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Adaptability and productivity evaluation of Desho grass (*Pennisetum pedicellatum*) varieties under Bako condition, Western Oromia, Ethiopia

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Abstract

Adaptability evaluation is a primary step in introducing new varieties (either forage or food crops) from their place of release to another new environment for further studies. This study was conducted in 2022 and 2023 to identify the best adaptable and highest herbage-yielding Desho grass variety/s. The treatment consists of four Desho grass varieties (Kindu Kosha-DZF-591, Kulumsa-DZF-592, Kindu Kosha-DZF-589, and Areka-DZF-590) arranged in a randomized complete block design with three replications. This study showed that Desho grass varieties varied significantly in most of the measured parameters across all sites. The highest plant height (74.00 cm) for Areka-DZF-590 at Bako was recorded; statistically similar higher tillers per plant (TPP) were recorded for Kulumsa-DZF-592 (34.80), Kindu kosha-DZF-589 (38.60), and Areka-DZF-590 (39.9). The highest dry matter yield (DMY) was obtained from Areka-DZF-590 (27.25 t ha^{-1}), followed by Kindu kosha-DZF-589 (21.97 t ha^{-1}), Kulumsa-DZF-592 (21.49 t ha^{-1}), and Kindu kosha-DZF-591 (19.46 t ha^{-1}). Tillering ability and forage DMY were among the traits of greater interest in this study. Even though there were some differences in some of the measured parameters, all the varieties produced a similar large number of TPP and DMY in all the sites. Generally, among the varieties of Desho grass tested in this study, Areka DZF # 590 was superior in producing the highest DMY and TPP during the experimental years. Thus, it is recommended that this variety be demonstrated and familiarized to the farming community to lessen the existing feed shortage in the study area.

Plain Language Summary

Feed shortages during the dry season are a major challenge in Bako, Ethiopia's sub-humid mid-altitudes. Soil erosion also harms crop and grazing lands. Desho grass,

Abbreviations: ANOVA, analysis of variance; BARC, Bako Agricultural Research Center; DMY, dry matter yield; LPP, leaves per plant; TPP, tillers per plant.

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which can be harvested multiple times in one season, is a vital feed source during these dry months when feed is scarce in tropical regions. Among the four Desho grass varieties studied, Areka DZF #590 has shown the best adaptability and the highest forage dry matter yield.

1 | INTRODUCTION

Livestock constitutes a crucial pillar of the Ethiopian economy, with crop-livestock integrated farming systems (Asresie et al., 2015) serving as the mainstay for the majority of small-scale agricultural communities. Despite its significance, the sector's productivity remains suboptimal due to several challenges, including inadequate management practices, insufficient healthcare, limited genetic potential for desirable traits in animals, and issues related to the availability and quality of feed (Mengistu, 2006). The most significant constraint among these is the insufficiency and poor quality of feed resources (Shapiro et al., 2015). The feed shortage is further exacerbated by rising human and livestock populations and the conversion of pasturelands into croplands. To address this deficit, there is an increasing need for high-quality and high-yield forage driven by growing interest in livestock sector development and a rising demand for animal products. One viable solution to tackle Ethiopia's livestock feed shortage is the utilization of native, resilient, and multipurpose forage species, such as Desho grass (*Pennisetum pedicellatum*). This perennial grass, indigenous to tropical Africa, is prevalent across East and West Africa, including Ethiopia (Asmare et al., 2016; Leta et al., 2013).

Desho grass, a native species of Ethiopia belonging to the Poaceae family, shares morphological similarities with the genus Brachiaria. It thrives in the acidic, wetter regions of southern Ethiopia and demonstrates remarkable resilience in mitigating water loss, rapidly recovering even under severe drought conditions (Keba, 2023). This perennial forage, well-known throughout Ethiopia, was first identified in 1991 in the Southern Nations, Nationalities, and Peoples' Regional State near Chencha (Ecocrop, 2010; Jabessa et al., 2014) and is highly palatable to both sheep and cattle; Desho grass is extensively utilized for animal feed and soil conservation (Debelo, 2020; Jabessa et al., 2014). Its drought resistance addresses critical feed shortages during dry spells, yielding more forage per unit area due to its multi-cut capability, ensuring a steady supply (Tolera, 2007). Desho grass flourishes at elevations ranging from 1500 to 2800 m above sea level, making it ideal for intensive management (Leta et al., 2013). Its ability to support multiple harvests in a single season positions it as a vital feed source during the dry months, crucial when feed availability in tropical regions is scarce (Serekebrhan et al., 2018).

The Debre Zeit Agricultural Research Center has released several Desho grass varieties noted for their high dry matter yield (DMY) and adaptability to various regions in Ethiopia. Notable varieties include Kindu Kosha DZF # 591, Kindu Kosha DZF # 589, Kulumsa DZF # 592, and Areka DZF # 590 (Mereba, 2023). These varieties are particularly recommended for the highland and midland regions of Ethiopia, where they can serve as a protein supplement for livestock and contribute to soil conservation. These released varieties, even though they are excellent and widely used as livestock feed in some midland and highland areas of Ethiopia, have not been introduced to Bako, western Oromia, Ethiopia. To familiarize and utilize the potential of these varieties, it is ideal to evaluate their adaptability and yield potential at the Bako Agricultural Research Center (BARC) and its sub-sites first. Therefore, this study was aimed at identifying the best adaptable and higher herbage-yielding Desho grass variety/s for the midland of Bako and similar agro-climatic zones of western Oromia.

2 | MATERIALS AND METHODS

2.1 | Description of the study area

The study was undertaken at three locations (BARC, Bonaya Boshe, and Gute sub-sites) of the Oromia regional state, western Ethiopia, in the 2022 and 2023 cropping seasons. A map and rainfall of the study region for each location are reported in earlier research work of Tulu et al. (2023), shown in Figure 1 below. Specific locations were Bako (9˚06′ N, 37˚09′ E; 1650 masl; 2285 mm mean annual rainfall), Bonaya Boshe (9˚54′ N, 37˚00′ E; 1645 masl; 1295 mm), and Gute (9˚01′ N, 36˚40′ E; 1880 masl; 1586 mm). The soil type at Bako location is classified as a Nitosol with 2.5% organic carbon, 10 ppm available P, 0.22% total N, and pH (H_2O) 5.18, while that at Bonaya Boshe is a clay loam with 1.86% organic carbon, 12 ppm available P, 0.16% total N, and pH (H_2O) 4.6; soil at Gute has 60% silt, 35% sand, and 5% clay with 1.98% organic carbon, 6.2 ppm available P, 0.17% total N, and pH (H_2O) 4.43. Farming systems in the study area are mixed crop-livestock systems, in which production of maize (*Zea mays*), teff (*Eragrostis tef*), noug (*Guizotia abyssinica*), sorghum (Sorghum spp.), hot pepper (*Capsicum annuum*), and sugar cane (*Saccharum officinarum*) are the

major crops, and cattle, small ruminants, and poultry are the most important livestock species.

2.2 | Experimental materials

For this experiment, four Desho grass varieties were brought from the Wondo Genet Agricultural Research Center. These include Kindu Kosha DZF # 591, Kulumsa DZF # 592, Kindu Kosha DZF # 589, and Areka DZF # 590. The treatments were arranged using a three-replication randomized complete block design, and the grass was planted using vegetative root splits in rows. Plot size was 2 m × 2 m = 4 m^2. Plants and rows were spaced 50 and 25 cm apart, respectively. Land preparation, planting, weeding, and harvesting were carried out by Leta et al. (2013). Note that 100 kg/ha nitrogen peroxide and 50 kg/ha urea were applied at planting and after establishment, respectively.

2.3 | Data analysis

To determine whether there were any differences among the treatments, the data collected were subjected to analysis of variance (ANOVA) using the general linear model procedures of SAS (2002) version 9.3. The least significant difference test at a 5% probability level was used to compare significant treatment means. The data were analyzed using the following model:

$$Y_{ij} = \mu + T_i + B_j + e_{ij},$$

where Y_{ij} is the measured response of treatment i in block j, μ is the grand mean of the experiment, T_i is the effect of treatment i, B_j is the effect of block j ($j = 3; 1, 2, 3$), and e_{ij} is the random error effect of treatment i in block j.

Core Ideas

- Different Desho grass varieties have been adapted and shown substantial yield performance in the sub-humid mid-altitudes.
- The leaf-to-stem ratio of the Areka DZF # 590 variety was highest in years 1 and 2.
- As the age of Desho grass increases, its productivity also increases.

2.4 | Data collection

The performance of Desho grass varieties was evaluated regarding plant height (cm), number of tillers per plant, number of leaves per plant (LPP), and leaf-to-stem ratio at harvest from five randomly selected plants of two inner rows of each plot. The measurement of plant height for Desho grass varieties was carried out by selecting five representative plants from the inner rows of each plot. Each plant was individually measured using a measuring tape, and the average height was calculated to determine the plant height.

Harvesting of forage biomass was performed to determine forage DMY. The herbage biomass yield was taken by harvesting the middle two rows at 10 cm above the ground level and weighing using a field balance. The harvested herbage mass was manually chopped up into shorter lengths using a sickle, and the subsample weighing 200 g was dried in an oven at 65°C for 72 h to determine herbage dry matter production.

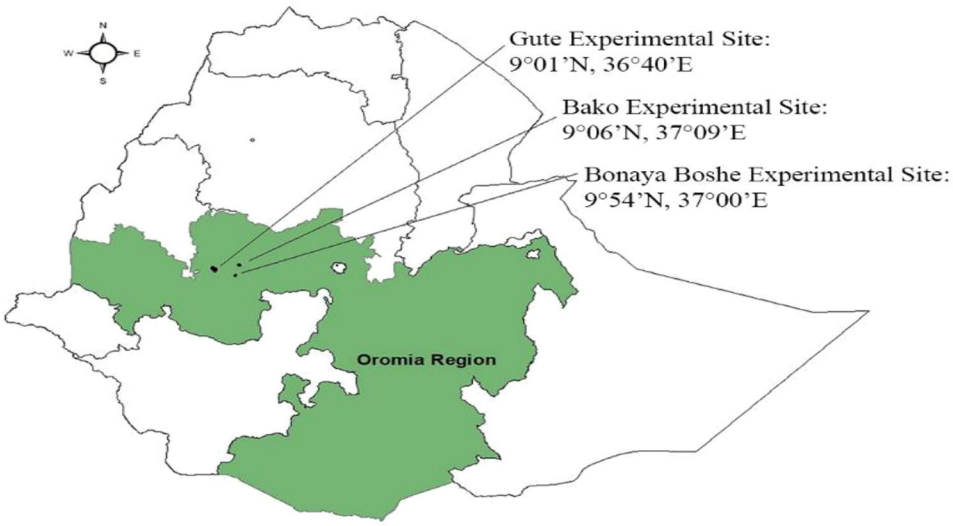

FIGURE 1 Map of the study area (Tulu et al., 2023).

TABLE 1 The analysis of variance (ANOVA) result of four Desho grass varieties at Bako in 2022 and 2023.

Source of variation	*df*	Mean squares	*F* probability
Variety (Var)	3	50.127	0.0001
Location (Loc)	2	18.643	0.0011
Year (Yr)	1	4280.900	0.0001
Var × Loc	6	2.369	0.4442
Loc × Yr	2	6.074	0.0886
Var × Loc × Yr	14	7.567	0.118

Abbreviation: *df*, degree of freedom.

DMY was calculated using the following equation (Tarawali, 1995):

$$\text{DMY (t/ha)} = 10 \times \text{TFW} \times \left(\frac{\text{DWSs}}{\text{HA} \times \text{FWSs}}\right)$$

where 10 is the constant for conversion of yields in kg/m^2 to ton/ ha, TFW is the total fresh weight from harvesting area (kg), DWSs is the sub-sample dry weight (g), HA is the harvested area (m^2), and FWSs is the sub-sample fresh weight (g).

3 | RESULTS AND DISCUSSION

3.1 | ANOVA

The three-way interactions of the ANOVA results of different desho varieties tested in the current study are presented in Table 1. Accordingly, no significant variations were observed regarding the interactions of variety (Var) × location (Loc), location × year (yr), and Var × Loc × Yr. Thus, the analysis results of the main effect were presented and discussed in the following sections.

3.2 | Dry matter yield and yield-related performance of four Desho grass varieties

3.2.1 | Plant height

Plant height at harvest, number of tillers per plant, number of LPP, leaf-to-stem ratio, and forage DMY of different Desho grass varieties are presented in Table 2. Accordingly, all the measured parameters were significantly varied ($p < 0.05$) among the varieties. The highest plant height was recorded from Areka DZF # 590, followed by Kindu Kosha DZF #589, Kulumsa DZF # 592, and Kindu Kosha DZF # 591 in descending order. The plant height of Desho grass obtained in the current study is higher than the value documented by Bantihun et al. (2022) in Mecha District, Amhara region, Northwestern Ethiopia, but lower than the findings of Hidosa et al. (2020) in Jinka Agricultural Research Center and Husein and Wana (2022) in Adami Tulu Agricultural Research Center. This could be attributed to the difference in agroecology, soil type, rainfall, and other environmental conditions.

3.2.2 | Number of tillers per plant

The number of tillers per plant immensely contributes to the DMY of forage crops, as it is part of the above-ground biomass production. The highest number of tillers counted was for Areka DZF # 590 (38.94), followed by Kindu Kosha DZF # 589 (37.77), Kulumsa DZF # 592 (31.09), and Kindu Kosha DZF # 591 (27.67). The current result is lower than the finding of Hidosa et al. (2020) in the South Omo Zone, Southwestern Ethiopia. The variation could be soil type, rainfall, and other growth factors.

3.2.3 | Number of LPP

The number of LPP is another desirable morphological trait of forage crops. Leaves are generally more edible fractions of forage biomass. The highest number of LPP (10.60) was recorded from Areka DZF # 590, followed by Kindu Kosha DZF # 589 (10.23), Kulumsa DZF # 592 (10.05), and Kindu Kosha DZF # 591 (9.72). In this study, all varieties other than Kindu Kosha DZF # 591 produced statistically similar LPP. The number of LPP obtained in this study is higher than the value obtained from the Fitche Agricultural Research Center by Mereba (2023) and the Bore Agricultural Research Center by Jabessa et al. (2021), but lower than the findings of Asmare (2016). This could be attributed to the difference in agroecology, rainfall, soil type, and other management practices.

3.2.4 | Leaf-to-stem ratio

The leaf-to-stem ratio of forage crops should be considered when selecting and evaluating the feeding suitability of the feed to livestock. Consequently, the leaf-to-stem ratio of desho varieties evaluated in this study ranged from 2.45 to 1.35. The highest (2.45) and the lowest (1.35) are for Areka DZF # 590 and Kindu Kosha DZF # 591, respectively. This result is in agreement with the finding of Yerosan et al. (2020) at Hawagalan, Kellem Wellega Zone of Oromia, in which the same Var gave the highest leaf-to-stem ratio among the tested varieties. However, the leaf-to-stem ratio value recorded in the current study is higher than the values stated in the findings of Jabessa

TABLE 2 Forage dry matter yield and yield components of different Desho grass varieties in 2022 and 2023.

Variety	PH (cm)	TPP	LPP	LSR	DMY(t ha^{-1})
KKDZF # 591	71.58^{c}	27.67^{d}	9.72^{b}	1.35^{d}	16.98^{d}
KLDZF # 592	76.12^{bc}	31.09^{c}	10.05^{ab}	1.75^{c}	19.14^{c}
KKDZF # 589	79.01^{ab}	34.77^{b}	10.23^{ab}	2.00^{b}	21.42^{b}
Ar DZF # 590	83.17^{a}	38.94^{a}	10.60^{a}	2.45^{a}	24.93^{a}
Mean	77.47	33.12	10.40	1.89	20.62
p value	0.0003	<0.0001	0.0709	<0.0001	<0.0001
LSD 0.05	4.989	2.288	1.011	0.17	1.46
CV (%)	9.6	10.3	14.6	13.4	10.6

Note: Means with different superscripts within the column are significantly different. KKDZF # 591 = Kindu Kosha DZF # 591, KL DZF # 592 = Kulumsa DZF # 592, KK DZF # 589 = Kindu Kosha DZF # 589, Ar DZF # 590 = Areka DZF # 590.
Abbreviations: CV, coefficient of variance; DMY, dry matter yield; LPP, leaves per plant; LSR, leaf-to-stem ratio; no, number; PH, plant height; TPP, tillers per plant.

et al. (2021), in which the leaf-to-stem ratio of all the varieties of Desho grass was <1. The difference could be attributed to the soil type, rainfall, temperature, humidity, management practices, and other growth resources.

3.2.5 | Forage DMY

DMY is the most important entity of forage crops. The highest DMY (24.93 t ha^{-1}) was recorded from the Areka DZF # 590 Var, followed by Kindu Kosha DZF # 589 (21.42 t ha^{-1}), Kulumsa DZF # 592 (19.14 t ha^{-1}) and Kindu Kosha DZF # 591 (16.98 t ha^{-1}). This result is similar to the finding of Jabessa et al. (2021), in which the same Var produced the highest DMY. The DMY obtained in the present study is greater than the yield recorded in the Adami Tulu Research Center by Husein and Wana (2022) but lower than the finding obtained from the Jinka Agricultural Research Center (Hidosa et al., 2020). The higher DMY of desho varieties in Jinka may be because southern Ethiopia is the origin of the grass. This is confirmed by the report of Abera et al. (2021), which discloses that Desho grass is indigenous to Ethiopia and widely cultivated in southern Ethiopia as the source of livestock feed.

3.3 | Effect of year on the productivity of Desho grass varieties

The impact of the year on the performance of different Desho grass varieties was analyzed and presented in Table 3. Accordingly, plant height, leaf-to-stem ratio, and LPP did not significantly vary over the years. However, DMY and number of tillers per plant showed significant variation in the years elapsed since the study. Higher DMY (22.79 t ha^{-1}) and number of tillers per plant (35.18) were recorded in the second year than in the first. This indicates that as the age of Desho grass advances, its productivity increases.

TABLE 3 Effect of year on dry matter yield and yield components of different Desho grass varieties.

Year	PH (cm)	TPP (no)	LPP (no)	LSR	DMY (t ha^{-1})
2022	76.19	31.06^{b}	10.71	1.93	18.44^{b}
2023	78.72	35.18^{a}	10.09	1.84	22.79^{a}
Mean	77.46	33.12	10.40	1.89	20.62
p value	0.1237	0.0014	0.101	0.1489	0.0001
$LSD_{0.05}$	3.239	2.456	0.740	0.117	1.129

Note: Means with different superscripts in the same column are significantly different.
Abbreviations: DMY, dry matter yield; LPP, leaves per plant, leaf-to-stem ratio; LSD, least significant difference; no, number; PH, plant height; TPP, tillers per plant.

The increase in productivity of Desho grass varieties over the years could be because perennial grasses establish themselves well and produce more tillers and biomass in consecutive years than in the first year of establishment. This result is consistent with Faji et al. (2022) and Hidosa et al. (2020).

3.4 | Correlation analysis of DMY and morphological characteristics of Desho grass varieties

The average simple correlation coefficients for all treatments are presented in Table 4. Statistically significant positive correlations were identified between forage DMY and all yield components of Desho grass varieties. Specifically, forage dry yield exhibited positive and significant correlations with plant height ($r = 0.49$), tillers per plant ($r = 0.57$), number of leaves per plant ($r = 0.17$), and leaf-to-stem ratio ($r = 0.36$**).

Consistent with these findings, Carpici and Celik (2010) reported that plant height at forage harvest is positively associated with forage DMY in forage maize (*Zea mays* L.). Furthermore, plant height exhibits a significant positive

TABLE 4 Correlation coefficients among yield and yield-related components of desho varieties (averages of overall data).

	DMY	Pltht	TPP	LPP	LSR
DMY	1	0.49**	0.57**	0.17	0.36**
Pltht		1	0.39**	−0.23	0.28*
TPP			1	0.11	0.54
LPP				1	−0.07
LSR					1

Note: Level of significance: $*p < 0.05$; $**p < 0.1$.
Abbreviations: DMY, dry matter yield; LPP, leaves per plant; LSR, leaf to stem ratio; Plht, plant height; TPP, tillers per plant.

correlation with the number of tillers per plant ($r = 0.39**$) and the leaf-to-stem ratio ($r = 0.28$), while showing a negative correlation with the number of LPP ($r = -0.23$). These results align with the findings of Gulnaz et al. (2011), yet contrast with those observed in rice by Yang et al. (2006). The inconsistencies may be ascribed to variations in varieties, climatic conditions, soil types, humidity, and other growth-related resources.

4 | CONCLUSION

In Ethiopia, a country with the highest livestock population, the use of multipurpose forage crops, known for their superior dry matter production and soil conservation advantages, is of utmost significance. Desho grass, in Ethiopia, is widely employed for animal fodder and soil conservation. Its resilience to drought effectively mitigates critical feed deficits during dry periods, producing a greater quantity of forage per unit area owing to its multi-cut capability. The results of this study indicated that among the tested varieties, the Areka DZF # 590 Var was superior in all the measured forage DMY and yield components. Therefore, Areka DZF # 590 is recommended to be demonstrated on farmers' fields as an alternative feed source to lessen the problem of feed scarcity in Bako and similar agro-climatic zones. Furthermore, additional research on animal feeding trials using this Variety is needed to fully document the impact of the Variety on animal performance.

AUTHOR CONTRIBUTIONS

Wakgari Keba: Conceptualization; data curation; formal analysis; investigation; methodology; software; supervision; visualization; writing—original draft; writing—review and editing. **Mekonen Diribsa**: Investigation; methodology; resources; supervision; writing—review and editing. **Abuye Tulu**: Investigation; methodology; software; supervision; writing—review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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