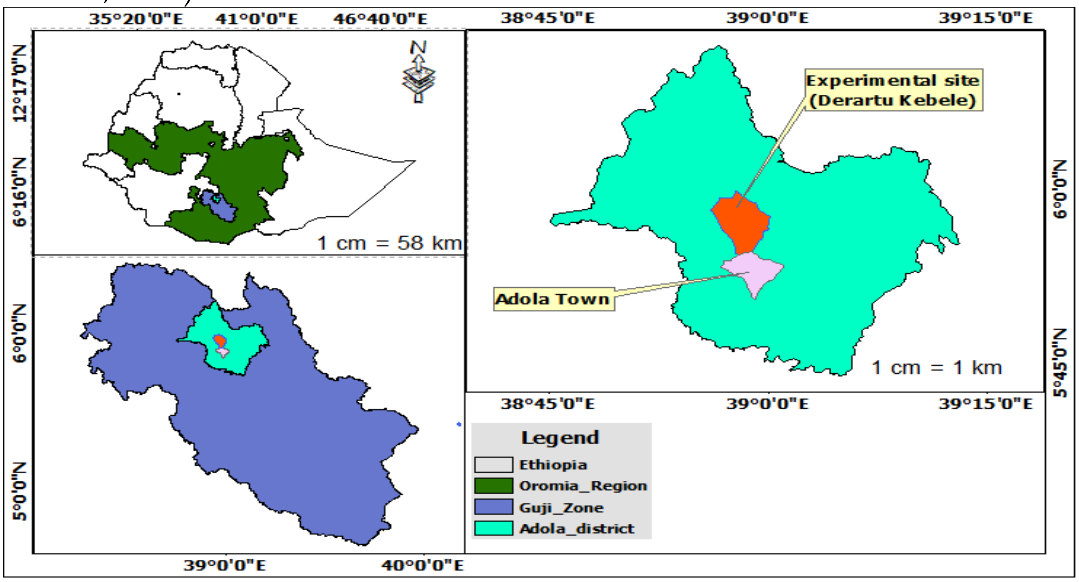

Figure 1. Map of the Study Site

Experimental Design and Treatments

Planting Desho grass seedlings (Acc. Areka# 590) were gathered from the Adola sub-site of the Bore Agricultural Research Center nursery. The study was designed using a randomized complete block design (RCBD) with three replications and a 3*3 factorial arrangement of treatments. Nine treatment combinations were used per block (11 m width*40 m length = 440 m2), and the treatments included three plant spacings within rows (10, 30, and 50 cm) and three harvesting stages following planting (75, 105, and 135 days). There were 27 plots total, each measuring 3 by 4 meters (12 by m2). Plots and blocks were separated by 0.5 and 1 m, respectively, and all plots had a row spacing of 50 cm (Genet et al., 2017). The terrainwas first plowed with a tractor, then twice with oxen, and once the ground was smoothed, the experimental plots were set up. Using hand hoeing during land preparation, the complete experimental plots were kept free of weeds. A combination of nitrogen, phosphorus, and sulfur

(NPS) fertilizers was administered for all treatments at a rate of 100 kg/ha prior to planting (Leta *et al*., 2013).

Methods of Data Collections

- **Chemical Composition**

Representative samples were taken collected every plot and kept apart in airtight containers before being oven-dried for 72 hours at 65°C to facilitate chemical analysis and the assessment of in vitro dry matter digestibility (IVDMD). Desho grass's dry matter (DM) content was ascertained by overnight drying the sample at 105 °C in a forced-draft oven (AOAC, 1990). The dry samples were ignited in a muffle furnace at 550°C for six hours to completely burn up the organic material in order to measure the ash content (AOAC, 1995). The Kjeldhal method was used to determine the N content, and N x 6.25 was used to get the CP content (AOAC, 1995). By multiplying the CP content by the total dry matter yield and dividing the result by 100, the crude protein yield (CPY) in tone per hectare was computed. yield of dry matter To calculate crude protein yield (CPY), the feed samples' CP content was multiplied by (DMY). The detergent extraction method was used to examine acid detergent lignin (ADL), neutral detergent fiber (NDF), and acid detergent fiber (ADF) (Van Soest et al., 1985). The formulas for calculating cellulose and hemi-cellulose were NDF minus ADF and ADF minus ADL, respectively.

- ***In-Vitro* Digestibility**

The Samples utilized for In-vitro Dry Matter Digestibility (IVDMD) were also utilized for chemical analysis. IVDMD was calculated using Tilley and Terry's (1963) two-stage rumen inoculum pepsin technique. One ruminally fistulated steer's rumen liquor was collected, and it was then brought to the lab in a thermos flask that had been pre-warmed to 39 OC. Before the animals were given food in the morning, rumen wine was consumed. A duplicate sample (0.5 g each) was incubated for 48 hours at 39 OC in a water bath with 30 ml of rumen liquor for microbial digestion, and then for a further 48 hours for enzyme digestion using an acid pepsin solution. Sample residues were dried for 24 hours at 105 OC. According to Jeans and Yolande (2007), IVDMD was computed as:

$$\text{IVDMD} = \frac{Dry\ sample\ weight - (residues - blanks)}{Dry\ sample\ weight} x100$$

The sample was then ashed to estimate *in -vitro* OM digestibility as:

$$\text{IVOMD} = \frac{\text{OM in the feed} - (\text{OM in residue} - \text{blank})}{\text{OM in the feed}} \text{x100}$$

Where OM = DM- Ash (measured after incineration of feed or residue). The ME content was estimated using the equation: ME (MJ kg^{-1} DM) = 0.15*IVOMD (Pinkrton, 2005).

- ***In-Sacco* Degradability**

Holeta Agricultural Research Center conducted an analysis on in-sacco degradability. For each treatment, a composite sample of Desho grass was obtained, dried for 72 hours at 65 OC in a forced draft oven, and pulverized using a Wiley mill to pass through a 2 mm sieve screen to test for In-sacco degradability (AOAC, 1995). Three rumen fistulated steers were given 3 g of dried forage samples in nylon bags with a pore size of 41 µm and a dimension of 6.5 x 14 cm. The steers were then incubated for 0, 6, 12, 24, 48, 72, and 96 hours to ascertain the ruminal In-sacco dry matter (DM) and organic matter (OM) degradability. Prior to incubation, the steers were given natural grass hay and oat straw to create a balance in the rumen environment. After the nylon bags were removed at the conclusion of each incubation hour, all of the bags—including the zero hour—were manually cleaned under running water until the water was clean, and they were gently squeezed to remove any remaining water. The dried bags were then removed from the oven, allowed to cool in desiccators, and weighed right away. The contents of dry matter (DM) and organic matter (OM) were measured in both the original samples and the residues using standard procedure (AOAC, 1990). The degradability of DM (DMD) and OM (OMD) of each incubation time was calculated as follows

$$.\text{IVDMD} = \frac{\text{weight of DM / OM incubated} - \text{weight of DM / OM residue}}{\text{weight of DM / OM incubated}} x100$$

Where, DM = dry matter and OM = organic matter

The The dry matter degradability (DMD) and organic matter degradability (OMD) values were fitted to the exponential equation, p = a + b (1 - e -ct), for t > to, at different intervals during incubation. Using the Neway Excel program, Ørskov and McDonald (1981) determined the following: a = washing loss (rapidly soluble fraction); b = slowly degradable fraction; c = degradation rate; e = natural logarithm; p = potential disappearance of DM / OM at time t; and t = time. The effective degradability of DM and OM (ED) was determined by Ørskov and McDonald (1997) using the formula ED = a + [(b*c)/(c + k)] at 0.03/hour for grass and 0.04/hour for legume rumen out flow rate (k). The potential degradability (PD) was approximated as (a + b). In which case; a, b, and are given above, with k standing for passing rate.

Statistical Analysis

The statistical analysis system (SAS, 2002) version 9.0's analysis of variance (ANOVA) algorithm for the General Linear Model (GLM) was used to analyze the data. The Tukey HSD test was used to differentiate treatment means at a 5% probability level. The following model was used to estimate the effects of spacing, harvesting age, and their interaction on morphological traits, yield, chemical compositions, in-vitro dry matter digestibility, and in-sacco degradability;

$$Y_{ijk} = \mu + H_i + S_j + (H*S)_{ij} + B_k + e_{ijk}$$

Where: Y_{ijk} = all dependent variables (chemical composition)
µ = overall mean
H_i = the effect of i_{th} harvesting age (1, 3)
S_j = the effect of j_{th} spacing between plants (1, 3)

B_k= the effect of k_{th} block
$(H*S)_{ij}$ = the combination of harvesting age and spacing
e_{ijk} = random error.
Since fistulated animals were used as a replication, the analysis of variance model for the *in*
sacco degradability parameters was $Y_{ij}= \mu + V_i+ T_j + e_{ij}$
Where: Y_{ij} = individual observation
μ = overall mean
V_i = Treatments effect (Plant spacing and Harvesting stage)
T_i = Time of incubation effect,
e_{ij} = residual error

RESULTS AND DISCUSSION

Chemical composition

Table 1 displays the significant ($p<0.01$) variation in the crude protein (CP) content of Desho grass among plant spacing and harvesting age combinations. This conclusion is consistent with Bemire et al.'s (2017) analysis, which found that there was variance in the crude protein contents among the Desho grass cultivars studied. The current study's results on the content of crude protein (CP) for all treatments that were evaluated were higher than those of previous studies conducted under various agro-ecologies by different authors (Bimrew et al., 2017; Bimrew et al., 2018). In comparison to the early and late stages of harvesting various forage grasses, the intermediate stage had the highest crude protein content. Crude protein concentration is a significant predictor of the quality of fodder (Rambau et al., 2016). The possible cause of the discrepancy is agro-ecology. variations in both variety and elevation.

Table 1 displays statistically significant ($p<0.05$) differences in total ash (TA) content and dry matter yield percentage amongst treatment combinations. The ranges of these values were 9.8 to 13.9% and 88.1 to 94.37%, respectively. The total ash content found in this study was consistent with the findings of Diriba and Vaars (2000), who found that natural dilution and translocation of nutrients from the vegetative section to the root system caused a drop in the mineral contents of forage plants during the maturation phase. According to McDonald et al. (2002), seasonal factors, soil nutrient levels, and type all affect the fall in mineral concentration as a person ages. The research of Genet et al. (2017) provided support for the present conclusion. Nevertheless, the current study's outcome was disagreed with Yehalem's (2004) and Mihret et al. (2018) findings, which showed that increasing plant maturity was associated with higher total ash concentrations. According to Jukenvicius and Sabiene (2007) and Gezahegn et al. (2016), the variance may be caused by the concentration of minerals in forages, which can be driven by factors such as plant developmental stage, morphological fractions, meteorological conditions, and soil properties.

Table 1. Effect of Plant Spacing and Harvesting Stage on the Chemical Composition (%) of Desho Grass

Spacing and Harvesting age	Chemical composition (%)								
	DM%	CP%	Ash%	OM %	NDF%	ADF%	AD%L	HC %	CL%
10*75	91.60[a]	9.30[cbd]	9.80[c]	81.80[a]	60.03[d]	37.70[b]	4.20[c]	22.30	32.80[bc]
10*105	89.20[bc]	8.96[ced]	12.00[ab]	77.26[bc]	64.90[bcd]	41.16[ab]	6.50[ab]	23.70	34.60[abc]
10*135	94.37[a]	7.80[ef]	12.60[ab]	81.70[a]	69.57[ab]	41.20[ab]	6.80[a]	24.30	38.30[ab]
30*75	90.10[bc]	10.30[b]	12.10[ab]	78.03[bc]	61.5[cd]	35.96[b]	4.46[c]	25.50	31.50[c]
30*105	89.27[bc]	12.37[a]	13.00[ab]	75.30[c]	66.26[abc]	37.90[ab]	4.47[c]	28.40	33.40[abc]
30*135	91.00[bc]	8.94[def]	13.10[ab]	77.90[bc]	71.37[a]	40.80[ab]	5.40[cb]	30.50	35.40[abc]
50*75	89.30[bc]	10.20[bc]	11.20[bc]	78.16[b]	66.70[abc]	38.40[ab]	4.70[c]	28.30	33.70[abc]
50*105	88.10[c]	9.20[cbd]	12.20[ab]	75.80[bc]	69.87[ab]	35.50[b]	5.40[cb]	36.57	30.10[c]
50*135	91.37[a]	7.20[f]	13.90[a]	78.40[b]	72.07[a]	46.90[a]	6.90[a]	22.9	40.10[a]
Mean	90.49	9.30	12.20	78.20	66.90	39.96	5.52	26.90	34.40
CV (%)	1.88	7.30	8.79	2.02	4.78	8.35	11.87	21.85	10.04
LSD	2.95	1.18	1.85	2.74	5.54	5.78	1.13	10.2	5.99
SL	*	**	*	**	**	**	*	NS	*

Within a category, means in a column with distinct superscripts differ ($p<0.05$); NS stands for non-significant, * for significant, and ** for very significant. Dry matter (DM), crude protein (CP), organic matter (OM), acid detergent lignin (ADL), total ash (ADL), hemicellulose (HC), cellulose (CL), coefficient of variation (CV), least significant difference (LSD), and significance level (SL) are the terms used in this study.

There was a significant ($p<0.05$) variation in the dry matter yield of Desho grass, ranging from 88.1 to 94.37% (Table 1). This outcome is consistent with research conducted on several pasture grasses by Alemu et al. (2007) and Berihun (2005). The current dry matter (DM) yield analysis is comparable to that of Tilahun et al. (2017), who found that the same Desho showed substantial differences in plant spacing and harvesting age. types of grass. This result is comparable to other reports (Melakie, 2005; Tilahun et al., 2017). The highest DM yield at the narrow spacing could be attributed to more number of plants per unit area where the closer the distance or the higher the plant population, the greater the amount of total DMY compared to wider spacing. While Mihret et al. (2018) demonstrated that the use of chemical fertilizer improved the dry matter yield (DMY) of forage grass, the DM yield for Desho grass in the current study was comparable to previous findings of Nemera et al. (2016). Delays in harvesting led to an increase in dry matter content, as proposed by Terefe (2017). This phenomenon may be explained by the aging of plants and their reduced leaf moisture content. This discrepancy could result from due to the increased vegetative growth and development, which increased resource competition in the environment of limited plant spacing.

As plant spacing increased and harvesting age was postponed, there was a substantial ($p<0.01$) impact on both acid detergent fiber (ADF) and neutral detergent fiber (NDF) (Table 1). The present investigation bears similarities to the study conducted by Teshale et al. (2021), wherein notable differences were noted. The study by Awoke et al. (2020), which found that the content of neutral detergent fiber (NDF) increased with a delay in harvesting age, also supports the current conclusion. Increases in stem percentage and mature lignin would account for the age effects, but wider plant spacing may have contributed to larger tiller development in the wider-spaced plants. Moreover, later harvesting ages and wider plant spacing were associated with higher contents of acid detergent lignin (ADL) and neutral detergent fiber (NDF). As stated by The main characteristics of growing forage plant density or tight spacing, as reported by Zewdu et al. (2002) and Bayble et al. (2007), were a significant decrease in the leaf-stem ratio, which led to an increase in the concentrations of lignin and cell walls in forage grass.

The study by Asmare (2016) for the same Desho grass varieties, which found that the concentration of neutral detergent fiber (NDF) rose from early harvesting age to late harvesting age, is consistent with the increasing tendency of NDF concentration with harvesting age. Singh and Oosting (1992) identified neutral detergent fiber (NDF) and acid detergent fiber (ADF) as predictors of forage quality; however, the quality of all Desho grass treatments in the current study was higher than the suggested medium and higher quality roughage feeds of 45-65 and below 45%, respectively. In the context of temperate forages, the amount of neutral detergent fiber (NDF) is connected with intake, and the amount of acid detergent fiber (ADF) with the forage's digestibility (Muir). in 2007). Age differences and varietal variances in the soil could be the cause of the discrepancy.

The range of acid detergent fiber (ADF) levels found in this study was between 40 percent, which is regarded as medium quality roughages, and the favorable range. This finding is consistent with research by Melakie (2005) and Tilahun et al. (2017), who found that increased plant densities of Desho grass and Bana grass, respectively, led to an increase in the concentration of acid detergent fiber (ADF). This increase in acid detergent fiber (ADF) content may have resulted from competition for resources under narrow plant spacing, which accelerated grass maturity. It has been reported that narrow plant spacing and wider plant spacing cause a higher proportion of immature tillers to be present, which accelerates grass maturity and leads to the accumulation of higher fiber content with high lignin in the plant tissue. helps explain why there is less fiber in the stem portion (Magani and Okwori, 2010).

When harvesting at a later age and with broader spacing than when harvesting at an earlier age and with narrower spacing, the highest mean percentage of acid detergent lignin (ADL) was observed (Table 1). The results of (Bimrew et al., 2017) are consistent with the current investigation of the acid detergent lignin (ADL) concentration of Desho grass. Genet et al. (2017) found that the acid detergent lignin (ADL) concentration of the same Desho grass varieties was significantly influenced by both plant spacing and harvesting age. This was much more than what the current study found. The planting system, harvesting age, altitude, soil type, and soil fertility of the experiment's location could all have an impact on the variations. In the current study, the impact of plant spacing on the amount of acid detergent lignin (ADL) is comparable to Melkie's (2005) research, which found that as plant spacing and harvesting age grew, so did the amount of acid detergent lignin (ADL) in Bana grass. This showed that the early maturity of plants under the narrow spacing led to a decreased concentration of soluble carbohydrates being replaced by the insoluble cell wall portion, which in turn raised the grass's lignin content. Overall, the current data demonstrated that as forage plants matured, the amount of acid detergent lignin (ADL) increased. This can be the outcome of fast lignification brought on by the accumulation of structural carbohydrates at a later stage of plant development. The current result was consistent with prior research that found fodder grass with longer growth ages had greater lignin concentrations (McDonald et al., 2002; 2010; Genet et al., 2017; Ansah et al.

Although the content varied depending on the combination of plant spacing and harvesting age, the cellulose content of Desho grass showed a significant ($p<0.05$) difference (Table 1). Morphological fractions have an impact on cellulose content (Fekede, 2004). Cardinal et al. (2003) found that the digestion of intact cell walls is restricted by the presence of cellulose.

The combination of plant spacing and harvesting age did not significantly ($p>0.05$) affect the hemicellulose content of Desho grass (Table 1). The overall mean of the hemi-cellulose concentration was 26.9%, with a range of 22.3% to 36.57%. The primary determinants of herbage digestibility are the make-up and concentration of the cell walls. The main components of cell walls are cellulose, hemicellulose, and lignin. Generally speaking, the variation may be due to the varying nutrient makeup of fodder crops. based on a variety of variables, including the plants' harvesting age and genotypic traits (Gezahagn et al., 2017).

- ***In-vitro* dry matter digestibility**

Desho grass Table 2 shows that the treatment combinations examined in this investigation had a significant ($p<0.01$) influence on the in vitro dry matter digestibility (IVDMD) and no significant ($p>0.05$) difference in the in vitro organic matter digestibility (IVOMD) in terms of metabolizable energy (ME). The current finding conflicts with a study by Tamirat et al. (2021) and Usman and Getachew (2014), which found no significant difference between in-vitro organic matter digestibility and in-vitro dry matter digestibility (IVDMD). In a similar vein, it concurred with the Tiruset al. (2019) study, which documented the substantial differences for matter of the several kinds of Desho grass. According to McDowell (2003), an in-vitro dry matter digestibility (IVDMD) value of more than 55% suggests a satisfactory feeding value, while values below this cutoff point lead to decreased intake because of impaired digestibility. The in vitro Getnet and Ledin (2001) for various forages grasses support the idea that higher voluntary intake and digestibility may arise from dry matter digestibility (IVDMD) values found in this study being over this threshold level. The current study's In-vitro Dry Matter Digestibility (IVDMD) value for Desho grass was comparable to the 50–60% digestibility range for tropical grasses (Own and Jaysuria, 1989). The usage of various animal species and grass types may be the likely cause of the variations.

The In-vitro Organic Matter Digestibility (IVOMD) of the Desho grass treatments varies significantly ($p<0.01$) (Table 2). The chemical composition and digestibility of pasture grasses are known to be significantly influenced by a number of factors, including climate, soil fertility, harvesting age and spacing, and other management practices (Bemire et al., 2017; Gezahagn et al., 2017; Tiruset et al., 2019). Crude protein, structural carbohydrates, and voluntary consumption are the primary factors that define the nutritional value of forages. Crude protein concentration (CP), amount of breakdown, and digestible dry matter (DM) all affect forage consumption (Minson, 1990). Table 5 shows a significant ($p<0.01$) difference in organic matter. According to Smith (1993), the organic matter digestibility organic matter content (OMD) of roughly 550 g/kg DM is necessary for keeping ruminants in good health. Dairy cows must have an OMD of 600–700 g/kg DM (ARC, 1984) in order to produce moderate amounts of milk (10–15 kg per cow per day). High milk production (>15 kg/cow/day) requires an OMD greater than 700 g/kg DM (ARC, 1984). Every treatment employed in this study produced results more than 75.3%, which allowed for the conclusion that the organic matter content (OMD) was higher.

Table 2 shows that there is a significant ($p<0.01$) difference in Desho grass's crude protein yield (CPY) depending on the harvesting age and plant spacing. Despite this, as harvesting was postponed, the crude protein (CP) percentage with time (CPY) grew dramatically. Melkie and Asmare (2016) have both observed similar findings for the Desho grass species. (2005), who documented the crude protein yield (CPY) of Bana grass at various ages.

Table 2. In-Vitro Digestibility, ME Content and CPY of Desho Grass Affected by Plant Spacing and Harvesting Stage

Plant spacing and Harvesting age	*In-vitro* Digestibility			
	CPY (t/ha^{-1})	IVDMD (%)	IVOMD (%)	ME (MJ kg)
10*75	9.16^{b}	57.00^{c}	48.10^{e}	9.40^{a}
10*105	6.40^{d}	66.30^{a}	58.60^{b}	9.07^{ab}
10*135	7.36^{cd}	58.80^{bc}	52.80^{cd}	8.5^{abc}
30*75	8.10^{c}	69.70^{a}	61.60^{a}	9.43^{a}
30*105	9.20^{b}	62.20^{b}	53.70^{c}	8.5^{abc}
30*135	11.20^{a}	58.80^{bc}	50.00^{de}	7.7^{bcd}
50*75	8.30^{bc}	61.80^{b}	52.60^{cd}	8.27^{abc}
50*105	8.10^{c}	59.67^{bc}	$50.10d^{e}$	7.40^{d}
50*135	7.60^{c}	61.00^{b}	53.00^{cd}	6.60^{cd}
Mean	6.69	61.70	53.40	8.30
CV (%)	4.78	3.34	3.17	9.40
LSD	1.02	3.56	2.94	1.35
SL	**	**	**	**

Means in a column within the same category having different superscripts significantly differ ($p<0.01$); IVDMD = *In vitro* Dry Matter Digestibility; IVOMD = *In vitro* Organic Matter Digestibility; OM = Organic Matter; ME = Metabolizable Energy; MJ = Mega Joule; CV=Coefficient of variation; LSD=Least Significance difference; SL= Significance level.

The difference in metabolizable energy (ME) content is statistically significant ($p<0.01$) (Table 2). The present study's results were consistent with those of McDonald et al. (2010), who found that a higher accumulation of cell wall components in plant tissue led to a decrease in the plant's digestibility, resulting in a fall in energy content and digestibility at later harvest ages. Desho grass has a mean metabolic energy (ME) content of 8.3 MJ/kg, which is higher than other species' results (Heuze and Hassoun, 2015). Desho grass's ME content, which may be related to species and environmental variables, was less than Napier grass's (9 MJ/kg) reported by Tessema and Alemayehu (2010) and nearly equal to Bana grass's (9.83MJ/kg) reported by Berihun (2005).

***In-Sacco* Rumen Dry Matter, Crude Protein Degradability and Its Characteristics**

Table 3 illustrates how the dry matter (DM) degradability properties of Desho grass varied considerably ($p<0.05$) during the course of the various incubation durations. With the exception of six hours of incubation, there were very substantial differences between the treatments in terms of In-sacco dry matter degradability. For 72 and 96 hours, treatment 30*105 demonstrated greater In-sacco DM degradability. Additionally, after a 12-hour incubation period, this treatment exhibited increased dry matter degradability, only surpassed by the 10*135 treatment. For a 12-hour incubation time, treatment 10*135 had the most In-sacco dry matter (DM) degradability, while treatment 10*105 had the lowest. For a 24-hour incubation period, treatment 50*75 had the

highest DM degradability, while treatment 10*105 had the lowest. When it comes to 72 In
addition, after a 96-hour incubation period, the highest In-sacco dry matter (DM) degradability was measured from treatment 30*105, while the lowest In-sacco DM degradability was measured from treatment 50*135; both results were obtained after a 30-hour incubation period. Treatments 10*75 and 50*135 had the highest and lowest In-sacco DM degradability throughout the 48-hour incubation period, respectively.

Table 3. *In-Sacco* Dry Matter Degradability and Rumen Degradability Characteristics of *Desho* Grass

Plant spacing andHarvesting age	*In-sacco* DMD and rumen degradability characteristics										
	6hr	12hr	24hr	48hr	72hr	96hr	A	B	PD	C	ED
10*75	16.60	19.97^{c}	31.05^{cd}	47.99^{a}	51.37^{ab}	57.47^{ab}	9.33^{abc}	55.12^{b}	64.4^{b}	0.02^{cde}	32.50^{bcd}
10*105	13.84	17.33^{c}	27.66^{d}	41.00^{cd}	51.29^{ab}	57.60^{ab}	8.64^{abc}	76.40^{a}	85.04^{a}	0.03^{b}	32.66^{bc}
10*135	15.99	29.83^{a}	33.39^{bc}	40.59^{cd}	47.53^{bc}	54.09^{bcd}	10.61^{ab}	42.54^{b}	53.15^{b}	0.02^{de}	30.52^{de}
30*75	11.64	20.75^{c}	29.42^{cd}	44.06^{abc}	50.62^{ab}	56.12^{bc}	7.23^{c}	59.03^{b}	66.26^{b}	0.03^{bcd}	35.86^{a}
30*105	19.01	28.40^{a}	36.13^{ab}	47.43^{ab}	54.12^{a}	60.44^{a}	11.34^{a}	51.18^{b}	62.52^{b}	0.03^{bc}	34.11^{ab}
30*135	17.28	21.61^{bc}	38.61^{a}	44.93^{abc}	54.10^{a}	57.76^{ab}	7.77^{bc}	52.00^{b}	59.77^{b}	0.05^{a}	34.24^{ab}
50*75	13.72	28.07^{a}	40.03^{a}	44.10^{abc}	49.08^{bc}	53.37^{cd}	6.69^{c}	45.19^{b}	51.88^{b}	0.051^{a}	33.91^{ab}
50*105	15.05	28.39^{a}	39.02^{a}	42.91^{bc}	47.37^{bc}	53.03^{cd}	7.94^{bc}	42.84^{b}	50.77^{b}	0.04^{b}	30.66^{cde}
50*135	13.66	26.49^{ab}	33.39^{bc}	37.94^{d}	45.59^{c}	50.05^{d}	8.62^{abc}	40.67^{b}	49.29^{b}	0.02^{cde}	32.50^{bcd}
LSD	5.36	5.46	4.75	4.94	4.07	4.05	2.94	23.41	0.01	24.31	2.14
CV	20.36	12.86	8.00	6.57	4.69	4.22	15.59	2.56	9.3	2.29	3.78
SL	NS	**	**	**	**	**	*	*	*	*	*

Means in a column within the same category having different superscripts differ ($p<0.05$); A= washing loss (rapidly soluble fraction); B = slowly degradable fraction; C = the rate of degradation; ED = Effective Degradability; DMD = Dry Matter Degradability; hr = hour; PD = Potential Degradability; LSD = Least significance difference; **= Highly Significant;*= Significant; NS= Non significant; SL= Significance level; CV= Coefficient of variation

Since most feeds remain in the animal digestive system for an hour, 48 hours of incubation time is generally regarded as the ideal measurement of In-sacco dry matter degradability (Ehargava and Ørskov, 1987) and the mean retention time of fibrous feeds in ruminants (Kimambo and Muya, 1991). After 48 hours of incubation, treatment 10*75 in this instance had a greater In-sacco dry matter degradability. As predicted, as the incubation time grew, so did the dry matter's degradability. According to Usman and Getachew (2014), treatments 10*75 and 30*105 had intermediate crude protein contents, and dry matter degradability was correlated with crude protein (CP) content; Tamirat et al. (2021) found that different forage grass cultivars had higher crude protein contents, which contributed to higher dry matter degradability. Conversely, However, treatment 50*135 has the lowest crude protein concentration and low dry matter degradability for the majority of the incubation period. The leaf-stem ratio was increased in treatment 50*135 while the crude protein and dry matter degradability were lower. According to Rambau et al. (2016) and Tamirat et al. (2021), dry matter degradability decreased with advanced grass forage maturity. This may be the result of Desho grass's reduced dry matter degradability and its degradability characteristics at increased spacing and age advancement. It also decreases crude protein.

The rumen degradability exhibited substantial ($p<0.01$) outflow rates for the effective degradability (ED) of DM, computed at ($K = 0.03$). The 30*75 and 30*135 treatments yielded the highest results, whereas the 50*105 and 10*135 treatments yielded the lowest values. The Desho grass treatments employed showed a reduced slowly degradable proportion (B) and potential degradability (PD), although the effective degradability value was higher than that observed by the findings of (Usman and Getachew, 2014; Usman et al., 2016; Tamirat et al., 2021). The species of forage grass utilized, the kind of animal used for incubation, the diet given to the fistulated animals, and the variations in environmental conditions during the growth of Desho grass could all be contributing reasons to the difference. A noteworthy ($p<0.05$) variation was also noted in the rate effective degradability (ED) and degree of degradation (C). Table 3 shows that the treatments with the highest degradation rate—30*135—had the lowest rate, whereas the treatments with the highest effective degradability—10*135—had the highest.

In-Sacco Rumen Crude Protein Degradability and Its Characteristics

Throughout the entire incubation period, there were notable ($p<0.01$) differences in the treatment combinations for the In-sacco crude protein degradability of Desho grass (Table 4). At 48 and 72 hours, the treatment combination 30*105 had a greater In-sacco crude protein degradability., and 96 hour incubation. This treatment also show higher crude protein degradability for 12 hour of incubation that only exceeded by 10*135 treatment. In 12 hour incubation period treatment 10*135 had higher *In-sacco* crude protein degradability and the lowest is obtained from treatment 10*75 and for 24 hour incubation period, the highest *In-sacco* crude protein (CP) degradability was obtained from 50*75 treatment and the lowest was recorded from 10*105 treatment. In case of 72 hour incubation period the highest *In-sacco* crude protein degradability was obtained from treatment 30*105 and the lowest was measured from 50*135 treatments. In addition to that 96 hour incubation period had highest *In-sacco* crude protein (CP) degradability was obtained from treatment 30*105 and the lowest was obtained from 50*135 treatments. The highest and the lowest *In-sacco* crude protein (CP) degradability for 48 hour incubation period was recorded from treatment 10*75 and 50*135 respectively. The current The outcome is consistent with research by Belachew et al. (2013) and Ribeiro et al. (2014), which revealed a decrease in elephant grass's crude protein (CP) rumen degradability as the plant matured. These findings have been extensively publicized. The decrease in protein content and increase in ADL content of mature grass may account for this decrease in disappearance. Regarding the crude protein degradability (CPD) of Desho grass, not much is known.

Table 4. In-Sacco Crude Protein Degradability Characteristics of Desho Grass

Plant spacing andHarvesting age	*In-sacco* CPD characteristics										
	6hr	12hr	24hr	48hr	72hr	96hr	A	B	PD	C	ED
10*75	17.09^{c}	21.75^{c}	31.70^{cde}	50.59^{a}	53.97^{ab}	60.07^{ab}	9.42^{abcd}	57.96^{bc}	67.39^{bc}	0.02^{de}	34.00^{bc}
10*105	13.97^{ef}	18.02^{c}	30.34^{de}	43.19^{bc}	53.48^{abc}	59.79^{abc}	8.53^{cde}	76.52^{a}	85.06^{a}	0.01^{e}	31.13^{e}
10*135	16.68^{cd}	31.84^{a}	34.68^{bcd}	42.94^{bc}	49.88^{bcd}	56.44^{bcd}	10.82^{abc}	44.50^{cd}	55.32^{cd}	0.03^{bc}	34.29^{bc}
30*75	12.53^{f}	21.93^{c}	29.43^{e}	47.14^{ab}	53.70^{ab}	59.20^{bc}	7.45^{de}	62.69^{ab}	70.14^{ab}	0.02^{de}	32.02^{de}
30*105	19.73^{b}	30.18^{ab}	35.53^{bc}	50.35^{a}	57.04^{a}	63.36^{a}	11.66^{a}	54.91^{bcd}	66.57^{bc}	0.03^{cd}	37.24^{a}
30*135	25.57^{a}	26.82^{b}	39.15^{ab}	47.53^{ab}	56.70^{ab}	60.36^{ab}	11.11^{ab}	50.01^{bcd}	61.12^{cd}	0.03^{bc}	37.41^{a}
50*75	14.12^{e}	28.77^{ab}	40.34^{a}	46.70^{ab}	51.68^{ab}	55.97^{cde}	6.84^{e}	48.16^{bcd}	55^{bcd}	0.04^{a}	35.42^{b}
50*105	15.49^{de}	29.80^{ab}	38.65^{ab}	44.89^{bc}	49.35^{bc}	55.01^{de}	8.29^{de}	44.88^{cd}	53.16^{cd}	0.04^{a}	34.86^{bc}
50*135	15.66^{cd}	28.36^{ab}	37.38^{ab}	39.92^{c}	47.57^{c}	52.03^{e}	8.83^{bcde}	41.09^{d}	49.91^{d}	0.04^{ab}	33.06^{cd}
LSD	1.54	4.41	4.61	5.10	4.21	4.10	2.29	14.83	16.12	0.01	1.81
CV (%)	5.31	9.66	7.56	6.42	4.63	4.08	14.33	16.05	14.87	18.36	3.78
SL	**	**	**	**	**	**	**	**	**	**	**

Means in a column within the same category having different superscripts differ ($p<0.01$); A= washing loss (rapidly soluble fraction); B = slowly degradable fraction; C = the rate of degradation; ED = Effective Degradability; CP = Crude Protein Degradability; hr = hour; PD = Potential Degradability; **= Highly Significant; SL= Significance level; LSD= Least Significance Difference; CV= Coefficient of variation.

CONCLUSIONS AND RECOMMENDATIONS

The current study was conducted with objectives to evaluate the appropriate combination of harvesting age and plant spacing on chemical compositions, Desho grass's potential for rumen degradability, dry matter and crude protein digestibility in vitro. The experiment was carried out at the Adola sub-site of the Bore Agricultural Research Center (BoARC), in the middle of the Guji zone. Using SAS, 2002 version 9.0's general linear model technique, the data was analyzed using ANOVA. The only non-significant ($p>0.05$) difference found throughout the studied treatments of Desho grass concerned hemicelluloses (HC). The parameters that differ significantly ($p<0.05$) among them include dry matter, total ash (TA), cellulose (CL), and acid detergent lignin (ADL). Among the Desho grass treatments examined, the chemical composition that demonstrated a significant ($p<0.01$) change was the acid detergent fiber (ADF), crude protein (CP), and neutral detergent fiber (NDF). It is suggested by this study that, this investigation was carried out in a single place during a single season. In light of this outcome, it is advised that,

- To evaluate and increase the yield and nutritive value of *Desho* grass more precisely, the study need to be repeated in successive years, in different harvesting ages, plant spacing on several location.

FURTHER STUDY

Further study on re-growth yield of Desho grass is useful to determine long-term productivity of herbage in terms of both yield and nutritive value.

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