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Research Article

On-farm Evaluation and Pre-extension Demonstration of Elephant grass (*Pennisetum purpureum*) Varieties in Mixed Farming Systems of West Arsi zone, Ethiopia

[1]Diribi Mijena and [2]Aman Getiso*

[1,2]Ethiopian Institute of Agricultural Research, Wondogenet Agricultural Research Center Shashemene, Ethiopia.

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***Corresponding author:** **Aman Getiso**
Ethiopian Institute of Agricultural Research, Wondogenet Agricultural Research Center Shashemene, Ethiopia.

Abstract

On-farm evaluation and pre-extension of elephant grass varieties (Zehone-02 and Zehone-03) were conducted in a mixed farming system in two districts (Shashemene and Wondo) in the West Arsi zone Oromia regional state in Ethiopia. Two representative peasant associations were selected from each district based on forage production potential and accessibility to field monitoring and visits. Ten farmers willing to accept and disseminate technology were purposefully selected from each peasant association and grouped into farmer research groups. In each farmer research group, four hosting farmers were selected, with the rest being participant/visiting farmers in each kebele. Hosting farmers were selected based on their ownership of suitable and sufficient land to accommodate trials, proximity to roads to facilitate the chance of being visited by many stakeholders, ability to manage planted crops, and willingness to share their knowledge and experience with others. One potential farmer training center in each district was used as a trial and demonstration site as well as a source of planting material for the future. Two elephant grass varieties (Zehone-02 and Zehone-03) were evaluated and visited at the farmers' training center with a plot size of 10 m × 10 m in each district. The number of tillers per plant, plant height at harvest, total fresh biomass yield, and total dry matter yield were all recorded in the second year of planting, whereas the plant survival rate was noted in the first. The findings showed that the plant survival rate, number of tillers per plant, and plant height at harvest did not significantly differ between the two tested varieties. In terms of forage yield, Zehone-02 gave a higher amount of total fresh biomass yield (44.05 tons ha^{-1}) and (12.71 tons ha^{-1}) total dry matter yield, while Zehone-03 produced (37.20 tons ha^{-1}) and (10.66 tons ha^{-1}) total fresh biomass yield and total dry matter yield at the study site. Based on the performance of the varieties and visiting farmers' feedback, further large-scale scaling of the two varieties should be conducted in the study area and areas with similar agro-ecologies.

Keywords: *Demonstration; Pre-extension; Varieties, Zehone-02; Zehone-03.*

1. Introduction

Despite the large and diverse livestock population of the country [1], the productivity of this sector is characterized by low productivity, with the major challenge being a shortage of feed resources, both in quantity and quality, especially during the dry season [2;3]. According to a previous report [1], the livestock feed supply of the country is derived in descending order from green fodder and grazing (57.77 %), crop residues (29.75 %), conserved hay (6.66 %), and other feed resources (3.89 %). Only 1.54% and 0.38% of the animal feed supply originated from industrial byproducts and improved forage crops, respectively.[4] noted that the natural pasture-based livestock feeding system is greatly influenced by feed supply, and the nutritional dynamics of range forages and feeds from natural pastures are characterized by high fiber (>55%) and low crude protein (CP) (< 7%) [5]. Thus, the total dry matter intake is restricted and rarely meets the maintenance requirements of animals.

To overcome these nutritional constraints, utilizing improved forage crops that are adaptable to the agro-ecological conditions of the area and can be used as feed resources is globally as well as locally recommended, as they are accustomed to being cultivated by smallholder farmers with low input [6]. Utilizing improved forages would greatly reduce pressure on natural pastures, support the system substantially and enhance natural assets and system reliance, improve soil fertility and erosion in marginal areas, and improve carbon sequestration to prevent climate change [7;8] For instance, desho grass, elephant grasses, sesbania sesban, Rhodes, oats, cow pea, and other enhanced fodder species can be utilized for the aforementioned functions [9]. Among the improved and available multipurpose and potential feed resources in the country, elephant grass (*Pennisetum purpureum*) is the most appropriate one, and using this multipurpose and adaptable species of fodder is one of the suggested strategies for mitigating feed shortages in the country [10;11].

Elephant grass (*Pennisetum purpureum Schumach*.), also known as merker grass, Napier grass, napier, Uganda grass, bana grass, and barner grass, is one of the most important and highest-yielding tropical grasses [12]. It is mostly utilized by smallholder farmers and can be vital in providing a substantial amount of high-quality fodder that can make up to 80% of the diet of cattle in many tropical and subtropical regions [13]. Because of its significance in small-scale livestock farming operations, Napier grass is one of the most often utilized fodder crops among Ethiopian livestock keepers in Ethiopia [14-16]. Additionally, it performs well in the low, mid, and highlands of Ethiopia [17]. It is a tall perennial and deep-rooted perennial bunch grass renowned for producing large yields and is mostly utilized in cut-and-carry feeding systems [18] and installations, or it is processed to make hay or silage.

In past few years, different elephant grass lines have been tested at the Holeta Agricultural Research Center for adaptation and fodder production. Among the tested lines, Zehone-02 and Zehone-03were found to be adaptable from medium to highland aro-ecologies and registered as varieties [19]. Even if these varieties were released by research centers for forage use and were found to be adaptable under on-station research conditions, to the best of the authors' knowledge, they have not been demonstrated under on-farm conditions to verify the possibility of their adoption by smallholder farmers in the mixed crop-livestock production systems of Ethiopia. Therefore, the current study was executed to evaluate the recently released desho grass varieties at farmer fields and to demonstrate the merit of the grass to smallholder farmers in the study area.

2. Materials and Methods

2.1 Description of the study area

The study was conducted in two purposively selected districts of the West Arsi zone (Wondo and Shashemene) in the Oromia Region, Ethiopia. The study site, Wondo district, is situated 260 km from Addis Ababa on the southeast escarpment of the Ethiopian Great Rift Valley, at latitudes of 7°06-07′N and longitudes of 38°37′–42′E. The altitude ranges from 1,700 to 2,300 meters above sea level [20]. Agro-ecologically, 90% of the district is in the midland zone, whereas 10% is in the highland zone, according to the Wondo District Agricultural Office. The district has a bimodal rainfall pattern, yielding 1210 mm annually. The rainy season ranges from March to September, and the comparatively dry period from December to February. The average annual temperature is 20°C. Fertile soil, water, forests, and wildlife are some of the natural resources of the district bestowed with it [21]. The valley plain of Wondo has fertile and loamy sand-textured soils that contain the most important nutrients, covering the area [22] to the south.

The Shashemene district is topographically located in the West Arsi zone of the central main Ethiopian Rift Valley [23] at a distance of 253 km from Addis Ababa, the capital city of the country, to the south, with latitudes of 70 04'50" to 70 22'45" N and longitudes of 380 23'00" to 380 48'00" E. The district is situated between 1683 and 2742 m above sea level, and soil type of the district is mainly dominated by Vitric Andosols, Eutric Vertisols, Mollic Andosols, Haplic Luvisols, Haplic Luvisols and Lithic Leptosols which account about 29.06%, 20.81%, 18.55%, 16.55% ,7.67% and 5.67% of the area, respectively (24). The annual rainfall varies from 500 to 1200 mm, and the temperature ranges from 10 to 25°C. Four different seasons occur in the area: the major rainy season (June–August), short rainy season (March–May), dry season (December–February), and autumn season (September–November). The district has considerable agricultural potential, as evidenced by the variety of crops and cattle produced for food and money [25].

2.2 Experimental site and experimental farmer selection

Four kebeles (two from each district) were selected based on livestock potential and soil and water conservation practices (soil bund on their farm) with the help of development agents and livestock experts. Ten farmers willing to accept and disseminate the technology were purposefully selected from each kebele and grouped into farmer research groups (FRGs). In each FRG, four hosting (trial) farmers were selected, with the rest being participating farmers in each kebele. Hosting farmers were selected based on their ownership of suitable and sufficient land to accommodate trials, proximity to roads to facilitate the chance of being visited by many stakeholders, ability to manage planted crops, and willingness to share their knowledge and experience with others. Farmer training centers (FTCs) at each kebele were used as demonstration sites and sources of planting materials for the future.

2.3 Experimental treatments and treatment management

A stem cutting of the chosen study material (Zehone-02 and Zehone-03) elephant grass varieties with three nodes was planted at 1m between rows and 0.5m between plants with a depth of 15-20 cm at an angle of 45^0 as recommended by [26] in July 2019, when continuous rain was assured for successful establishment. These varieties are released/registered as livestock forage for midland to highland agro-ecology of Ethiopia. At each peasant association, four trial farmers established one of the selected varieties in a 10m x 10m plot area. Each trial farmer was considered a replicate. Blended NPS fertilizer was uniformly applied to all plots at a rate of 121 kg ha^{-1} at planting. After each harvest, all plots were top-dressed uniformly with 50 kg N ha^{-1}, of which one-third was applied during the first shower of rain, and the remaining two-thirds were applied during the active growth stage of the plant. During the experimental period, the plots were maintained under uniform management to ensure that the root system remained intact during the long dry spells. All other crop management practices were used uniformly in all plots as recommended.

2.4 Technology promotion approach

Farmers can participate in many ways in on-farm research activities to direct extensions for the further promotion of varieties and agricultural technologies. Demonstrating this at some trial sites as a learning point and extending the results to many farmers is the most popular approach to the agricultural extension system in Ethiopia. This activity also facilitated the farmer extension research approach by organizing farmers on plots as host (trial) farmers, and others will learn from them [27]. For proper technology transfer, an effective extension approach and method are mandatory to enhance farmers' knowledge and skills, which can sustain and promote the production of improved varieties in agricultural farming [28].

2.5 Data collection and Analysis method

Trial plots were regularly observed during the experimental period (2019/2020 - 2021/2022). The first year was considered as the establishment year, and data on agronomic growth, such as plant height at harvest, tiller number, and herbage yield, were recorded by observation, counting, and measurement in the second year of production. The plant survival rate of each variety was recorded during the first year after confirming plant establishment and was calculated as the ratio of the number of surviving plants per plot to the total number of plants planted per plot, then multiplied by 100. The number of tillers per plant was counted from five randomly selected culms in each plot. Plant height at each harvest was measured from five culms randomly selected from each plot using steel tape from the ground level to the highest leaf. Fresh biomass and dry matter yields were obtained from two harvests conducted in a year. Pearson's correlation, t-tests, and descriptive statistics were used to analyze the data. Tables and graphs were used to visualize the data.

3. Result and Discussions

3.1 Establishment performance of the varieties

Establishment performance is an important consideration during forage crop cultivation because of its considerable effect on forage productivity. There was no Significant difference ($p>0.05$) in the average survival rates of the tested elephant grass varieties across the study site (Figure 1). This result was consistent with that of [29], who reported that the survival rates of five tested Napier grass varieties were not statistically different under rainfed conditions in the Gambella region of Ethiopia. The absence of variance showed that the varieties could adapt to a wide range of agro-ecologies, and that the environment was favorable for them. The highest value (91%), followed by 90%, was recorded for Zehone-02 varieties in the Wondo and Shashemene districts, respectively, while the lowest values (89% and 88%) were recorded for Zehone-03 in the Shashemene and Wondo districts, respectively. The current result is in line with the 92% survival rate for Zehone-03 that was reported by [30] discovered in the Ethiopian Rift Valley. But greater than 76% for five Napier grass cultivars under farmer conditions in West Hararghe Zone, Oromia Region, Ethiopia, reported by [31]. These variations might be due to agro-meteorological factors such as rainfall, air and soil temperatures, wind, relative humidity or dew point temperature, solar radiation, as well as crop management approaches. According to [32], during the overall three-year trial period, Napier grass had an average survival rate of 73.8% in the central highlands. The reduction in plant number had no effect on herbage production because of the vigorous growth performance of tillers produced by the remaining stands.

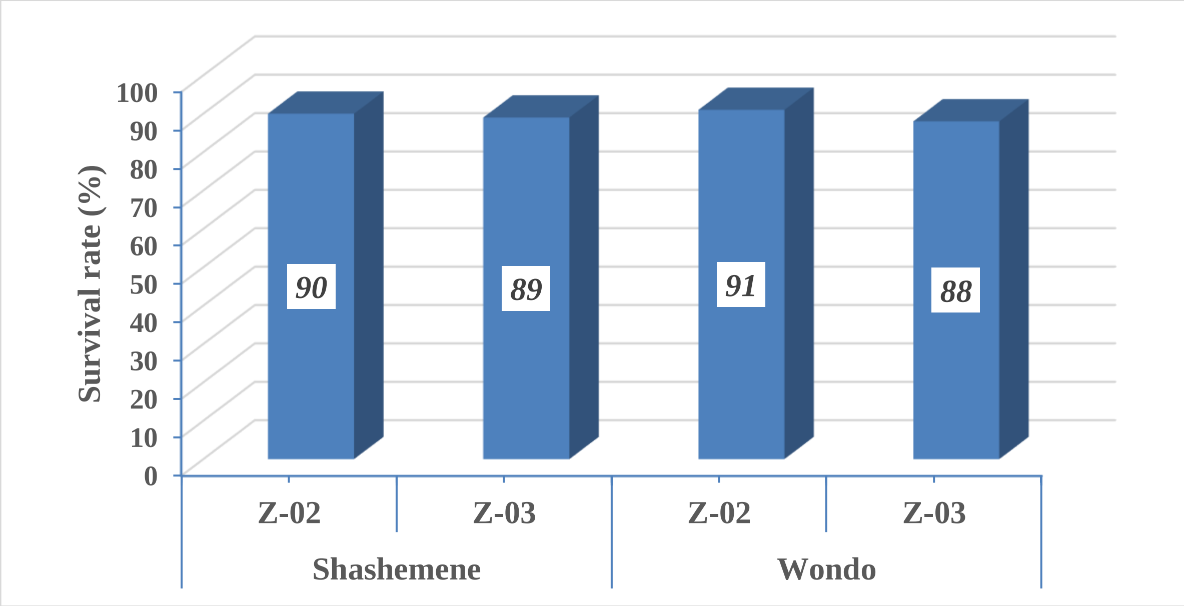

Figure 1: Survival rate of the tested elephant grass varieties across the district

3.2 Agronomic performance of the tested varieties

Table 1 shows the average number of tillers per plant and plant height at forage harvest for the evaluated elephant grass cultivars. Plant tillering performance is a vital structural feature to consider when selecting suitable fodder crops to increase fodder production and productivity. Combined analysis revealed a statistically significant difference ($p<0.05$) in the mean number of tillers per plant between the cultivars. The mean tiller numbers per plant were 14.04 and 12.26 for Zehone-02 and Zehone-03, respectively.

The Zehone-02 variety produced a high number of tillers per plant, which progressively covered the plot and provided adequate feed supply. Genetic differences and interactions with the environment of the varieties may account for the variance in the number of tillers generated by each variety. The current figure is by far lower than the findings of [31], which vary from 17.32 to 19.48 and 30.83 to 43.83 during the first and second harvests, respectively, for the five Napier grass cultivars tested under farmer conditions in West Hararghe Zone, Oromia Region, Ethiopia. [29] also reported a higher number of tillers per plant (41.26) for five tested released Napier grass varieties under rainfed conditions in the Gambella Region of Ethiopia. The variation in the number of tillers produced per plant across the varieties of Napier grass may be caused by genetic variation between the varieties and their interactions with the environment. The tillering number might vary because of rainfall patterns and amounts, soil health, and fertility [33].

There was no statistically significant difference ($p>0.05$) between the two tested Napier grass varieties in terms of plant height at the forage harvest. This finding is similar to of that [34] and [35], who reported no significant difference ($P>0.05$) in plant height of six Napier grass cultivars at Mechara Research Station, Eastern Oromia, Ethiopia, and Zehone-02 and Zehone-03 Napier grass varieties in midland agro-ecologies of the Guji zone, Oromia, and Ethiopia, respectively. However, among the varieties, the mean values were different. The combined mean of the plant heigh at forage harvest was (130.35 cm) for Zehone-03 and (110.75 cm) for Zehone-02 at the current study. The current result is comparable with [36] and [31], who reported different plant heigh at forage harvest at different agro-ecologies of zones of Ethiopia [(AdamiTulu (110.75 cm), Debrezeit (120.33 cm), Hawassa (140.53 cm)] for different Napier grass accessions and 125.34 cm for six Napier grass cultivars under farmer conditions in West Hararghe Zone, Oromia Region, Ethiopia, respectively. But lower than the values reported by [30] and [29], which were 251.90 cm and 231.00 cm under rainfed conditions in the rift valley and Gambella region of Ethiopia, respectively. Numerous studies on cutting Napier grass have shown that the choice of cutting height and interval is critical to performance. Defoliation intensity is the primary factor that influences the development, yield, and persistence of swards [37].

Table 1: Agronomic performance of the tested grass varieties across districts

Variety	NTPP			PHH (cm)		
	Districts		Mean	Districts		Mean
	Shashemene	Wondo		Shashemene	Wondo	
Zehone-02	13.58[a]	14.50	14.04[a]	110.52	110.00	110.75
Zehone-03	11.70[b]	13.44	12.26[b]	126.23	135.00	130.65
Mean	12.33	13.97	13.15	118.37	123.02	120.70
CV (%)	10.09	13.15	13.36	24.10	26.72	24.19

Means followed by different superscript letters within a column are significantly different from each other at P<0.05. NTPP, number of tillers per plant; PPH=Plant height at harvest; CV=Coefficient of variation; cm, centimeter.

3.3 Yield performance of the tested grass across the district

Table 2 shows the overall production of total green fodder and the dry matter yield for each of the tested varieties in the district. Fresh biomass can be stored and utilized as hay during the dry and scarce seasons, or it can be used during the rainy season when other forages are also accessible. This feeding system can sustain year-round feed supplies for livestock and help improve production and productivity in the livestock sector. Between the two tested varieties, there was a statistically significant difference ($p<0.05$) in total green fodder yield at the study site. Zehone-02 had the highest yield, 44.05 tons ha^{-1}), whereas Zehone-03 produced 37.20 tons ha^{-1}. The present value is much more than the yield observed in the midland agro-ecologies in the Guji zone, Oromia, Ethiopia, by [35], which was 8.30 tons ha^{-1} for Zehone-02 and 6.61 tons ha^{-1} for Zehone-03 varieties.

There was a statistically significant difference ($p<0.05$) in the total dry matter yield (ton ha-1) among the tested cultivars. Zehone-02 had the highest yield (12.71 tons ha^{-1}), whereas Zehone-03 produced 10.66 tons ha^{-1}. The difference between the varieties might be related to the number of tillers per plant (Zehone-02 produced a larger number of tillers per plant than Zehone-03), which progressively covered the plot and provided adequate feed supply. The current combined mean value (11.68 tons ha^{-1}) is lower than the yield reported by [29] that was 16.24 tons ha^{-1} for five tested released Napier grass cultivars under rainfed conditions in the Gambella region of Ethiopia. Harvesting stage differences, soil physiochemical variations, agro-ecological variations, and field management techniques might all contribute to the variations in fresh biomass yield and dry matter yield. The findings of [38] and [39], who indicated that the dry matter yield increased with maturity, validated this finding.

Table 2: Yield performance of the tested varieties

	TFBMY (tons ha^{-1})			TDMY (tons ha^{-1})		
Variety	Districts			Districts		
	Shashemene	Wondo	Mean	Shashemene	Wondo	Mean
Zehone-02	40.04[a]	48.05[a]	44.05[a]	11.55	13.86[a]	12.71[a]
Zehone-03	36.13[b]	38.27[b]	37.20[b]	10.25	11.08[b]	10.66[b]
Mean	38.09	43.16	40.62	10.90	12.47	11.68
CV (%)	6.69	7.57	10.21	8.48	7.86	10.97

Means followed by different superscript letters within a column are significantly different from each other at P<0.05. TFBMY=Total fresh biomass yield, TDMY=Total dry matter yield, CV=Coefficient of variation, cm=centimeter.

4. Conclusion and Recommendations

On-farm evaluation and pre-extension demonstration of Napier grass varieties, namely "Zehone-02 and Zehone-03," were carried out in selected districts of the West Arsi zone of the Oromia region to evaluate the on-farm agronomic and yield performance of the varieties, create awareness, demonstrate to smallholder farmers, and popularize the varieties. The evaluation and pre-extension demonstration results revealed that both Zehone-02 and Zehone-03 varieties had a high number of tillers per plant, plant height at harvest, green fodder, and dry matter yields at all tested sites. based on assessment and pre-extension demonstration results. Moreover, both varieties are preferred by hosting and visiting farmers for future cultivation. Accordingly, this study helps to alleviate the limitations that farmers face when producing fodder through their particular approaches. Consequently, even though both varieties are preferred by farmers, less attention is given to forage than other food crops to cover their land by forage for a long time, and this evidence led to the following suggestions:

- It is important to popularize on large scale both or either of the elephant grass varieties in the study area and areas with similar agro-ecologies

- It is also recommended that forage production techniques, including intercropping, backyard farming, areas around farms and river basins, soil bunds, sloping areas, and roadsides, are the best ways to solve livestock feed shortages in the study area.

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