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Adaptation and Performance Evaluation of Released Napier Grass Varieties under Rain Fed Condition, in Gambella Region, Ethiopia

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Abstract— *Five Napier grass varieties were evaluated for agronomic performance and yield at Abobo agricultural research center under rain fed condition in Gambella. The experiment was conducted in randomized complete block design with three replications. Data on agronomic parameters such as plant height, survival rate, leaf to stem ratio, node number per plant, internodes length per plant, tillering performance and dry matter yield were analyzed using general linear model(GLM) procedure of SAS, least significant difference (LSD) at 5% was used for mean separation. Combined analysis indicated that tested varieties varied significantly ($p<0.05$) for survival rate, plant height, leaf to stem ratio, tillering performance, internodes length per plant and dry matter yield. The highest plant survival rate (86.33%) was recorded for Check followed by varieties 16819(73.60%), 16984(71.92%), and 16791(67.83%) respectively. On the other hand, variety 15743(66.67%) showed the lowest plant survival rate. The mean plant height ranges from 2.09m to 2.49m with an overall mean plant height of 2.31m. The tallest mean plant height (2.49m) was recorded in 15743 while shortest mean plan height (2.09m) was recorded in check. The mean leaf to stem ratio range from 1.71 to 1.28 with the overall mean of 1.52, and The higher leaf to stem ratio value (1.71) were recorded from check, followed by 16984(1.67), 15743(1.59), 16819(1.35) while the lowest value were recorded in 16791(1.28). In a combined analysis the mean dry matter yield range from 20.02 t/ha to 14.05 t/ha with the overall mean of 16.24 t/ha. The higher dry matter yield value (20.02 t/ha) were recorded from 16819, followed by 16791(16.77t/ha) and check (16.12t/ha) respectively. The lowest mean dry matter yield were recorded in 16984(14.05 t/ha) and 15743(14.26t/ha). Generally, Napier grass varieties tested has shown variation for agronomic performance and yield under rain fed condition in Gambella*

Keywords— ***Agronomic performance, Napier grass, Varieties, Rain fed, Dry matter yield***

I. INTRODUCTION

Livestock production contributes up to 80 percent of farmers' income in Ethiopia and about 20 percent of agricultural GDP. Ethiopia has the largest livestock population of any country in Africa (Mengistu *et al.*, 2016). Ethiopian smallholder farmers have traditionally relied on natural open grazing animal feed practices. Although, Ethiopia has one of the highest livestock

populations in Africa, it lacks modern and improved livestock feeding practices. As a result, current livestock productivity is low, while the cattle population continues to rapidly increase in both the highlands and lowlands of the country (Tekalign, E. 2014). Sustainable livestock and crop production in Ethiopia is dependent on drastic changes in livestock and land management systems. More efficient integration of livestock and cropping systems is essential to improve livestock productivity and sustainability of the mixed system. The key components of these changes are a shift towards more intensive feeding systems, with more emphasis on cut and-carry feeding, forage production in the midlands and highlands, and to rationalized grazing, particularly in the lowlands areas (Alvarez Aranguiz, A., and Creemers J., 2019).

Nutritional factors are the binding constraint to sustaining livestock production in the country. During the latter part of the dry season, livestock feed is normally in short supply and is also of poor quality (Mengistu *et al*., 2016). The amount and quality of available feed will be one of the key determinants of the future livestock development Potential of the country (Shapiro B.I., 2017). Improved feed supply, quality and feeding practices would increase animal productivity and production. In addition to their feed value, improved forage species also play an important role in minimizing greenhouse gas (GHG) emissions from livestock, improve soil fertility, reduce soil erosion and ensure better crop–livestock integration (Eshetu Y. and Teklu K., 2015). The ultimate goal of improved forage introduction, collection and evaluation is to release superior species/varieties/ cultivars for wider utilization as feed and natural resource conservation in the farming system in a suitable agro-ecology (Fekede et al., 2018).

Gambella Regional state is one of lowland part of Ethiopia, dominated with Agro pastoral production system and the livestock feeding system has been entirely depended on rangeland feed resources which could not provide nutrients requirements beyond their maintenance requirement due to seasonal feed variability in quantity and quality (Emana, *et al*.,2017). Therefore, in order to mitigate such a nutritional deficient during dry period and improve livestock productivity performance, it is importance to introduce and evaluate improved forage grass species. Among the improved forage species evaluated and released in Ethiopia, and intended for this study to be evaluated in Gambella is Napier grass (*pennisetum purepueum*). Napier or Elephant grass (*Pennisetum purpureum*) is widely distributed in tropical and subtropical regions of the world, and is highly productive in areas with good soil fertility and high rainfall, growing well up to or <2,000 masl (Kumar 2013 ; Kesang, et al 2015; Mengistu et al., 2016). Elephant grass is fast growing and has a high annual productivity that depends on climatic and soil conditions. Yields ranged from 20 to 80 t/ DM/ha/year under high fertilizer input. On farm dry matter yields of elephant grass from different regions averages about 16t/ha/year and with no or inadequate fertilizers, yields are on the range of 2 – 10 t DM/ha/year as reported by (Muhammad, 2016). However, in the study area, there is no documented information on the performance evaluation and adaptability of Napier grass varieties under rain-fed conditions. . Thus, the present study was intended to evaluate Elephant-grass varieties for agronomic-parameters.

II. MATERIALS AND METHODS

Description of the Test Environment

The study station is located in Abobo District, located at a distance of 42 km south of Gambella town and about 808 km from Addis Ababa in the western direction. It lies between 07° 50′ 47.3″ to 08° 01′ 59.3″ N and 34° 28′ 59.5″ to 34° 34′ 37.1″ E. The altitude of the study area ranges from 446 to 490 meter above sea level (masl) with slope ranging from level (0.2-0.5%) to gently sloping (2-5%). The climate of the region is influenced by the tropical monsoon which is characterized by high rainfall in the wet period from May to October and has little rainfall during the dry period from November to April. The mean minimum monthly temperature of the area varies from 16.2 to 21.2°C and the mean maximum monthly temperature ranges from 32.1 to 38.2°C, whereas the average annual rainfall is 955.5 mm (table 1).The geology of Abobo is characterized by

undifferentiated Pleistocene Holocene deposits. Granite, gneisses, schist, sandstone and basalt are the rock types existed in the region. The major soils of Abobo District include Dystric and Eutric Plinthosols, Dystric and Chromic Cambisols, Eutric Vertisols and Planosols, where Cambisols occur at the upper slope north of Abobo while Plinthosols and Vertisols exist at the middle and lower slopes, respectively (Yitbarek et al., 2017)

Experimental design and layout

The four released varieties of Napier grass (ILRI-16819, ILRI-15743, ILRI-16984, ILRI-16791) and local check were used for this experiment. The planting materials of the varieties were collected from Holleta Agricultural Research Center. The varieties were tasted on station of Abobo Agricultural Research Center under rain fed condition during main cropping season from 2021/22 to 2022/23. Each grass varieties were drilled on plot area of 4 m x 3m = ($12m^2$) in completely randomized block design (RCBD) with three replications and the varieties assigned randomly to plots within block. Root splits were planted in a four rows per plot at a distance of 100cm and 50cm inter and intra row spacing respectively at the start of the main rains in June. There were an alleyway of 2 m width between blocks and 1m width between plots.

Crop Management and Data Collection

The crop management practice like hoeing, weeding and diseases and pest inspection were carried out and continuous monitoring was done every day in a week during the whole trial period. The agronomic data collected includes plant survival rate, number of tillers per plant, plant height, forage DM yield, leaf to stem ratio, number of nodes per plant and inter node length per plant. Plant survival rate were calculated as the ratio of the number of a live plant per plot to the total number of plants planted per plot and then multiplied by 100. The number of tillers was measured after harvesting. Plant height were measured based on five culms taken randomly in each plot, measured using a steel tape from the ground level to the highest leaf. For determination of biomass yield, the optimum harvesting stage, when the plant reaches to 1m height. When the plant reaches 1m height, the varieties were clipped at 5cm from the ground level from two rows next to the guard rows. Weight of the total fresh biomass yield (500 g sample) was recorded from each plot in the field manually fractionated in to leaf and stem.

Table 1: description of the test environment for soil characteristics and geographical position

SN	Parameters	Abobo
1	Altitude	470.74
2	Longitude	34° E
3	Latitude	7° N
4	Distance from Addis Ababa	751 km
5	Daily minimum temperature(^{o}c)	38.2
6	Daily maximum temperature(^{o}c)	21.2
7	Annual rain fall (mm)	955.5
8	Soil type	Clay loam
9	Texture class	Clay
10	PH	7.1
11	Total organic matter (%)	2.98
12	Total nitrogen (%)	0.24
13	Available phosphorus (ppm)	0.22

The morphological parts were separately weighed to know their sample fresh weight, oven dried for 24 hours at a temperature of 105^{o}c and separately weighed to estimate the proportions of these morphological parts. Accordingly, leaves were separated from stems and the leaf to stem ratio (LSR) was estimated based on the dry weight of each component. Number of nodes per plant and inter node length (cm) was taken from five randomly selected plants per plot.

In order to measure dry matter yield, the harvested fresh sample was measured right in field by sensitive weight balance and 300g subsample per plot was brought to Bore Agricultural Research Center and

sampled sample was placed to oven dried for 72 hours at a temperature of 65°C for dry matter determination.

Then dry matter yield (t/ha) was calculated by formula.

The dry matter yield (t/ha) = TFW × (DWss /HA × FWss) ×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 and 10 is a constant for conversion of yields in kg/m to t/ha.

Statistical analysis

Differences among accessions were tested using analysis of variance (ANOVA) procedures of SAS general linear model (GLM) to compare treatment means (SAS, 2002). Least significance difference (LSD) at 5% significance level was used for comparison of means. For the data for combined analysis, the following model was used:

$Yijk = \mu + Vi + Yj + (VY)ij + Bk(j) + eijk;$

Where, Yijk = measured response of varieties i in block k of year j; μ = grand mean; Ai = effect of varieties i; Yj = effect of year j; VY= varieties by year interaction; Bk (j) = effect of block k in year j; eijk = random error effect of varieties i in block k of year j.

For each year analysis, the model was used:

$Yij = \mu + Vi + Bj + eij;$

Where, Yij = measured response of varieties i in block j; μ = grand mean; Ai = effect of accession i; Bj = effect of block j; eij = random error effect of varieties i in block j.

Table 2: Mean Survival rate of Napier grass varieties during the experimental periods in Abobo Research station

SN	Varieties	Year		Combined mean over years
		2021/22	2022/23	
1	16819	82.20[a]	65.00[a]	73.60[ab]
2	15743	61.67[b]	71.67[a]	66.67[b]
3	16984	78.83[a]	65.00[a]	71.92[ab]
4	16791	62.33[b]	81.67[a]	67.83[b]
5	Check	84.33[a]	88.33[a]	86.33[a]
	Mean	73.87	74.33	73.27
	CV%	11.28	20.55	20.25
	LSD	15.69	28.77	17.99
	p-value	0.0179	0.4282	0.2316

Means followed by different superscript letters within a column are significantly different from each other at P<0.05

III. RESULT AND DISCUSSION

Establishment Performance of Napier Grass Varieties

The performance of Napier grass varieties tested over years at Abobo is indicated in Table (2). The result of combined analysis showed that the survival rate was not statistically varied significantly (p>0.05) among the tested varieties. This result is in line with the finding of Gadisa B., *et al* (2021), who reported that lack of variation indicated that the environment was suitable for all genotypes and could adapt to a wide range of agro ecology. The highest plant survival rate (86.33%) was recorded for Check followed by varieties 16819(73.60%), 16984(71.92%), and 16791(67.83%) respectively. On the other hand, variety 15743(66.67%) showed the lowest plant survival rate. The current study combined mean survival rate of Napier grass during the two years of experimental period was 73.27%, and Similar result was reported by Kebede G. *et al.*, (2016), that the average survival rate of Napier grass during the three years of experimental period was 73.8%

and the reduction in the number of plants did not affect the herbage yield of the grass, and this could be attributed to the vigorous growth performance of the tillers produced by the remaining stands. Mijena D. and Getiso A., (2023), cited that the growth and development of crops are significantly impacted by agro-metrological factors such as rainfall, soil and air temperatures, wind, relative humidity or dew point temperature, and sun radiation.

Table 3: Mean number of tillers of Napier grass varieties tested at Abobo Research station

SN	Varieties	Year		Combined mean over years
		2021	2022	
1	16819	15.63^{c}	55.20^{b}	35.42^{ab}
2	15743	12.20^{c}	60.07^{b}	36.13^{b}
3	16984	26.90^{a}	57.43^{b}	42.17^{b}
4	16791	15.15^{c}	57.17^{b}	36.16^{b}
5	Check	22.40^{c}	93.16^{a}	56.45^{a}
	Mean	18.46	64.61	41.26
	CV%	12.58	11.81	15.08
	LSD (5%)	4.37	14.36	7.55
	p-value	0.0005	0.0033	<.0001

Means followed by different superscript letters within a column are significantly different from each other at P<0.05

Number of tillers per plant

The mean number of tillers per plant of the tested Napier grass varieties is indicated in Table (3). Tillering performance is an important morphological characteristic to be considered during selection of appropriate forage crops to improve production and productivity. In a combined analysis the mean number of tiller per plant among varieties were shown statistically very significance difference (p<0.05). The higher number of tillers per plan (56.45) were recorded from check followed by 16984(42.17), 16791(36.16) and 15743(36.13) while the lowest value were recorded in 16819(35.42) and it range from 35.42 to 56.45 with overall mean of 41.26. The difference in tillers produced per plant among the accessions of Napier grass could be attributed to genetic variations among the accessions and their interactions to the environment. Tillering performance also varies with production years due to variation in distribution and amount of rainfall (Kebede *et al.,* 2017).

Plant height (M) at forage harvesting

The mean plant height of the tested Napier grass varieties is indicated in Table (4). In a combined analysis, the mean average of plants height of the tested varieties were significantly (P<0.05) different between treatment, and it ranges from 2.09m to 2.49m with an overall mean plant height of 2.31m. Generally, the tallest mean plant height (2.49m) was recorded in 15743 while shortest mean plan height (2.09m) was recorded in check. This result was almost agreed with result reported by Denbela *et al.,* (2022) under rain fed condition in South Omo, Ethiopia with an average mean of 2.12m. Mijena D. and Getiso M, (2023) reported nearly similar result with a combined mean plant height of 250.9cm in the rift valley of Ethiopia. According to report by Getiso A. and Mijena D., (2021), the mean plant height which ranges from 2.0m to 2.66m under rain fed condition in Wendo Genet. B.P. Singh *et al.*, (2013) has reported existence of a considerable amount of variation among elephant grass accessions for stem

thickness as well as another desirable trait, plant height. The various cutting studies with Napier grass revealed that both the choice of cutting interval and height of cutting are crucial to their performance and found that the main factor affecting growth, yield and persistence of swards is the defoliation intensity (Lounglawan *et al.*, 2014).

Table 4: Mean plant height (m) of Napier grass varieties tested at Abobo Research station

SN	Varieties	Year		Combined mean over years
		2021	2022	
1	16819	2.36a[b]	2.47[ab]	2.41[ab]
2	15743	2.31a[b]	2.67[a]	2.49[a]
3	16984	2.03[b]	2.32[ab]	2.18[bc]
4	16791	2.50[a]	2.30[ab]	2.40[ab]
5	Check	190[b]	2.20[b]	2.09[c]
	Mean	224	2.39	2.31
	CV%	10.62	825	8.93
	LSD	0.45	0.37	0.25
	p-value	0.19	0.2109	0.0320

Means followed by different superscript letters within a column are significantly different from each other at P<0.05

Table 5: Mean number of nodes per plant of Napier grass varieties tested at Abobo Research station

SN	Varieties	Year		Combined mean over years
		2021	2022	
1	16819	9.33[ab]	10.53a	9.93[ab]
2	15743	5.42[b]	11.33a	8.38[b]
3	16984	8.67[ab]	9.33a	9.30[ab]
4	16791	9.40[a]	10.87a	10.13[ab]
5	Check	11.50[a]	10.40a	10.95[a]
	Mean	8.86	10.61	9.74
	CV%	23.72	14.27	19.51
	LSD	3.96	2.85	2.30
	p-value	0.1188	0.7417	0.0733

Means followed by different superscript letters within a column are significantly different from each other at P<0.05

Node number per plan (cm)

The mean node number per plant of the tested Napier grass varieties is indicated in Table (5). The mean node number per plant among tested varieties did not shown significance difference (p>0.05). In a combined analysis of the present study the mean node number per plant range from 8.38 to 10.95 with the overall mean of 9.74. The highest mean node number per plant (10.95) were recorded from check followed by 16791(10.13), 16819(9.93), and 16984(9.30) while the lowest value were

recorded in 15743(8.38). The result of current finding agreed with the report by (Kebede *et al.,* 2017).

Internodes length per plan (cm)

The mean internodes length per plant of the tested Napier grass varieties is indicated in Table (6). In a combined analysis the mean internodes length per plant among tested varieties were shown significance difference ($p<0.05$). In a combined analysis of the present study the mean node number per plant range from 12.88 to 16.44 with the overall mean of 15.16. The highest mean internodes number per plant (16.44) were recorded from16819, followed by 16791(16.20), 15743(15.72) and 16984(14.57) while the lowest value were recorded in check (12.88). In general, as other agronomic traits, stem elongation also influenced by variation in soil type, temperature, amount and distribution of rainfall, genotypes and genotype by year interaction effects.

Table 6: Mean internodes length (cm) per plant of Napier grass varieties tested at Abobo Research station

SN	Varieties	Year		Combined mean over years
		2021/22	2022/23	
1	16819	18.55^{a}	14.33^{a}	16.44^{a}
2	15743	16.43^{b}	15.00^{a}	15.72a^{b}
3	16984	15.07^{c}	14.07^{a}	14.57^{b}
4	16791	18.20^{a}	14.20^{a}	16.20^{ab}
5	Check	11.43^{d}	14.33^{a}	12.88^{c}
	Mean	15.94	14.37	15.16
	CV%	1.31	13.81	8.89
	LSD	0.41	3.74	1.63
	p-value	<0001	0.9955	0.0005

Means followed by different superscript letters within a column are significantly different from each other at P<0.05

Table 7: Mean leaf to stem ratio of Napier grass varieties tested at Abobo Research station

SN	Varieties	Year		Combined mean over years
		2021/22	2022/23	
1	16819	0.54^{a}	2.17^{a}	1.35^{a}
2	15743	0.44^{ab}	2.73^{a}	1.59^{a}
3	16984	0.44^{ab}	2.90^{a}	1.67^{a}
4	16791	0.33^{b}	2.23^{a}	1.28^{a}
5	Check	0.46^{a}	2.97^{a}	1.71^{a}
	Mean	0.44	2.60	1.52
	CV%	14.55	22.08	26.78
	LSD	0.12	1.08	0.49
	p-value	0.09	0.4055	<.0001

Means followed by different superscript letters within a column are significantly different from each other at P<0.05

Leaf to stem ratio at forage harvesting (LSR)

Leaf-stem ratio of Napier grass varieties were presented in (Table 7). The mean leaf to stem ratio (LSR) among varieties were shown statistically very significance difference ($p<0.05$). In a combined analysis of the present study the mean leaf to stem ratio range from 1.71 to 1.28 with the overall mean of 1.52. The higher leaf to stem ratio value (1.71) were recorded from check, followed by 16984(1.67), 15743(1.59), 16819(1.35) while the lowest value were recorded in 16791(1.28). According to Tulu, *et al.,* (2021) studied Dry matter yields and quality parameters of ten Napier grass (Cenchrus purpureus) genotypes in three location(Bako,Bonaya anf Gute) and reported a mean leaf to stem ratio of 1.82(Bako),1.94(Bonaya) and 1.94(Gute) which were higher than this study. According to (Sarker *et al*., 2021; Dinkale *et al*., 2021 and Onjai-uea *et al*., 20231) reported significant variations among Napier Grass varieties with respect to leaf to stem ratio harvests. The mean leaf to stem ratio value lower than current result were reported (Deribe, 2017, and Jabessa *et al*., 2022). Generally, the leaf/stem ratio is another area of research on which to focus, as a greater proportion of stem to leaf is desirable in biofuel feedstock (B.P. Singh *et al*, 2013) and the strong relationship between animal performance and the number of leaves in the diet, the leaf to stem ratio relates to high nutritional quality of the forage (Mijena D. and Getiso M, 2023).

Table 8: Mean DM yield (t/ha) of Napier grass varieties tested at Abobo Research station

SN	Varieties	Year		Combined mean over years
		2021/22	2022/23	
1	16819	22.03[a]	18.01[a]	20.02a
2	15743	11.26[d]	17.25a	14.26bc
3	16984	12.36[d]	15.74ab	14.05c
4	16791	15.59[bc]	17.94a	16.77b
5	Check	17.96[b]	14.28b	16.12bc
	Mean	15.84	16.65	16.24
	CV%	13.49	9.37	13.20
	LSD	4.02	2.94	2.60
	p-value	0.0026	0.1125	0.0007

Means followed by different superscript letters within a column are significantly different from each other at $P<0.05$

Forage dry matter yield

The average dry matter yield of Napier grass varieties tested over the years at Abobo research station were presented in (Table 8). The mean dry matter yield (t/ha) among varieties were shown statistically significance difference ($p<0.05$). In a combined analysis the mean dry matter yield range from 20.02 t/ha to 14.05 t/ha with the overall mean of 16.24 t/ha. The higher dry matter yield value (20.02 t/ha) were recorded from 16819, followed by 16791(16.77t/ha) and check (16.12t/ha) respectively. The lowest mean dry matter yield were recorded in 16984(14.05 t/ha) and 15743(14.26t/ha). This result agreed with the report of Gadisa et al., (2021) with a mean of 17.61t/ha, Mijena D. and Getiso A., (2023) with a mean value of 16.30 t/ha. The result of current finding is also lower than previously reported values by Denbella and Sintayehu(2020) which range from 34.06 t/ha to 51.56t/ha in south Omo. Similarly, lower mean dry matter yield value than current report were reported in previous studies in the country (Jabessa *et al*., 2022; kebede *et al*., 2016; Tesfaye M, 2018; Negasu G. and Gizahu W., 2017). The yield estimates of Napier Grass vary depending on the climate, soil, cultivar and

cultural practices (Singh *et al.*, 2013). Kebede et al., (2017), cited that Herbage yield of Napier grass may be affected by the harvesting day after planting; increasing foliage height increased biomass yield and the taller varieties showed higher dry matter yields than the shorter varieties. The DM yield of Napier grass increased as frequency between cuttings increased and this indicates that a long harvest interval is necessary to achieve high herbage yields (Tessema et al., 2010). Yields depend on agro-ecological zone and management but on average Napier grass can give 12 to 25 tons/ha of dry matter yield. Under optimal management practices Napier grass can give yields 40 t/ha/year in high rainfall 1200 mm to 2400 mm of rainfall (Kabirizi et al 2015).

IV. CONCLUSION AND RECOMMENDATION

Napier grass varieties respond differently for agronomic performance values at Abobo environmental conditions. Measured agronomic parameters such as plant survival rate, leaf to stem ratio, plant height, tillering performance, forage dry matter yield and internodes length per plant showed variations among the tested Napier grass varieties. This indicates that different varieties have different characteristics in terms of agronomic performance under rain fed conditions. Varieties which had optimum yield and performance should be selected for promotion in the study area. Therefore, based on its performance, height and dry matter yield Napier grass varieties ILRI#16819 is recommended for further promotion in the Lowland areas of Gambella. The finally, further research work should be done on chemical composition and variety feeding effect on animal performance.

AUTHOR CONTRIBUTIONS

Yien Deng: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; validation; visualization; writing—original draft; writing—review and editing.; **Wasihun Gebeyehu**: methodology; data collection and supervision; **Mesfin Dejene**: Conceptualization; methodology; project administration; resources and validation.

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