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Agronomic Performance Evaluation of Elephant (*Pennisetum purpureum* L.) Schumach) Grass Cultivars for Fodder Production at Mechara Research Station, Eastern Oromia, Ethiopia

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Abstract: Ethiopia livestock production has been mainly constrained by inadequate supply and poor quality of available feed resources. Feed shortage is leading to low production and productivity of livestock products.Thisresearch was conducted at Mechara Agricultural Research center on- station for two consecutive 2016 and 2017 cropping years. The objective of the study was to identify the well adaptable and highherbage yielder of Elephant grass (*Pennisetum purpureum*) cultivars for fodder production in study area. The cultivars evaluated were ILRI #*16798, ILRI #*16800, ILRI #*16801, ILRI #*16840*, ILRI #*16787 and local check. The trial was arranged by Randomized Complete Block Design (RCBD) with three replications.The result of the study indicated that percentage of plot cover, biomass yield, number of leaf per plant, plant aspect, dry matter yield and number of node per plant were shown significance difference (P<0.05) among the cultivars. However, regeneration percentage, leaf to stem ratio, plant height and number of tiller per plant were not shown significance difference (P>0.05) among the cultivars. The highest dry matter yield was obtained from ILRI#16800 (31.17 t/ha) followed by ILRI#16840 (30.04 t/ha) and local (27.27 t/ha). The highest green biomass yield was also produced from ILRI#16800 (163.17 t/ha) followed by ILRI#16840 (157.3 t/ha) and local (143.17 t/ha). The dry matter yield was positively correlation with agronomic parameters in this study. Based on the study result, #16800 and ILRI#16840 genotypes were well adapted and performed under Mechara condition. From the overall results, #16800 and ILRI#16840 genotypes were recommended for further demonstrated and scaled-up for Mechara areas and similar agro-ecologies of Western Hararghe areas.

Key words: Cultivars · Dry Matter Yield · Elephant Grass · Hararghe · Leaf to Stem Ratio

INTRODUCTION

Livestock production is an integral part of subsistence crop - livestock mixed farming systems of Ethiopia. Despite Ethiopia having a largest livestock population in Africa 1, the productivity of livestock is low. The major constraint that influences productivity of livestock isshortage of both quality and quality of feed resource 2. Due to poor quality and provide inadequate protein, energy, vitamins and minerals 34. For the combat of existing livestock feed resource constraints, one option is to adapt and popularize improved animal forage plants which have high quality and produced high biomass as they familiar to smallholder farmers, grow with low inputs and suitable with agro-ecological conditions 5. Because forages production is essential in animal production systems it is known as a cost-effective feed rather than commercial concentrate 67. The substitution of forage to concentrate from 30 to 70% in dairy cattle diet could reduce up to 30% cost of production 8.

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Napier grass (*Pennisetum purpureum* L.) Schumach), also known as elephant grass, originated from sub-Saharan tropical Africa 9. Napier grass is a tall and deep-rooted perennial bunch grass well known for its high yielding capability and mainly used for cut-and-carry feeding systems 10 and fed installs, or it is made into silage or hay. It is a C4 type tropical grass and commonly used as ruminant feedstuffs and continuous supply for the animals during a shortage of feed as well as preserving the quality of the grasses due to its promising yield 11. It is adaptable, vigorous, highly productive and withstands considerable periods of drought. Napier grass yielded from 9 to 12 tones dry matter yield (DMY) ha^{-1} cut^{-1} with a cumulative mean of more than 20 tones ha^{-1} yr^{-1}. 1213.

In West Hararghe zone, low access to improved forage grasses, poor extension services on livestock forages and feed scarcity are the major constraints in livestock production. Despite this, livestock fattening (oxen and goat) practices, dairy cattle production and goat production are the major livestock production systems found in the area. The cut and carry system is one of the feeding systems found in the area due to the absence of grazing land and land shortage in the area. The farmers are used industrial by-products, crop residues, local grasses and natural pasture to feed their livestock in the area 14.

Most farmers of the western Hararghe establish Napier grass on soil bund, roadside and in their arable land. This enthusiasm of farmers was very inspired, however, the grass was adapt years ago. Therefore, the quality was segregated and some farmers that claim, Elephant grass is decreasing the soil fertility of the land. However, the reality Napier grass characterization is resisting drought due to had ability to uptake water from the soil, therefore it needs up cutting interval addition of fertilizer for maintenance and rotate the crop even at five years. Some farmers also found local grass from schools, religious institutions and communal lands through purchasing by their own money. However, this pasture also lows in quality and quantity. Therefore, this experiment was designed to select the best adaptable, high biomass and nutritive values of five accessions and one local variety under rain feed conditions.

MATERIALS AND METHODS

Description of Mechara Agricultural Research Station. The trial was undertaken in Mechara Agricultural Research Center (McARC) during the 2016– 2017 cropping season consequently for two years. It found 40° 19' and latitude and 08° 35' E longitude with an altitude of 1, 700 meters above sea level. Mechara Agricultural Research Station has been located 434 km east of Addis Ababa in Daro Labu district, West Hararghe zone of East Ethiopia. The major soil type of the station is sandy loam with a reddish color. The ambient temperature of the center ranges from 14 to 26°C with an average of 16°C with an average annual rainfall of 96 mm/year 15.

Source of Planting Material and Experimental Design: The experiment was conducted during the 2016 and 2017 cropping seasons. Five Napier (P*ennisetum purpureum*) grasses were brought from Bako Agricultural Research center in western Oromia and planted at Mechara Agricultural Research center in Eastern Oromia with one local check of Napier grass for performance and adaptability evaluation. The Napier grass cultivars were ILRI #*16798, ILRI #*16800, ILRI #*16801, ILRI #*16840*, ILRI #*16787 and local check. These experimental materials were arranged with Randomized Complete Block Design (RCBD) with three replications. The local check was widely adopted under farmer's conditions and used as a control to compare the performance of cultivars in the study area. A single plot of 3m x 4.5m ($13.5m^2$) containing four rows, each row 1m apart and planted 0.5 within rows.

Land Preparation and Planting: A total area of 324.5 m^2 was prepared for this experiment. The land was ploughed in February and harrowed in June 2016. The prepared experimental land was divided into three blocks, which consist of about eighteen (18) plots with each plot measuring $13.5m^2$ areas. The cultivars were planted using vegetative cutting methods in 4 rows on well-prepared soil. To plant the materials uniform cutting was buried in soil up to 15-20cm deep at an angle of 45°. The spacing between rows and plants was 1m and 0.5m, respectively. Land preparation, planting, weeding and harvesting were done according to the requirement of crops. Blanket basal phosphorus fertilizer was uniformly applied to all plots in the form of diammonium phosphate (DAP) at the rate of 100kg/ha during planting and urea were applied after establishment at the rate of 50 kg/ ha and 25kg/ha for maintenance at each harvesting cycle. Weeding and all other related crop management practices were uniformly applied accordingly requirements by crop manually.

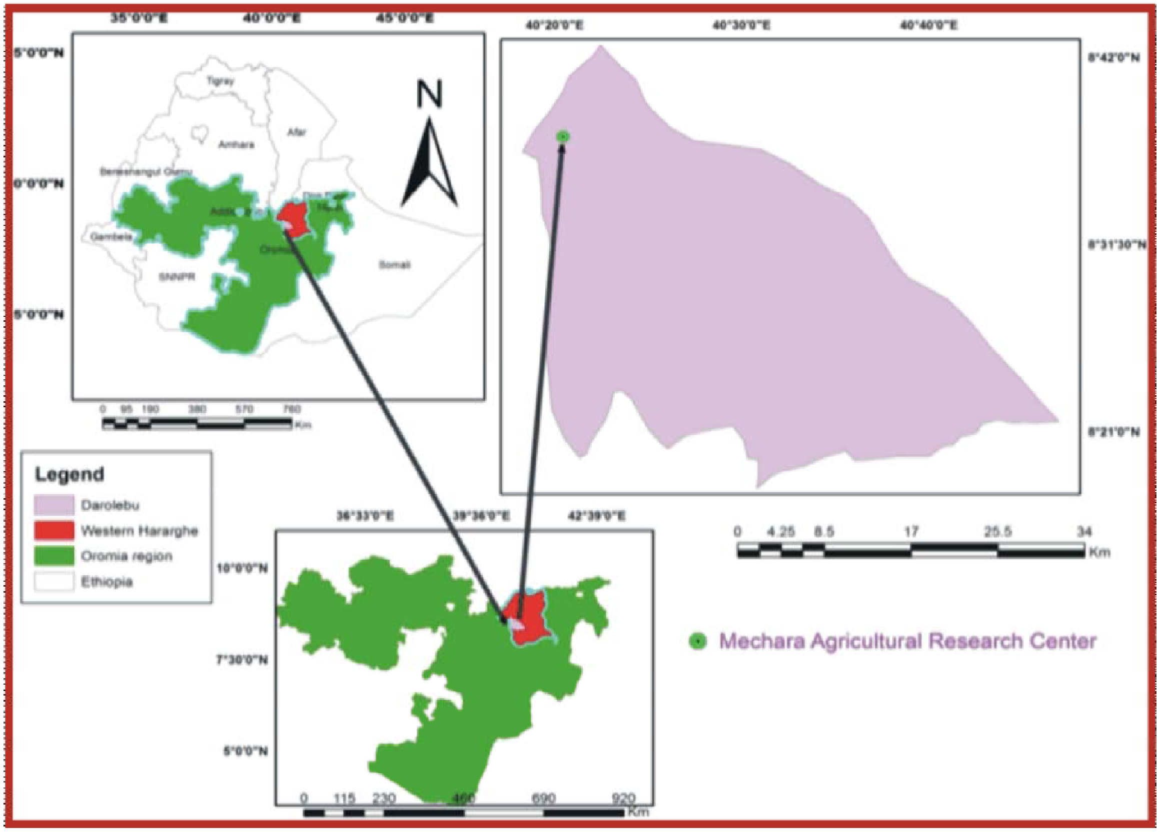

Fig. 1: Map of study area

Agronomic Data Collection: The agronomic data taken during the experimental trial was including regeneration percentage, plant aspect (stand vigor), plot cover percentage, leaf to stem ratio, biomass yield, tiller number and dry matter yield. Plant aspect (Vigor) was rated visually on the scale of 1 = excellent to 5 = Poor. Five plants in each treatment were randomly selected to record the number of tiller per plant (NTPP). Tiller numbers were recorded as randomly selected five plants from each treatment. Leaf to stem ratio was calculated after the division of leaf weight to stem weight. Plant height was based on five culms taken randomly in each plot, measured using steel tape from the ground level to the highest leaf. Biomass yield was determined as harvested forage at the harvesting stage from two rows next to the guard rows of 5 to 10cm above the ground level then converted to total plat yield and hector. To evaluate dry matter yield the samples taken from each plot was weighed to know their sample fresh weight and then oven-dried overnight at a temperature of 105°C.

Statistical Analysis: The difference among cultivars was tested using the analysis variance (ANOVA) procedure of SAS version 9.0 with General Linear Model (GLM) to compare treatment mean. The mean separation among treatments was carried out using the least significance difference (LSD)test at 5% probability level. The statistical model for the analysis data was:

$$Yijk = \mu + Aj + Bi + eijk$$

where;

Y_{ijk} = response of variable under examination
μ = overall mean
A_j = the j^{th} factor effect of treatment/ cultivars
B_i = the i^{th} factor effect of block/ replication
e_{ijk} = the random error

RESULTS AND DISCUSSION

Performance of Elephant Grass: The performances of Elephant grass at Mechara research station were presented in Table 1. The result was not indicated a significant difference (P>0.05) in regeneration percentages among Elephant grass cultivars. This indicated that the environment was suitable for all genotypes and could adapt to a wide range of agroecology. This result was supported by Jones *et al*. 16 who reported that Elephant

Table 1: Performance of Napier grass at Mechara research station

Treatment	R%	PC%	BMt/ha	NLPP	LSR	Ph	PA	NTPP	DMY	NNPP
ILRI#16840	90.67	90.67^{ab}	157.3ab	12.33^{a}	0.67	106^{a}	2^{abc}	27.8^{ab}	30.04^{ab}	15.33^{c}
ILRI#16798	55.95	88.33^{b}	104.8^{d}	12.73^{a}	0.62	101^{ab}	1.67^{bcd}	26.2^{ab}	20.02^{d}	18.67^{b}
ILRI#16801	51.24	97^{a}	133.77^{bc}	14^{a}	0.57	102^{ab}	1^{d}	32.47^{ab}	25.55^{bc}	22.33^{a}
Local	58.33	75^{c}	143.17^{cd}	12.43^{a}	0.64	98.33^{ab}	2.33^{ab}	22.27^{b}	27.35^{abc}	16.33^{bc}
ILRI#16787	45.25	78.33^{c}	120.47^{cd}	10.07^{b}	0.88	84^{b}	2.67^{a}	37.4^{a}	23.01^{cd}	14^{c}
ILRI#16800	54.77	93^{ab}	163.17^{a}	12.73^{a}	0.79	101^{ab}	1.33^{cd}	26.6^{ab}	31.17^{a}	19^{b}
Mean	50.8	87.06	137.11	12.47	0.7	98.72	1.83	28.79	26.19	17.61
CV%	33.71	5.3	9.95	7.67	29.83	11.2	26.35	22.66	9.95	8.78
LSD	31.16	8.39	24.81	1.74	0.38	20	0.84	11.87	4.74	2.82
Sing.	0.74	0.001	0.003	0.01	0.5	0.29	0.015	0.16	0.003	0.0007

*=significance difference at 0.05, **= significance difference at 0.01, ***= significance difference at 0.0001, R= Regeneration percentage, PC%= Plot cover percentage, NLPP= Number of leaf per plant, LSR= Leaf to stem ratio, Ph = Plant height, PA= plant height, TNPP= Tiller number per plant, DMY= Dry matter yield, NNPP= Number of node per plant

grass is a native plant species in tropical; therefore, it is highly adapted to different ecological and environmental conditions.

The analysis of the result indicated that there was shown strongly significant difference (P>0.01) on green biomass yield per hector among six Elephant grass cultivars considered in this study. This difference was indicated the genotype's potential for green fodder production among cultivars. The highest green biomass yield was recorded from ILRI#16800 (163.17 t/ha), followed by ILRI#16840 (157.3 t/ha) and local (143.17 t/ha).

The listed square mean for the number of leaf per plant were shown a significant difference (P>0.05) among cultivars of Elephant grass considered in this experiment. The highest number of leaf per plant was recorded from ILRI#16800 (12.73) and ILRI#16798 (12.73) followed by ILRI#16840 (12.33). This result on the mean value for some leaf per plant was lower than Rambau *et al*. 17 who reporters the mean value for Napier grass at a different stage of maturity (early 70.6, 88.9 intermediate, 104.5 late mature).

The analysis of variance was not indicated significance dereference (P>0.05) on the leaf to stem ratio among elephant grass cultivars considered in this experiment. However, there were shown numerically different list square mean values among Elephant grass ecotypes evaluated in this experiment. The highest mean of the leaf to stem ratio was produced from ILRI#16787 (0.88) followed by LRI#16800 (0.79) and ILRI#16840 (0.67). In the present study, the LSR ranging from 0.57 (ILRI#16801) to 0.88 (ILRI#16787) were different from the range of ratios reported by Deribe *et al.*18 who reported that 0.31 to 1.01 and Elkana *et al.*19 reported that 1.7 to 3.1 was might be due to varietal differences of Elephant grass.

The analysis of variance was not shown a significant difference (P>0.5) in plant height among cultivars. However, the least square means value among thus cultivars was recorded differently. The highest plant was recorded from ILRI#16840 (106cm) followed by ILRI#16801 (102 cm). In otherwise lowest plant height was recorded from ILRI#16787 (84cm). This current result was comparable with Kebede *et al*. [18] who reported different mean values of Napier grass height at a different location/agroecology of Areka (106.67cm), Holota (96.3cm), Adami Tulu (110.75cm).

The ANOVA table indicated that there was no significant difference (P<0.05) on plant aspects between the cultivars evaluated in this trial. Plant aspect is including uniformity, vigorous, stand count and performances of crops. All parameters depend on genetic makeup and external factors/management practices. The good plant aspect was recorded from ILRI#16801 (1.00) followed by ILRI#16800 (1.33).

The least-square mean value for the number of tillers per plant among cultivars was not shown a statistical significance difference (P>0.05). However, numerically the number of tiller per plant among cultivars was different. The highest number of tiller per plant was produced from ILRI#16787 (37.4) followed by ILRI#16801 (32.47). Similarly, Rambau *et al*. 17 report that the number of tillers and leaves per plant did not show a significant difference (*P* >0.05) on different Napier grass genotypes. These numbers of tiller per plant obtained from the current trial were lower than Tessema 20 who reported the highest number of tiller per plant from Napier grass (62.3). This difference might be due to plant density, age harvesting and genotypes difference. The number of leaves per plant and number of tillers per plant is increased with the maturity of the grass Rambau *et al*. 17.

The least-square mean value of Dry matter yield was shown a highly significant difference (P<0.01) among Elephant grass cultivars considered in this experiment.

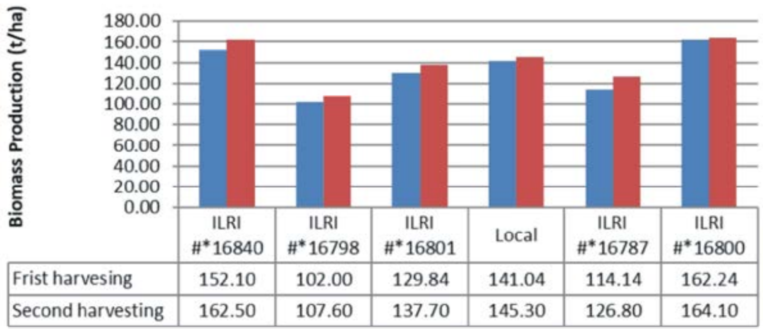

Fig. 2: Fresh biomass production of Elephant grass cultivars

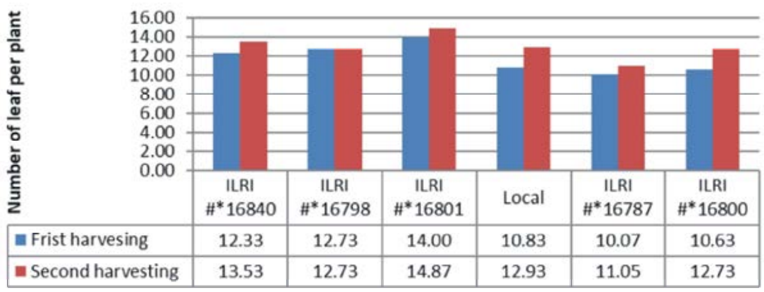

Fig. 3: Number of leaf per Elephant grass cultivars

This dry matter yield variation might be based on the genetic makeup of the crops. The highest dry matter yield was obtained from ILRI#16800 (31.17 t/ha) followed by ILRI#16840 (30.04 t/ha) and local (27.27 t/ha). In this study, dry matter yield was higher than Diriba and Adugna 21 who report 11.04 to 14.71 of herbage dry matter yield under sub-humid climatic conditions of Ethiopia. This differential result was supported by Rengsirikul *et al*. [22] and Utamy *et al*. [23] who reports the performance and yield of Napier grass are heavily influenced by agro-ecology, climatic conditions, management practices and other edaphic factors. According to Kebede *et al.* [8], the most significant factor affecting DM production of Napier grass is the environment, followed by genotype by environment interactions and then the genotype.

Performance of Six Elephant Grass Cultivars During First and Second Harvesting Year

Biomass Production (t/ha): The average biomass (herbage) yield during first and second-year harvesting was shown in Fig. 2. According to the result in the figure was indicated, almost all cultivars were produced more fresh biomass production during the second harvesting year than the first. The highest fresh biomass production during this study period was produced from ILRI#1640 and followed by ILRI#16800 cultivars. In otherwise lowest fresh biomass was produced by ILRI#16798 cultivar. This fresh biomass production difference might be due to genetic potential production and adaptability of genotypes to location/ ecology.

Number of Leaf per Plant: The average number of leaf per plant among cultivars was presented in Figure 3. As the result in the figure indicated that the second harvesting year was recorded a higher number of leaf per plant from all Elephant grass cultivars considered in this experiment. The highest number of leaf per plant during experimental periods was recorded from ILRI# 16801 (14 first and 14.87 second harvesting year).

Plant Height (cm): The mean value of plant height among cultivars was presented in Figure 4. As the result in the figure indicated, there was no more difference means value difference among the first and second harvesting time. This might be due to harvesting at the same stage of maturity. However, thehighest plant height was produced by ILRI # 16840 and ILRI # 16800 cultivars.

Leaf to Stem Ratio: The mean value of stem to leaf ratio among Napiergrass cultivars was presented on Figure 5. During the first and second harvest, the leaf to stem ratio of ILRI # 16840 and ILRI # lines were 0.7; 0.67 and 0.87;0.79, respectively. Relatively, this result was comparable with Tessema 20 who reports that 0.94, 0.95 and 0.90 from a different population of Napier grass at Haramaya University, Ethiopia.

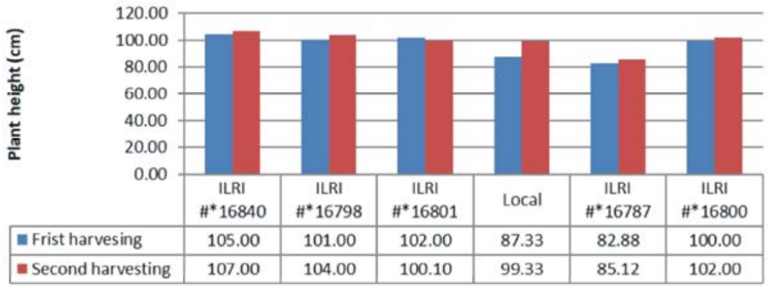

Fig. 4: Plant height (cm) of Elephant grass cultivars

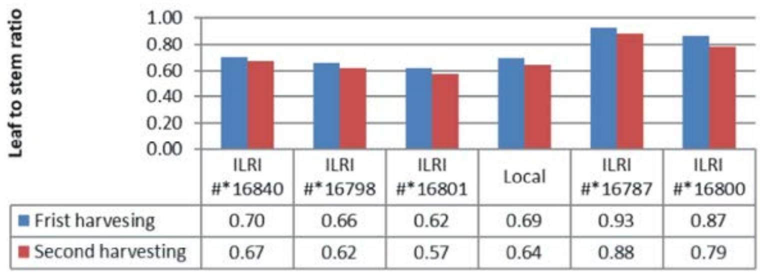

Fig. 5: Leaf to stem ratio of Elephant grass cultivarsNumber of tiller per plant: The mean value of tiller number

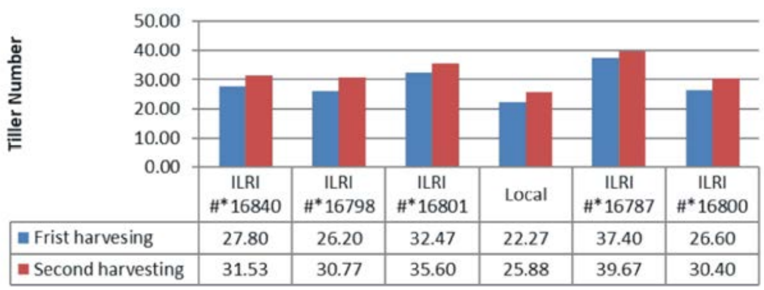

Fig. 6: Tiller number of Elephant grass cultivars

Table 2: Correlation between agronomic components of Elephant grass cultivars

	R	BY	NLPP	LSR	Ph	PA	NTPP	DMY
R	1							
BY	0.19	1						
LNP	0.11	0.16	1					
LSR	0.03	0.08	0.52*	1				
Ph	-0.3	0.18	0.58**	-0.65**	1			
PA	-0.077	-0.16	-0.64**	0.32	-0.47*	1		
TNPP	-0.54*	-0.28	-0.17	0.22	-0.16	0.25	1	
DMY	0.19	1***	0.16	-0.03	0.18	-0.16	-0.28	1

*=significance difference at 0.05, **= significance difference at 0.01, ***= significance difference at 0.0001, R= Regeneration, BY= Biomass yield, NLPP= Number of leaf per plant, LSR= Leaf to stem ratio, Ph = Plant height, PA= plant aspect, NTPP= Number of tiller per plant, DMY= Dry matter yield

Number of Tiller per Plant: The mean value of tiller number per plant among cultivars was presented in figure 6. As the result obtained from all Elephant, grass cultivars were indicated, the number of tiller per plant was increased from first to second harvesting year. This might be due to the nature of perennial crops, which produce more tillers and high vegetative growth up to half lifetime. This idea is supported by Tessema 24 and Ndikumana 25 who test on different Napier grass accessions in the northwestern parts of Ethiopia and many African countries.

Correlation of Elephant Grass Agronomic Parameters: The correlation of agronomic attribute with dry matter yield was presented in Table 2. Nonetheless, dry matter yield is a more meaningful way of comparing fodder yield.

From the study, Pearson's correlation coefficients of dry matter yield were indicated a significant difference ($P<0.001$; $r=1$) only between biomass yield. The analysis result of regeneration percentage, number of leaf per plant, leaf to stem ratio, plant height, plant aspect, number of tiller per plant were shown a weak correlation coefficient with the dry matter. Dry matter yield was a positive correlation with regeneration percentage, biomass yield, number of yield per plant and plant height, however, negative correlation with a leaf to steam ratio, plant aspect and number of tiller per plant.

CONCLUSIONS AND RECOMMENDATIONS

The plot cover, biomass yield, leaf number per plant, plant aspect and dry matter yield were affected by deferent Elephant grass cultivars. However, regeneration percentage, plant height, leaf to stem ratio and a number of tillers were not affected by Elephant grass cultivars. In general, dry matter yield is a positive correlation with agronomic parameters. Among the cultivars, ILRI#16800 and ILRI#16840 were well performed, produced more fresh biomass yield, a higher number of leaf per plant, leaf to stem ratio and dry matter yield. Hence, it was concluded that the cultivars of ILRI#16800 and ILRI#16840 were found promising to be scaled up/out along with the previously adapted local Elephant grasses for smallholder households under similar climatic conditions within Mechara Agricultural research center in the future demonstration. These selected Elephant grass cultivars were recommended as further demonstrated and scaled-up/out at Mechara on-farm condition and similar agro-ecologies of Hararghe areas.

Conflict of Interest: The authors stated that there is no conflict of interest between authors and the organization.

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