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Research Article
Evaluation of *Pennisetum perpureum* Grass Variety to Improve Feed Availability in South Omo

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Abstract
Background and Objective: The *Pennisetum perpureum* grass species could play an important role in providing a significant amount of high quality dry matter yield to the livestock. Therefore, this study was initiated to evaluate dry matter yield and chemical composition of 5 *Pennisetum perpureum* grass varieties in irrigated lowland in South Omo. **Materials and Methods:** The five *Pennisetum perpureum* grass varieties were evaluated at Dassanech and Hamer irrigated lowland in randomized complete block design with 3 replications per variety. The data on dry matter yield, plant height, tillers per plant, leaf to stem ratio and nutritional qualities were analyzed using the general linear model procedures of SAS. **Results:** The higher ($p>0.05$) dry matter yield (51.56 t ha^{-1}) was recorded for ILRI16840 variety and whereas, the lowest dry matter yield (34.06 t ha^{-1}) was for ILRI168902 variety. Moreover, significantly higher ($p<0.05$) Crude protein (161.70 g kg^{-1}, DM) recorded for ILRI16815 and whereas, significantly lowest ($p<0.05$) crude protein (126 g kg^{-1}, DM) for ILRI168902 variety. **Conclusion:** On basis of results it can be calculated that the pastoral communities who living in irrigated lowland areas of South Omo Zone and other areas having comparable agro-ecology could plant ILRI16840 variety followed by ILRI16815variety for higher dry matter yield and whereas, for crude protein content pastoral communities could plant ILRI16815 variety followed by ILRI16813 variety.

Key words: *Pennisetum perpureum*, chemical composition, dry matter yield, herbage, grass varieties

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Ethiopia has large livestock population in Africa possessing 60.39 million cattle, 31.30 million sheep, 32.74 million goats, 2.01 million horses, 8.85 million donkeys, 0.46 million mules, camels 1.42 million and 56.06 million poultry population[1]. However, the overall production and productivity performances of livestock in Ethiopia are generally low due to many determinants[2]. Among these determinants, the poor feed quality and inadequate feed supply are one of top nutritional impediments[2].Under such conditions, the demand for livestock products by consumers in country cannot be sustainably satisfied. Likewise, in study regions the livestock feeding system is completely natural pasture based feeding system[3-5]. It is obvious that the natural pasture based feeding system is greatly influenced by feed supply and nutritional dynamics of pasture forages[6]. Moreover, these feed resources could not fulfill the nutritional requirement of animals particularly in the dry season and the supply of these feed resources is inconsistently distributed over the seasons and characterized by high fiber (>55%) and low crude protein contents[7,8] (<7%) feed intake level by animal is limited and they barely satisfy even the maintenance requirements. This is triggering to increase high slow growth, mortality, longer calving intervals and substantial weight loss[6] and will be made the communities minimum benefits from livestock production system. In this respect, it is not imagined the surplus livestock productivity which refers to the ability of the animals grown to produce economic outputs such as livestock products and by-products of good quality (meat, milk, animal draft power, manure, hides, skins and wool) unless the immediate action undertaken in improving feed quality and quantity issues in to study area[3-5]. Therefore, testing locally adaptable and nutritionally qualified forages species to supplement pasture based feeding system is only way to overwhelm feed shortage in to study areas[9]. Amongst the promising forage species promoted in Ethiopia, *Pennistum perperum* grass species could play an important role in providing a significant amount of high quality forage to the livestock[10,11] both under the small holder farmers and intensive livestock production systems with appropriate management practices[12,13]. The grass can withstand repeated cutting and regrows rapidly, producing a high biomass that is very palatable in the leafy stage[14]. Moreover, the biomass yield and chemical composition of *Pennisetum perpureum* grass may vary significantly depending on variety, age, season, location and management practices[15,16]. Accordingly, the dry matter yields of *Pennisetum perpureum* ranged from 20-80 t ha^{-1} under high fertilizer input and irrigated condition[17] and while, the dry matter yields are on the range of 1.4-18 t ha^{-1} without fertilizers and irrigation[10,14]. Moreover, the protein content of elephant grass varies from 4.4-20.4%[10,18-20] and NDF and ADF ranges from 57-76 and 30-47%, respectively[21-23]. However, with this promising potential, different *Pennisetum perpureum* grass varieties have not been evaluated for dry matter yield, plant growth parameters and their chemical composition in irrigated lowland of South Omo Zone. Therefore, objective of this study were 1 to evaluate high dry matter yielding *Pennisetum perpureum* grass varieties in irrigated lowland for South Omo and to assess the nutrient contents of *Pennisetum perpureum* grass variety for study regions.

MATERIALS AND METHODS

Description of study site: The study was conducted from July, 2018-September, 2019 in pastoral areas of the Hamer and Dassanech districts of South Omo Zone. The Dassanech Woreda has lied astronomically 5°14'N latitude, 36°44'E longitude and 1000 km from Addis Ababa and has temperature which ranges from 25-40°C and rainfall from 350-600 mm with bimodal rainfall erratic distribution. The altitude of the study Dassanech district is the ranged from 350-900 m above sea level. While, in Hamer the average temperature of is above 37°C in most parts of district and altitude varies from 450-1765 m above sea level. The average annual rainfall is 400 mm and it is estimated that 66% of the population lead a pastoral production system and 34% of the population practice a crop livestock mixed production system.

Experimental treatments and design: The four *Pennisetum perpureum* grass varieties such as; ILRI16913, ILRI16815, ILRI16902 and ILRI16817 were collected from Areka Agricultural Research Center and evaluated at both districts. The *Pennisetum perpureum* grass variety called ILRI16840 which used as local check was formerly introduced and well adapted in study regions was collected from the Jinka Agricultural Research Center. The 5×2 factorial combination was arranged in randomized complete block design with three replicates per variety. The tested varieties were planted in 4×3 m plot area and each variety was assigned randomly to plots within block and cuttings were planted in four rows per plot with 0.75 cm between row and 0.5 cm between plants with 1 m between plots. Then the parent plants were cut into stems with three nodes per cutting and planted at 20 cm deep at an angle of 40° by recommendation of Gemiyo *et al.*[10]. The furrow irrigation was used and all the plots were irrigated uniformly and accordingly per the intended irrigation schedule. The two testing location were evaluated in order to identify suitable location for *Pennisetum perpureum* grass variety production.

Data collection: The growths data like Plant Height (PH), Leaf to Stem Ratio (LTSR) and tillers per plant were measured by harvesting middle of 2 rows by using suckles. The numbers of tillers per plant were counted from the 5 culms after harvesting and plant height was taken from 5 culms randomly from each plot and measured using a steel tape from the ground level to the highest leaf. Biomass yield was determined *Pennisetum perpureum* varieties were clipped at 5 cm from the ground level from 2 rows next to the guard rows. The weight of the total fresh biomass yield was measured from each plot in the field and the estimated 300 g sample was taken from each plot and brought to Jinka Agricultural Research Center and allotted in to oven dried at 105°C for overnight for dry matter determination. The dry matter yield was calculated by using recommended formula by Mutegi *et al.*[24]:

$$\text{Dry matter yield (t ha}^{-1}) = \text{TFW} \times \left(\frac{\text{DWss}}{\text{HA} \times \text{FWss}}\right) \times 10$$

Where:

TFW = Total fresh weight kg/plot
Dwss = Dry weight of subsample in grams
Fwss = Fresh weight of subsample in grams
HA = Harvest plot area in square meters
10 = Constant for conversion of yields in kg m^{-1} to t ha^{-1}

In order to measure leaf to stem ration, the morphological parts were separately weighed to know their sample fresh weight, oven dried for 24 h at a temperature of 105°C and separately weighed to estimate the proportions of these morphological parts. Accordingly, leaves were separated from stems and the fractions were estimated based on the dry weight of each component.

Chemical analysis: The laboratory analysis was done at Debre Birhan Agricultural Research Center, Debre Birhan, Ethiopia. Forage samples of two locations were oven dried (65°C for 72 h) and ground to pass through 1 mm sieve size screen for chemical analysis. Analysis was made for the different nutritional parameters (DM, Ash, CP, NDF, ADF and Ash). The DM, CP and Ash were analyzed by procedures of AOCA[25]. The NDF value was also calculated by procedure of Van Soest *et al.*[26] and whereas, the ADF value was analyzed procedures of Van Soest and Robertson[27].

Data analysis: The data such as dry matter yield, plant height, leaf to stem ratio, tillers per plant and chemical composition were subjected to Analysis of Variances (ANOVA) using the General Linear Model (GLM) procedure of Statistical Analysis System (SAS) software[28]. The significant differences among the means were declared at $p \leq 0.05$ and means were separated using Duncan's Least Significant Difference (LSD) test with model of:

$$Y_{ijk} = \mu + V_i + L_j + V_i \times L_j + e_{ijk}$$

Where:

Y_{ijk} = All dependent variables
μ = Overall mean
V_i = Effect of variety
L_j = Effect of testing locations
$V_i \times L_j$ = Interaction effects of variety and locations
e_{ijk} = Random error

RESULTS

Effects of variety on forage dry matter yield, plant height, tillers per plant and LTSR: The effects of tested *Pennisetum perpureum* grass varieties under irrigated condition in Dassanech and Hamer districts on dry matter yield, plant height, tillers per plant and LTSR were presented in Table 1. The result from this study revealed that the forage dry matter yield, plant height, tillers per plant and LTSR were not significantly ($p>0.001$) affected by tested *Pennisetum perpureum* varieties. However, the higher dry matter yield and taller plant height were obtained from ILRI16840 variety which was used as local check in this study followed by ILRI16815 variety and while, the lower dry matter yield was observed for ILRI16902 and whereas, the shortest plant height (m) was for ILRI16913 variety. Moreover, higher tillers per plant and LTSR were observed for ILRI16817 variety and lowest were for ILRI16902 variety.

Effect of location on forage dry matter yield, plant height, tillers per plant and LTSR: The effects of location on forage dry matter yield, plant height, tillers per plant and leaf to stem ration were presented in Table 2. The results from this study revealed that the forage dry matter yield and plant height were not significantly ($p>0.05$) affected by tested locations. But, the higher forage dry matter and taller plant height were obtained from Dassanech location than Hamer location. Conversely, significantly more ($p<0.05$) tillers per plant and leaf to stem ration were also obtained from Dassanech location and whereas, lower tillers per plant and LTSR were from Hamer location.

Table 1: *Pennisetum perpureum* grass varieties on forage dry matter yield, plant height, tillers per plant and leaf to stem ratio

Tested varieties	Dry matter yield (t ha^{-1})	Plant height (m)	Tiller per plant	LTSR
ILRI16902	34.06	2.92	15.33	1.07
ILRI16815	45.25	3.10	17.50	1.46
ILRI16913	34.61	2.09	18.66	1.55
ILRI16840	51.56	3.13	16.50	1.13
ILRI16817	40.42	2.26	19.33	1.82
F-value	01.26	1.09	0.23	2.10
p-value	00.32	0.38	0.91	0.000
SEM	09.33	5.60	4.77	0.09
LSD	19.60	1.17	10.03	0.20

SEM: Standard error of mean, LSD: Least Significance difference

Table 2: Effects of locations on forage dry matter yield, plant height, tillers per plant and LTSR

	Tested locations						
Parameters	Dassanech	Hamer	Mean	F-value	p-value	SEM	LSD
Dry matter yield (t ha^{-1})	45.01	37.34	41.80	01.69	0.21	5.90	12.40
Plant height (m)	05.86	03.54	04.70	0.43	0.52	3.54	07.45
Tiller per plant	22.00^{a}	13.00^{b}	17.46	08.23	0.01	3.02	10.03
LTSR	02.07^{a}	0.78^{b}	01.41	21.10	0.00	0.06	0.12

Means with the same letter (a and b) in across row for dry matter, plant height, tillers per plant and LTSR at 50% flowering stage are not significantly different (p>0.05), SEM: Standard error of mean, LSD: Least significance difference

Table 3: Variety interaction effect on forage dry matter yield, plant height, tillers per plant and LTSR

		Parameters measured			
Tested varieties	Locations	Dry matter yield (t ha^{-1})	Plant height (m)	Tiller per plant	LTSR
ILRI16902	Dassanech	38.10^{abc}	2.21^{b}	16^{abc}	1.39^{c}
	Hamer	30.02^{c}	3.64^{b}	14^{bc}	0.74^{d}
ILRI16815	Dassanech	59.93^{a}	3.90^{ab}	23^{ab}	2.15^{b}
	Hamer	30.56^{bc}	3.73^{b}	12^{bc}	0.78^{d}
ILRI16913	Dassanech	41.88^{abc}	2.47^{a}	29^{a}	2.31^{b}
	Hamer	27.33^{c}	2.30^{b}	8^{c}	0.79^{d}
ILRI16840	Dassanech	57.98^{ab}	2.86^{b}	15^{abc}	1.45^{c}
	Hamer	45.15^{abc}	3.40^{b}	18^{abc}	0.81^{d}
ILRI16817	Dassanech	48.10^{abc}	1.47^{b}	25^{ab}	2.83^{a}
	Hamer	32.74^{abc}	3.06^{b}	13^{bc}	0.81^{d}
F-value		01.79	1.04	1.79	0.17
p-value		0.17	0.41	19.21	0.00
SEM		13.19	7.93	6.75	0.13
LSD		27.72	1.66	14.19	0.28

Means with the same letter (a, b, c and d) in across column for forage dry matter yield, plant height, tillers per plant and LTSR at 50% flowering stage are not significantly different (p>0.05), SEM: Standard error of mean, LSD: Least significance difference, t ha^{-1}: Tone per hectare, m: Meter

Location by variety interaction effect on forage dry matter yield, plant height, tillers per plant and LTSR: The location by varieties interaction effect on forage dry matter yield, plant height, tillers per plant and leaf to stem ratio were presented in Table 3. The results for location and variety interaction effect revealed that significantly higher (p<0.05) forage dry matter yield, plant height, tillers per plant and leaf to stem ratio were observed between the location by keeping tested variety constant and however, it was insignificant (p>0.05) among the tested varieties by keeping location constant. Accordingly, better forage dry matter yield and taller plant height were observed for ILRI16815 *Pennisetum perpureum* grass variety followed by ILRI16840, ILRI16913, ILRI16817 and ILRI16902 *Pennisetum perpureum* varieties at Dassanech location and whereas, better forage dry matter yield was observed for ILRI16840 variety followed by ILRI16817, ILRI16815, ILRI16902 and ILRI16913 *Pennisetum perpureum* at Hamer location. Moreover, the results from this study shown that the taller plant height were observed at Hamer location for ILRI16815 followed by ILRI168902, ILRI16840, ILRI16817 and ILRI16913 *Pennisetum perpureum grass varieties*, respectively. Furthermore, the result on LTSR for location by variety interaction effect revealed that the ILRI16817 grass variety gave better LTSR at Dassanech location followed by ILRI16913, ILRI16815, ILRI16840 and ILRI168902 *Pennisetum perpureum* grass varieties and whereas, in case of Hamer location, the

Table 4: Chemical compositions of tested *Pennisetum perpureum* grass varieties

Tested varieties	DM (%)	Ash (%)	Crude protein	Neutral detergent fiber	Acid detergent fiber
ILRI16902	92.00	14.77[ab]	12.60[b]	70.00[a]	50.82[b]
ILRI16815	92.00	15.02[ab]	16.17[a]	65.39[b]	49.59[b]
ILRI16913	91.00	18.18[a]	13.28[ab]	69.15[a]	51.83[ab]
ILRI16840	91.60	13.27[ab]	12.76[b]	61.05[c]	58.82[a]
ILRI16817	91.48	10.33[b]	13.08[ab]	68.03[ab]	49.65[b]
F-value	0.89	3.57	2.39	11.68	2.91
P-value	0.51	0.005	0.013	0.002	0.002
SEM	0.62	2.13	1.34	1.49	3.18
LSD	1.44	4.92	3.10	3.44	7.34

DM: Dry matter, SEM: Standard error of mean, LSD: Least significance difference

ILRI16840 and ILRI16817 varieties were gave better LTSR followed by ILRI16813, ILRI16815 and ILRI16902 varieties means with the same letter (a, b and c) in across column for dry matter percent, crude protein, ash, neutral detergent fiber and acid detergent fiber at 50% flowering stage are not significantly different (p>0.001)

Chemical composition of grass varieties: The chemical compositions of tested *Pennisetum perpureum* grass varieties for Dassanech location were presented in Table 4. The results from this study revealed that significantly higher (p<0.05) crude protein (16.17%) recorded for ILRI 16815 variety than ILRI16840 and but, it was not significantly varied (p>0.05) to ILRI16813 and ILRI16817 varieties. The result obtained from this study also demonstrated that ILRI168902 variety gave significantly (p<0.05) higher neutral detergent fiber than ILRI16840 variety but, it was significantly (p>0.05) similar to ILRI16815, ILRI16813 and ILRI168917 varieties. Pertaining to acid detergent fiber, ILRI16840 variety gave higher acid detergent fiber than ILRI168902, ILRI16815 and ILRI16817 varieties and but, it was similar (p>0.05) to ILRI16813 variety.

DISCUSSION

The higher dry matter yield and taller plant height from this study for *Pennisetum perpureum* grass varieties is due to high genetic potential of variety to adapt a given agro ecology. The previous studies reported by Xie *et al.*[16], Skerman and Riveros[17] were demonstrated that the wider range of dry matter yield difference between *Pennisetum perpureum* grass varieties could be attributed due to differences in genetic potential of varieties. The dry matter yield obtained from this study for all tested *Pennisetum perpureum* grass varieties was higher than previously reported values by Gemiyo *et al.*[10] which ranged from 12-18 t ha^{-1} for 10 elephant grass varieties under rain fed condition, Mamaru[14] reported 1.4-7 t ha^{-1} for ten elephant grass varieties rain fed condition. However, it was comparable to previously reported values by Skerman and Riveros[17] and Turano *et al.*[29] which ranged from 20-80 t ha^{-1} under high fertilizer input and irrigated condition. Furthermore, finding from this study for plant height was slightly comparable to previously reported values which ranged from 1.86-2.78 m by Mamaru[14] and higher than reported values which ranged from 0.58-0.82 m by De Carvalho *et al.*[30]. Moreover, Mamaru[14] reported that the tillering performance is an important morphological characteristic to be considered during selection of appropriate forage crops to improve production and productivity. The difference in tillers produced per plant among the varieties of *Pennisetum perpureum* grass from this study could be attributed to genetic variations among the varieties. The variation in tiller number among different varieties of *Pennisetum perpureum* grass was previously reported in central Kenya by Mwendia *et al.*[31]. The result on tillers per plant for *Pennisetum perpureum* grass varieties from this study were higher than reported values by Mamaru[14] which ranged from 9-12 tillers per plant from Ethiopia. Zewdu[11] from Ethiopia had reported that the leaf and stem fractions were affected by tillering performance, plant height and age of harvesting. The leaf fraction has significant implications on the nutritive quality of the grass as leaves contain higher levels of nutrients and less fiber than stems. The result indicated that the leaf fraction is an important factor affecting diet selection, quality and intake of forage Bayble *et al.*[23]. The leaf fraction is associated with high nutritive value of the forage because leaf is generally of higher nutritive value described by Feyissa *et al.*[32] and the performance of animals is closely related to the amount of leaf in the diet. Furthermore, the higher forage dry matter, plant height, tillers per plant and leaf fraction were observed at Dassanech location than Hamer location from this study is might be due to suitable temperature and favorable soil parameters in Dassanech location which make faster plant growth and triggering more leaves per plats which are responsible for more dry matter yield and other agronomic parameters. In supports to the result from this study, the previous studies reported had confirmed that forage dry matter yield of forage species greatly influenced by weather conditions such as rainfall, temperature and precipitations[33-35]. The difference for tested parameters over location by variety interaction effect for tested varieties is might be due to variability in climatic and soil condition which indicated that the genetic make-up of tested grass varieties were influenced by environmental factors which shows to us different varieties have differential response to different planting locations. The previous studies reported by Gamachu and Wekgari[36] and Anindo and Potter[37] were demonstrated that variety by environment interaction is the result of changes in cultivar's relative performance across environments due to differential responses of the genotypes to various edaphic, climatic and biotic factors and this is help to identifying suitable genotype for specific location. The similarity in crude protein content among the tested grass variety in to study area is due to similarity in make-up to accumulate similar nitrogen contents in a given environments reported by Zewdu *et al.*[38]. The higher protein content for ILRI16815, ILRI16813 and ILRI16817 from this study is due to higher leaf fraction. The previous studies reported by Kebede *et al.*[39] and Bediye *et al.*[40] were demonstrated that a high rate of decline in the proportion of leaves in relation to stems which resulted reduction in crude protein content of elephant grass varieties. The other studies reported by Singh *et al.*[41] and Mahala *et al.*[42] also indicated that the crude protein content of herbaceous species is higher at a young stage of growth than at maturity stage. The previously reported studies by Leng[43] and Smith[44] indicated that crude protein content of about 60-70 g kg^{-1}, DM is required for maintenance of ruminant livestock and whereas, the CP content of 80-130 g kg^{-1}, DM is required for moderate milk production (10-15 kg/cow/day) for dairy cows reported by ARC[45] and Humphhreys[46]. Therefore, the CP content obtained from our study for all tested grass varieties is above the maintenance requirement for ruminant livestock and enough to satisfy protein requirement for dairy Cow to produce 10-15kg milk/ cow/day. The neutral detergent fiber approximates the total cell wall constituents and is used to predict intake potential in livestock and whereas, acid detergent fiber primarily represents cellulose and lignin and is often used to calculate digestibility of feeds according to Van Soest[47]. The values obtained from this study for neutral detergent fiber was comparable to the previous study reported values which ranged from 57-76% reported by Cassoli *et al.*[22] and Babyle *et al.*[23]and while, acid detergent fiber was higher than previously reported values which ranged from 46.77-49.28% by Kebede *et al.*[39] for 10 Nipper grass accessions. Generally, the Singh and Oosting[48] and Kellems and Church[49] reported that feeds containing NDF values of less than 45% could be classified as high quality, those with values ranging from 45-65% as medium and those with values higher than 65% as low quality. Based on this classification most of tested elephant grass except ILRI16840 variety can be classified as low quality forages class and this is indicated that ruminant feeding system should be supplemented with legume forages.

CONCLUSION

The higher dry matter yield was recorded for the ILRI16840 variety and whereas, the lower dry matter yield was for ILRI16902 variety. Moreover, ILRI 16815 variety gave higher crude protein and ILRI 16902 and ILRI16840 varieties gave the lower crude protein. Based on result from this study, it was concluded that pastoralists and agro pastoralists who live in irrigated lowland areas of South Omo could plant both ILRI16840 and ILRI16815 varieties for higher dry matter yield and whereas, pastoralists and agro pastoralists could plant ILRI16815 variety followed by ILRI16913 and ILRI16817 varieties for CP production.

SIGNIFICANCE STATEMENT

This study identified the adaptability potential of the *Pennisetumperpureum* grass varieties to improve the dry matter yield availability for livestock to dry land area of South Omo. The findings from this study will be beneficial for livestock producers to improve nutritional shortfall and hence, improve livelihood of livestock producers. This study will also help the researchers to uncover the critical areas of livestock feeds that many researchers were not able to explore before.

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