**Performance Evaluation of Phalaris Grass Accessions in Northwestern Highlands of Sekela District, Amhara Region, Ethiopia**

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**ABSTRACT**

A field experiment was conducted to assess the adaptability, morphological characteristics, dry matter yield, and chemical composition of four Phalaris grass accessions in Sekela district, located in the northwestern Amhara Region of Ethiopia. The treatments included the common Phalaris aquatica grass from the area as a control, along with three accessions (ILRI 6853, ILRI 10552, and ILRI 14353) sourced from Debre Berhan Research Center via root splits for experimentation. The study was carried out using a randomized complete block design (RCBD) with five replications over two consecutive years. Data were collected at 10% heading of the Phalaris grass during each harvest in the two main rainy seasons. Measurements for plant height (PH) and leaf length (LL) were taken from ten plants in the middle rows, excluding the border rows. The collected data were analyzed using analysis of variance (ANOVA) with SAS software. Results from both experimental years showed that Phalaris accessions ILRI 6853 and ILRI 14353 had significantly higher (P<0.05) plant height (PH), number of tillers per plant (NTPP), and dry matter yield (DMY) compared to the control. Additionally, accession ILRI 6853 exhibited significantly lower neutral detergent fiber (NDF) and acid detergent fiber (ADF) content than the other tested accessions. Based on overall performance, accessions ILRI 6853 and ILRI 14353 were selected for their superior production performance and lower fiber content, making them well-suited to address the critical feed shortages for improved livestock production in the study area. Therefore, Phalaris grass accessions ILRI 6853 and ILRI 14353 are recommended for further demonstration and adoption in the study area and similar agro-ecologies within the region.

**Keywords**: Dry matter yield, Feed, Growth characteristics, , Phalaris grass, Sekela district

1. **INTRODUCTION**

The Ethiopian highlands, situated above 1500 meters above sea level, receive more than 700 mm of annual rainfall and maintain a mean daily temperature of less than 20°C (Zinash et al., 2000). Ethiopia is home to a vast livestock population, comprising 70.3 million cattle, 42.9 million sheep, 52.5 million goats, 2.15 million horses, 10.8 million donkeys, 0.38 million mules, 8.1 million camels, and 57.0 million poultry (CSA, 2021). The highlands of Ethiopia are characterized by crop-livestock mixed farming systems, where livestock plays an integral role in most agricultural activities across the country.

Livestock contributes significantly to Ethiopia’s economy, accounting for 15–17% of the national gross domestic product (GDP), 35–47.7% of agricultural GDP, and 37–87% of household incomes (IGAD 2011; G/Mariam et al., 2013). It also contributes 15% of export earnings and supports 30% of agricultural employment (Behnke, 2010). In addition to its economic contributions, livestock production improves the nutritional status and income of the population by providing meat, milk, eggs, cheese, butter, as well as by-products such as hides, skins, and live animals for both home consumption and export. Livestock also helps mitigate risks in times of crop failure (CSA, 2021). Despite its importance, the livestock sector struggles to meet the growing demand for animal products due to low productivity per animal (IGAD, 2011). One of the major factors contributing to this low productivity is the persistent feed shortage, both in quality and quantity, which adversely impacts livestock production (Alemayehu et al., 2017).

Improving livestock feeding through the adoption of sown forages can significantly enhance productivity. Among the many perennial forage grasses, Phalaris grass stands out as one of the most promising options for the Ethiopian highlands. Phalaris is well-suited to highland areas (Kediret et al., 2007), known for its high yield and ease of propagation and management (ILRI, 2010). Phalaris aquatica, for example, has an average dry matter yield of about 4.75 t/ha (Venkataramanan et al., 2014), and its seed yield ranges from 300-400 kg/ha under optimal conditions (Alemayehu et al., 2017). The grass is typically propagated either vegetatively using root splits or by seed, with the propagation method varying across agro-ecologies (Getnet and Gezahagn, 2012).

Phalaris is a key grass species for both forage development and soil conservation in Ethiopia. It boasts excellent forage quality and is best used in combination with other forages to optimize its value as livestock feed. Phalaris thrives at altitudes between 1800 and 3000 meters, is frost and drought tolerant, and can grow effectively with more than 400 mm of annual rainfall. While it requires fertile soils for strong growth, it can still survive on poorer soils, although its soil conservation value is diminished due to weaker growth. Phalaris is particularly suitable for use in contour forage strips for soil conservation and can also be integrated into backyard forage systems and mixed pastures (Alemayehu et al., 2017). It offers a continuous supply of green forage throughout the year, making it ideal for intensive small-scale farming systems (Alemayehu et al., 2017).

However, yield performance of Phalaris grass varies across different environments, and there is limited information on the performance of various accessions. Therefore, the objective of this study was to evaluate selected Phalaris grass accessions for their yield, chemical composition, and desirable agronomic characteristics.

1. **MATERIALS AND METHODS**

**2.1. Description of Study area**

The study was conducted in the Sekela district, located in the West Gojjam Zone of the Amhara region, Ethiopia. Sekela is one of the fifteen woredas (districts) in the West Gojjam Zone, situated 459 km northwest of Addis Ababa. It is also 160 km southeast of Bahir Dar, the capital of the Amhara region, and 74 km northeast of Finote Selam. The district is bordered to the southwest by the Bure district, to the west by the Awi Zone, to the north by the Mecha district, to the east by the Quarit district, and to the southeast by the Jabi Tehnan district. The administrative center of Sekela is Gish Abay town. The district comprises a total of 27 kebeles, with 26 rural kebeles and 1 urban kebele (SWAO, 2017).

**2.2. Land preparation and planting**

The study was conducted on a farmer's field under a contractual agreement, with a plot size of 30m x 20m rented from the farmer. After selecting the land, it was ploughed using oxen, and the seedbed was prepared prior to planting. The root splits were planted in June 2021 on the well-prepared experimental plot. The study spanned two main rainy seasons in 2021 and 2022. Weeding, hoeing, and urea application were carried out at each growth stage, as needed, to support the growth of the grasses.

**2.3. Experimental design and treatments**

The treatments in this study consisted of four Phalaris grass accessions: control, ILRI 6853, ILRI 10552, and ILRI 14353. Root splits of each accession were planted on well-prepared land at the start of the 2021/2022 main rainy season. The treatments were randomly assigned to plots within a block. For fertilization, NPS fertilizer was applied at a rate of 100 kg ha⁻¹ at planting, followed by urea application at 50 kg ha⁻¹ after establishment and at each cutting interval. The experiment was conducted using a randomized complete block design (RCBD) with five replications. Plot size was 3m x 4m (12m²), with a row spacing of 50 cm, a plant spacing of 30 cm, and a 1m gap between plots and blocks.

**2.4. Data collection**

Data were collected at 10% heading of Phalaris grasses during each harvest of the two main rainy seasons. Morphological parameters, including plant height (PH) and leaf length (LL), were measured from ten plants in the middle rows, excluding the border rows. Additionally, the number of tillers per plant (NTPP) was counted from ten plants in the middle rows, excluding the border rows. The leaf-to-stem ratio (LSR) was determined by separating the leaves and stems, drying, and weighing each component, with the ratio calculated by dividing the dry weight of the leaves by the dry weight of the stems. Dry matter yield (DMY) was calculated by multiplying the fresh biomass collected from the sampling area by the dry matter percentage (DM%) for each accession.

**2.5. Chemical composition analysis**

Chemical analyses of forage samples were conducted using representative samples from the harvests of each respective year. The feed samples were dried in a forced air-draft oven at 60°C for 72 hours to determine dry matter (DM) percentage. After drying, the samples were milled using a laboratory mill and passed through a 1 mm sieve. The analyses for dry matter (DM) content, ash, neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were performed at the Andassa Livestock Research Center's nutrition laboratory. The procedures for analyzing NDF, ADF, and ADL followed the methods outlined by Van Soest et al (1991).

**2.6. Data analysis**

The data collected on morphological characteristics, dry matter yield, and chemical composition were analyzed using analysis of variance (ANOVA) with SAS software (SAS 2002). Significant differences between treatment means were determined using the least significant difference (LSD) test at p < 0.05.The statistical model for the analysis of data was:

Yijk = μ + vi + + Eijk

Where: Yijk= all dependent variables,

μ = Overall mean, vi = effect of accessions (four accessions),

 Eijk = residual error

1. **RESULT AND DISCUSSIONS**

**3.1. Growth characteristics of various Phalaris grass accessions**

Phalaris accessions exhibited significant variation in growth characteristics. Accession ILRI 14353 had the highest plant height, while ILRI 6853 showed the best leaf length and number of tillers per plant. ILRI 6853 also had the highest dry matter yield (DMY) in both years, supporting its potential for high biomass production. In general, accessions ILRI 6853 and ILRI 14353 outperformed the control in growth and yield. Plant height is a key factor influencing biomass yield in forage crops and serves as a critical indicator of growth achieved during the growing season (Tessema et al., 2002). The growth traits, including plant height (PH), leaf length (LL), number of tillers per plant (NTPP), and dry matter yield (DMY), exhibited consistent patterns (P>0.05) across two production years. This consistency offers an opportunity to select accessions with similar growth habits and yields for further evaluation. Among the Phalaris accessions, ILRI 14353 demonstrated significantly greater plant height (P<0.05) compared to accession ILRI 6853 and the control, although no significant difference was observed when compared to accession ILRI 10552.

**Table 1** Growth and dry matter yield parameters of Phalaris grass

|  |  |  |
| --- | --- | --- |
| Treatments | Year 1 (2021) | Year 2 (2022) |
| PH(Cm) | LL(Cm) | NTPP(Count) | LSR | DMY (tha-1) | PH(Cm) | LL(Cm) | NTPP(Count) | LSR | DMY (tha-1) |
| Control | 75.94b | 30.74c | 52.71b | 1.26d | 4.39b | 78.36b | 33.45c | 56.08b | 1.33d | 5.48b |
| 6853 | 72.25b | 46.75a | 63.51a | 1.45a | 5.18a | 76.22b | 48.95a | 68.35a | 1.78a | 6.67a |
| 10552 | 77.22ab | 39.52b | 56.58ab | 1.39b | 4.59b | 80.16ab | 42.56b | 59.76b | 1.59b | 5.79b |
| 14353 | 82.94a | 36.23b | 62.70a | 1.32c | 5.06a | 84.45a | 39.3b | 68.74a | 1.45c | 6.71a |
| Mean | 77.10 | 38.31 | 58.88 | 1.35 | 4.80 | 79.80 | 41.07 | 63.23 | 1.54 | 6.16 |
| SEM | 2.459 | 1.563 | 2.474 | 0.007 | 0.251 | 2.561 | 1.63 | 2.65 | 0.009 | 0.267 |
| P -Value | 0.0204 | 0.0475 | 0.0426 | <.0001 | 0.0309 | 0.0031 | 0.0451 | 0.002 | <.0001 | 0.034 |

*PH= plant height, LL= leaf length, NTPP= number of tillers per plant, LSR= leaf to steam ratio, DMY/t/ha= Dry matter yield ton per hectare*

In contrast to plant height, Phalaris accession ILRI 6853 exhibited significantly (P<0.05) higher leaf length (LL) compared to the other accessions in both production years. The number of tillers per plant (NTPP) is a key agronomic trait as it directly influences the biomass yield of forage grasses. Among the tested Phalaris accessions, the control accession had significantly (P<0.05) fewer tillers per plant than the other three accessions in both years. This may be attributed to genetic deterioration of the control accession and the prolonged effects of its introduction into the environment.

The dry matter yield (DMY) over two harvest years ranged from 4.39 to 5.19 t/ha in the first year and 5.48 to 6.71 t/ha in the second year (Table 1). In our study, two Phalaris grass accessions (14353 and 6853) exhibited similar patterns in terms of their number of tillers per plant (NTPP) and DMY, with accessions that had higher NTPP producing better dry matter yields. This aligns with findings by Bimrew et al. (2017) and Misganaw et al. (2022), who also reported higher dry matter yields associated with greater NTPP in desho grass under similar agro-ecological conditions. Additionally, Laidlaw (2005) highlighted the importance of tiller mass in grasses, noting that it enhances survival chances and increases the available forage, a finding consistent with our results.

However, the relationship between plant height (PH) and dry matter yield was not consistent in our study. While accession 14353 showed better DMY at a higher PH, accession 6853 achieved higher DMY despite having a relatively shorter plant height. This contrasts with other grass species, such as desho grass, where higher PH typically correlates with increased DMY (Bimrew et al., 2017; Misganaw et al., 2022).

Furthermore, Phalaris grass accession 6853 exhibited a higher leaf-to-stem ratio (LSR) than the other tested accessions, which is a critical factor affecting digestibility (Yasin et al., 2003) and the overall nutritive value of the grass, as leaves contain more nutrients and less fiber than stems (Tessema, 2005). Conversely, the control accession had a significantly lower (P<0.05) LSR compared to the other accessions in both experimental years, likely due to genetic deterioration and the prolonged effects of its introduction to the environment.

**3.2. Combined growth properties and dry matter yield of Phalaris grass**

In a similar pattern across both production years, the growth characteristics such as plant height (PH), leaf length (LL), number of tillers per plant (NTPP), and dry matter yield (DMY) exhibited consistent trends when analyzed over the combined years. Phalaris grass accession 14353 showed significantly higher (P<0.05) PH compared to accession 6853, although no significant difference was observed between accession ILRI 14353, ILRI 10552, and the control. In contrast to PH, accessions ILRI 6853 and ILRI 14353 had higher NTPP than accession ILRI 10552 and the control in the combined year analysis. Consistent with the growth characteristics, both accession ILRI 6853 and ILRI 14353 recorded significantly higher (P<0.01) DMY than the other tested accessions. Additionally, the leaf-to-stem ratio (LSR) of accession ILRI 6853 was significantly (P<0.05) higher than that of the other Phalaris accessions, indicating better nutritional quality. Conversely, the control treatment showed the lowest LSR, which likely reflects the genetic deterioration of the control Phalaris grass and the long-term effects of its introduction to the environment.

**Table 2** Combined dry matter yield and related parameters of Phalaris grass

|  |  |
| --- | --- |
| Treatments  | **Parameters** |
| PH (cm)  | LL (cm)  | NTPP(count)  | LSR  | DMY (t-1yr-1) |
| Control | 77.15ab | 32.10c | 54.39b | 1.30d | 4.93b |
| ILRI 6853  | 74.24b | 47.85a | 65.93a | 1.61a | 5.92a |
| ILRI 10552  | 78.69ab | 41.04ab | 58.17b | 1.49b | 5.19b |
| ILRI 14353  | 83.70a | 37.77bc | 65.72a | 1.39c | 5.89a |
| Mean  | 78.44  | 39.69 | 61.05  | 1.45 | 5.48  |
| SEM  | 2.01  | 1.13  | 2.32  | 0.0045  | 0.235  |
| P -Value  | 0.0301 | 0.0452 | 0.0312 | <.0001 | 0.0305 |

*PH= plant height, LL= leaf length, NTPP= number of tillers per plant, LSR= leaf to steam ratio,* DMY t-1yr-1*= Dry matter yield ton per hectare*

**3.3. Chemical composition of Phalaris grass accessions**

 The chemical composition of the various Phalaris grass accessions is presented in Table 3. The dry matter (DM) percentage of Phalaris grass accession ILRI 6853 was higher than the control, although no significant differences were observed between accession ILRI 14353, ILRI 10552, and the control. However, Ash content did not differ significantly among the accessions.

Regarding fiber fractions, Phalaris grass accession ILRI 14353 exhibited significantly higher (P<0.05) neutral detergent fiber (NDF) content compared to accession ILRI 6853, while no significant variation was found between accession ILRI 10552 and the control. Additionally, Phalaris grass accessions ILRI 14353 and ILRI 10552 had significantly higher (P<0.05) acid detergent fiber (ADF) content than accession 6853 and the control. The NDF content in both Phalaris grass accessions in this study was lower than the values reported by Misganaw et al. (2022) for Napier and desho grasses under various fertilizer treatments in similar agro-ecologies.

On the other hand, the acid detergent lignin (ADL) content in the Phalaris accessions was higher than the values reported by Bimrew et al. (2017), though similar to those reported by Misganaw et al. (2022) for desho grass. The differences between our findings and previous studies may be attributed to genetic variation, soil conditions, and environmental factors that can influence the chemical composition of grasses. Roughage diets with an NDF content ranging from 45-65% are generally considered medium-quality feeds, while those with NDF content below 45% are classified as high-quality feeds (Singh and Oosting ,1992). In this study, the NDF content of all Phalaris grass accessions was below 65%, classifying them as medium-quality feeds. The NDF content ranged below the 66.2% average value reported for tropical grasses (Van Soest, 1994). Therefore, the Phalaris grass accessions tested in this study could serve as suitable ruminant feed in the study area and similar agro-ecologies in other regions.

**Table 3** Chemical Composition of Phalaris grass grown under rain feed condition

|  |  |
| --- | --- |
| Treatments | Chemical composition parameters (% DM) |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | DM  | ASH  | OM  | NDF  | ADF  | ADL  |
| Control  | 89.70b  | 6.92  | 93.08  | 60.09ab | 33.32  | 11.28b  |
| ILRI 6853  | 90.60a | 8.41 | 91.59  | 58.68b | 32.26 | 11.06b  |
| ILRI 10552  | 90.30ab | 8.15 | 91.86 | 60.51ab | 32.58 | 15.12a  |
| ILRI 14353  | 90.13ab | 8.31  | 91.69 | 62.04a  | 32.76 | 16.48a  |
| Mean  | 90.18  | 7.95 | 92.05  | 60.33  | 32.73 | 13.49 |
| CV (%) | 5.1 | 12.6  | 1.1 | 3.2  | 6.8 | 13.6  |
| SEM  | 0.131  | 0.272  | 0.272  | 0.532  | 0.507  | 0.735  |
| P-Value  | 0.0453  | 0.1829  | 0.1829  | 0.01631  | 0.9197  | 0.0023  |

*ADF= acid detergent fiber; ADL= acid detergent lignin; DM= dry matter; NDF= neutral detergent fiber; OM= organic matter*

1. **CONCLUSION AND RECOMMENDATIONS**

In terms of most morphological characteristics and dry matter yield, Phalaris grass accession ILRI 6853 demonstrated the highest performance in both years, followed by accession ILRI 14353. Additionally, accession ILRI 6853 recorded the lowest fiber contents (NDF, ADF, and ADL). Based on the current observations, both of the Phalaris accessions have supported to be frost-tolerant perennials in the study district. Accessions ILRI 6853 and ILRI 14353 were selected for their superior production performance and lower fiber content, making them well-suited to address critical feed shortages and support enhanced livestock production in the region. Therefore, these two accessions ILRI (6853 and 14353) are recommended for further demonstration and evaluation in the study area and similar agro-ecologies.

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