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Effect of Plant Spacing and Harvesting Stage on Morphological Characteristics and Yield of Desho Grass (*Pennisetum Glaucifolium L*) at Adola sub-site of Bore Agricultural Research Center, Oromia Region, Ethiopia

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A B S T R A C T

In order to evaluate the effects of a combination of harvesting stage and plant spacing on the morphological features and yield of Desho grass, a study was carried out in the midland of the Guji zone. Three replications of a randomized full block design with 3*3 factorial arrangements were employed. Three plant spacings (10, 30, and 50 cm) and three harvesting stages (75, 105, and 135 days) are used in this experiment. All plots received an application of nitrogen, phosphate, and sulfur (NPS) fertilizer at a rate of 100 kg/ha-1 before to planting. Plot cover (PC), vigorousity, dry matter yield (DMY), plant height (PH), leaf length per plant (LLPP), number of leaves per plant (NLPP), number of tillers per plant (NTPP), leaf to steam ratio (LSR), and survival rate (SR) are among the statistics gathered. Every piece of data were exposed to SAS, 2002, version 9.0, GLM ANOVA methods. The findings showed that, with the exception of leaf to steam ratio and plot cover, all morphological features were significantly ($p<0.01$) impacted by the treatments. Ten*75 treatments yielded the lowest mean number of tillers per plant (NTPP) of 21.53, while fifty*135 treatments produced the highest number of tillers per plant (NTPP) of 59.3. 30*105 treatments produced the highest plant height (100.43 cm), while 30*75 treatments produced the lowest plant height

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INTRODUCTION

Ethiopia has the largest livestock population in Africa, with around 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 (CSA, 2021). Livestock is an indispensable component of subsistence crop-livestock systems, providing rural people with draft power, cash income, assets, and nutrition (Sere et al., 2008). The amount of feed and its quality are the key determinant of the livestock sector in Ethiopia ACDI (2017), as it affects animal production and productivity (Malede, 2013). In Ethiopia, natural pasture accounts for 54.54% of livestock feed, with crop residue coming in second at 31.13%. Only 0.57% of animal feed comes from improved forage (CSA, 2021). The availability of feed from natural pasture varies according to the seasonal patterns of rainfall (Solomon et al., 2008). Livestock still mainly eats crop residues and aftermath, but their nutritional limitations prevent them from supporting animal productivity (Tewodros and Meseret, 2013).

Land degradation, scarcity, and low soil fertility are the main causes of livestock feed constraints (Tewodros *et al.,* 2007). Grazing areas are also getting smaller as a result of the pressure of a rapidly growing human population. Therefore, increasing cattle productivity and production can be achieved by introducing high yielding, drought- and disease-tolerant, and widely-adapted agro-ecology fodder (Shapiro et al., 2015). Using native, farmed multipurpose forages as animal feed is one way to lessen the current nutritional restrictions on cattle (Abebe et al., 2008; Anele et al., 2009).

LITERATURE REVIEW

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 The low yields in terms of quantity and quality are found in natural pasture and all crop wastes (Tessema et al., 2002; Tessema and Baars, 2004). Thus, feeding animals properly continues to be a significant concern for the country's livestock producers, especially in the dry season when pasture and cereal crop residues limit quantity as well as quality (Muhammad, 2016). Minimal voluntary intake from low-quality feed resources results in a deficiency of nutrients and reduced productivity (Benin et al., 2003). Thus, it is important to consider methods for increasing pasture yield and nutritional value in order to raise cattle productivity (Ashagre, 2008).

Moreover, the biomass production and nutritional value of Desho grass are primarily determined by the following characteristics: soil fertility, altitude, morphological components, maturation stage, environmental factors, 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 essential to assess the grass's morphological characteristics, chemical makeup, production status, agronomic methods, and application in a range of agro-ecological conditions (Bimrew et al., 2016; Genet et al., 2017). However, there is insufficient data on the effects of proper plant spacing and harvesting stage on Desho grass yield. In order to ascertain the optimal plant spacing and harvesting stage for the morphological traits and biomass output of Desho grass in the Adola sub-site of the Bore Agricultural Research Center, the current study was carried out.

METHODOLOGY

Description of Study Area

The study was conducted in the Adola sub-site of the Bore Agricultural Research Centre (BoARC) Guji zone, southern Oromia, which is located in Adola town (Darartu's "Kebele") on the west side of the main road that leads to Negele town. The area lies between latitude 55°36'31"N and longitude 38°58'91"E, 1721 meters above sea level. In the region, April to August is the first and most important rainy season, and September to November is the second wet season. The rainfall in the area is bimodal. The district is split into three agro ecologies: lowland (60%), midland (29%), and highland (11%), and receives 1084 mm of rainfall yearly. The average annual highest temperature at the research site is 9.89 °C, while the average annual lowest temperature is 15.93 °C.

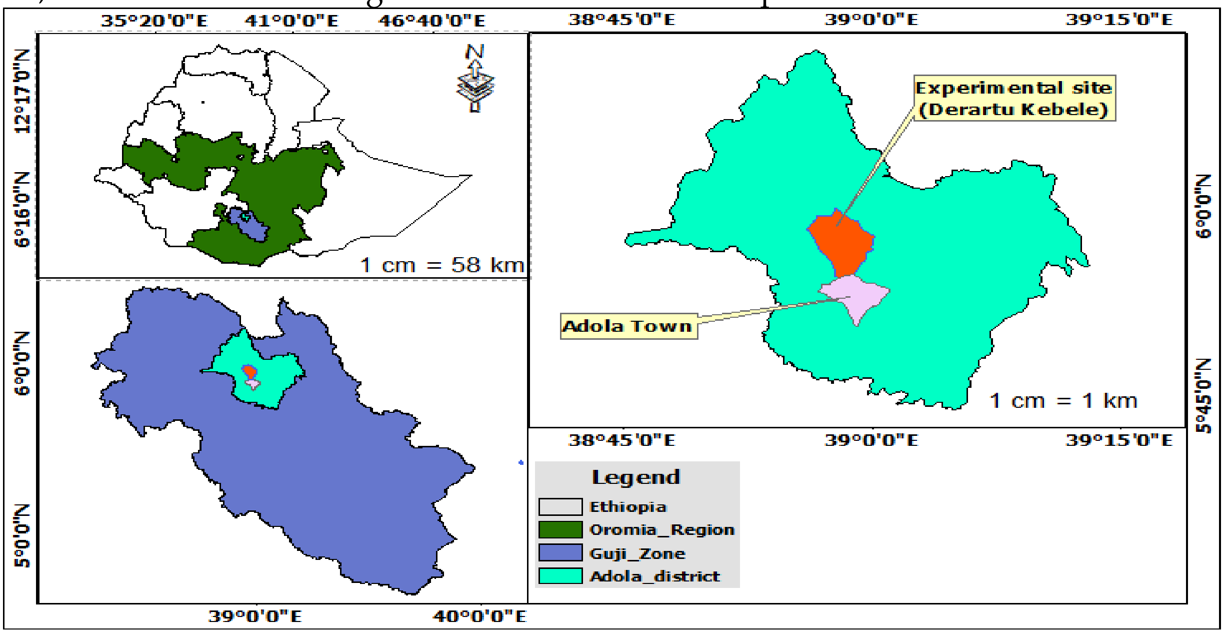

Figure 1. Map of the study site

Experimental Design and Treatments

Seedlings and planting material of Desho grass (Acc. Areka# 590) were gathered from the nursery at the Bore Agricultural Research Center's Adola sub-site. A 3*3 factorial treatment arrangement and a randomized complete block design (RCBD) with three replications were used in the study's design. Each block, which measured 11 m in width by 40 m in length, contained nine treatment combinations. The treatments comprised three plant spacings within rows (10, 30, and 50 cm) and three harvesting phases (75, 105, and 135 days) after planting.

There were a total of 27 plots, with dimensions of 3 by 4 meters (12 by m2). Blocks and plots were spaced 0.5 and 1 meters apart, respectively., and all plots had a row spacing of 50 cm (Genet et al., 2017). After smoothing the ground with a tractor, the site was ploughed twice with oxen, and then the experimental plots were set up. At the time of field preparation, the entire experimental plots were kept free of weeds by manual hoeing, and before planting, a combination of nitrogen, phosphorus, and sulphur (NPS) fertilizers was administered at a rate of 100 kg/ha for all treatments (Leta et al., 2013).

Methods of Data Collections

Morphological Data

To reduce the impact of boundary rows, all samples were taken from the 3 m*3 m (9 m2) one day prior to the second harvest. With the exception a sample of four stems or tillers of plants was randomly selected from the net plot area of each plot and utilized for the evaluation of all growth parameters. The measurements of tillers per plant, plant basal circumference, and tiller weight were obtained from additional four representative plant samples. Plant heights were measured using a steel tape, measuring each plant from the base to the longest leaf. By counting the plants that were randomly chosen from the plot, four tillers were identified. The number of plants that emerged divided by the total number of plants seeded multiplied by 100 was used to calculate the survival rate. By measuring the leaves of four randomly chosen plants from each plot that was recorded during the harvesting stage, the leaf length per plant was calculated. , and their mean was expressed as a number of leaves per plant (Khan *et al*., 2014; Gebremedhn *et al*., 2015).

Herbage Yield Determination

Herbage was harvested 10 cm above the ground and weighed with a field balance in the field. To determine the dry matter content, fresh sub-samples were taken individually from each plot, weighed, and chopped into pieces ranging from 2 to 5 cm. To determine the dry matter yield, the weighed fresh subsamples (FWss) were oven dried at 60°C for 72 hours and then reweighed (DWss).

The dry matter yield (t/ha) = (10 x TotFW x (DWss / HA x FWss)) (Tarawali *et al*., 1995).

Where: TFW = total fresh weight from plot in kg

DWss = dry weight of the sample in grams

FWss = fresh weight of the sample in grams.

HA = Harvest area in meter square and

= 10 is a constant for conversion of yields in kg m^2 to t/ha^{-1}

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 (morphological data and biomass yield)

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.

RESULT AND DISCUSSION

Morphological Characteristics of Harvesting Age and Plant Spacing of *Desho* Grass

Number of Tiller Per Plant

Among treatment combinations, there was a significant (p<0.01) difference in the number of tillers per plant (NTPP) (Table 1). This conclusion was consistent with the findings of Genet et al. (2017), who reported that northwest Ethiopia was the location of the largest and smallest number of tillers per plant (NTPP) of Desho grass. Awoke et al. (2020) found that the number of tillers per plant of Desho grass was significantly influenced by the harvesting stage and plant spacing. According to the results of (Bimrew et al., 2017), the number of tillers per plant increased in the current study along with the harvesting age and plant spacing. Wider spacing allows light to reach the base of the plant more easily, which may have encouraged the formation of tillers. Additionally, underGreater spacing reduces nutrient competition, and a single plant can maintain more tillers, according to similar results. that increased as age of maturity proceed increment in photosynthetic rate of the grass (Mehiret, 2008). This difference might be due to varietal and soil nutrient availability.

Plant Height at Harvesting

Combinations of plant spacing and harvesting age Plant height was significantly (p<0.01) impacted (Table 2). Numerous academics' studies on different kinds of Desho grasses corroborate this conclusion. As opposed to findings by Birmaduma et al. (2019) and Tekalegn et al. (2017), Teshale et al. (2021) found that for a number of Desho grass varieties, 91.2–102.6 m. The current results surpassed those of Bimrew et al. (2017b), who found that the mean height of Desho grass plants (39.4 cm) in northern Ethiopia under irrigation was higher than expected. This discrepancy could be caused by variations in soil type, harvesting age, cropping season, and variety.

Leaf Length Per Plant

When harvesting age and plant spacing were combined, the mean length of leaves per plant varied considerably (p<0.01) (Table 1). The current study's average leaf length (40.9 cm) across all treatment groups was longer than what previous studies had found (Genet et al., 2017; Bimrew et al., 2017). This discrepancy could be caused by differences in planting techniques, elevations, and seasons.

Table 1. Leaf length Per Plant, Plant Spacing and Harvesting Stage in Desho Grass Determine the Number of Leaves Per Plant, Plant Height (Cm), and Number of Tillers Per Plant.

Plant spacing and Harvesting age	PH(cm)	NTPP (count)	NLPP (count)	LLPP (cm)
10*75	69.43^{ab}	21.53^{d}	12.13^{c}	37.43^{bc}
10*105	96.27^{ab}	28.53^{d}	34.43^{abc}	41.77^{abc}
10*135	95.87^{ab}	50.83^{ab}	16.77^{bc}	46.73^{ab}
30*75	63.53^{b}	26.60^{d}	14.87^{bc}	31.37^{c}
30*105	100.43^{a}	42.93^{bc}	38.17^{ab}	49.70^{ab}
30*135	90.70^{ab}	45.70^{abc}	20.93^{bc}	46.03^{ab}
50*75	67.53^{ab}	32.80^{cd}	11.37^{c}	31.60^{c}
50*105	83.97^{ab}	44.43^{bc}	50.43^{a}	32.03^{c}
50*135	98.37^{ab}	59.30^{a}	21.43^{bc}	51.13^{a}
Mean	85.10	39.20	24.50	40.90
LSD	19.84	13.10	22.74	11.92
CV (%)	13.50	19.30	28.20	16.90
SL	**	**	*	**

Means with different superscripts in a column are significantly different from each other (p<0.05 and P<0.01); NTPP = Number of tiller per plant; NLPP = Number of leaf per plant; LLPP = Leaf Length Per plant; PH (cm) = Plant Height; * = significant; ** =highly significant; CV=Coefficient of variation; LSD=Least Significance difference; Significance level.

Number of Leave Per Plant

The number of leaves per plants (NLPP) was significantly (p<0.05) different among combination of plant spacing and harvesting age (Table 2). The results of Bimrew et al. (2017) and Minchl et al. (2019), which showed a significant impact of number of leaves per plant (NLPP) on the same kinds of Desho grass, are corroborated by the current experiment. The results of Genet et al. (2017), who demonstrated that the combination of plant spacing and harvesting age did not significantly influence the length of leaves per plant, are in conflict with the conclusions of this study. Variations in the tillers' performance between treatment combinations may be the cause of this disparity.

Leaf to Stem Ratio and Plot Cover

Table 3 demonstrates that for the leaf to stem ratio and plot cover percentage, there were no significant variations (p>0.05) amongst the different combinations of plant spacing and harvesting stage. Aweke et al., 2020; Birmaduma et al., 2019; Dembela et al., 2020) reported that the current leaf to steam ratio results for the Desho grass treatment combinations were as follows. Because leaves typically have higher nutritional values than other plant materials, the leaf portion of the feed is linked to higher nutritive values. According to Denbela et al. (2015), an animal's performance and the amount of leaf in their diet are closely correlated. One criterion used to assess the quality of various types of grass is the leaf to stem ratio (LSR), as a higher percentage of leaves relative to stems suggests.

Dry Matter Yield

Table 3 displays a significant ($p<0.01$) variation in dry matter yield (DMY) t/ha-1 between combinations of plant spacing and harvesting age. This study confirms the results of Genet et al. (2017), who discovered that the dry matter yield (tone per hectare) (DMY) of Desho grass was significantly ($p<0.01$) impacted by plant spacing and harvesting age. Worku et al. (2017) and Mimili (2018), two more authors, reported similar results, indicating that harvesting age and spacing significantly affected the dry matter yield tone per hectare (DMY) of Desho grass.

The results of Dembela et al. (2020); The current findings were in line with the hypothesis put forth by Tekalegn et al. (2017) that Desho grass had a lower dry matter yield than the findings reported here. Researchers Awoke et al. (2020) and Bimrew et al. (2017) found that there were substantial differences in their findings regarding dry matter yield (DMY) between the age at which Desho grass is harvested and plant spacing. In a similar vein, Ansah et al. (2010) demonstrated that the dry matter yield in Napier grass rose with harvesting age. The current results showed that the maximum dry matter yield (DMY) was produced by optimal plant spacing and late harvesting age. In a similar vein, research by Genet et al. (2017) and Tiruset et al. (2019) demonstrated that Desho grass lines the outcome. The most plausible reason one explanation for this could be that plants develop new tillers, leaves form, extend stems, and undergo vegetative growth, all of which cause a spike in delayed dry matter yield (DMY).

Table 2. Shows How Plant Spacing and Harvesting Stage Affect the Leaf to Steam Ratio, Plot Cover, Dry Matter Production, Plant Vigor, and Survival Rate of Desho Grass

Plant spacing and Harvesting age	DMY(t/ha^{-1})	LSR	PC (%)	SR (%)	Vigor (%)
10*75	5.04^{d}	0.58	62.97	56.93^{c}	63.00^{ab}
10*105	14.40^{bcd}	0.23	85.20	67.23^{bc}	77.80^{ab}
10*135	24.93^{ab}	0.76	62.97	66.97^{bc}	77.80^{ab}
30*75	8.72^{cd}	0.61	70.40	93.33^{a}	63.00^{ab}
30*105	31.87^{a}	0.33	62.97	93.37^{a}	74.07^{ab}
30*135	18.53^{bc}	0.75	77.77	89.17^{a}	85.200^{a}
50*75	4.400^{d}	0.83	48.13	85.70^{ab}	55.60^{b}
50*105	12.77^{bcd}	0.39	55.57	85.70^{ab}	55.60^{b}
50*135	18.67^{bc}	0.72	70.40	92.83^{a}	85.20^{a}
Mean	15.50	0.58	66.24	81.20	70.80
LSD	11.39	0.49	31.96	19.53	21.91
CV (%)	22.00	48.7	27.9	13.90	17.90
SL	**	NS	NS	**	*

Means with different superscripts in a columns are significantly different from each other ($p<0.01$) and ($p<0.05$) SR% = Survival rate; DMY t/ha^{-1} = Dry matter yield tone per hectare; PC% = Plot cover; NS = Not significant, ** =highly significant; CV=Coefficient of variation; LSD=Least Significance Difference; SL= Significance level.

Establishment Performance (Survival Rate)

There are statistically significant ($p<0.01$) variations in the survival rate (or establishment performance) between the Desho grass treatments. The current result differs from Teshale et al. (2021) who found no significant difference in the number of establishment performance (surviving) individuals. However, Tamirat et al. (2021) found significant variances in the number of elephant grass kinds. In comparison to Tamirat et al. (2021), the total mean value was greater. Variations in species and spacing could be the cause of the variation.

Vigour

The mean value of plant vigor was impacted by treatment combinations in a significant ($p<0.05$) way (Table 3). The current findings conflicted with research conducted by other researchers, like Teshale et al. (2021), Birmaduma et al. (2019), and Tekalegn et al. (2017). This could be because plants with more distance between them could get more light., nutrients and other resources than the plant of close spacing

CONCLUSIONS AND RECOMMENDATIONS

This study suggests that it was carried out in a single setting throughout a single season. In light of this outcome, it is advised that,

- Further study need to be made over seasons and more locations, and also using different harvesting stages and plant spacing to arrive at a dependable conclusion
- 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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