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Performance of Perennial Grass Species under Supplemental Irrigation

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ABSTRACT

The study was conducted at Agricultural Research Centre with the objective of identifying the best-performing perennial grass species under supplemental irrigation and advising the promising cultivated fodder grass for smallholder livestock producers. Randomized Complete Block Design of six perennial grass species with three replications was employed. The six perennial grass species used were T1 (*Brachiaria mutica*_18659), T2 (*Cynodon aethiopicus*), T3 (*Pennisetum sphacelatum*), T4 (*Brachiaria decumbense*), T5 (*Chloris gayana cv. Masaba*), and T6 (*Brachiaria mutica*_6964). The result revealed that agronomic performance of cover, vigor, and height was varied ($P<0.001$) among perennial grass species. Furthermore, effects of cover ($P<0.05$), vigor ($P<0.05$) and height ($P<0.001$), and dry matter contents ($P<0.05$) of perennial species over years were found. The dry matter yields and contents of *P. sphacelatum* (22.85 ton ha^{-1} and 41.7%) followed by *C. aethiopicus* (12.53 ton ha^{-1} and 40.6%) of perennial grass species performed better ($P<0.001$) than others. The highest ($P<0.001$) dry matter yield (20.3 ton ha^{-1}) was obtained during the second year of harvest than the first (12.65 ton ha^{-1}) and third (11.36 ton ha^{-1}) year harvests. Similarly, the highest ($P<0.001$) dry matter percent of the perennial grass species was also found during the second year harvest (50.1%) than the first (25.8%) and third (40.0%) year harvests. The lowest dry matter yield was recorded by *C. gayana* at the first year (8.5 ton ha^{-1}) and third year (8 ton ha^{-1}) harvests. Likewise, *B. mutica*_18659 provided the lowest dry matter yield (12.9 tons ha^{-1}) during the second harvest period. Hence, smallholder farmers can preferably be advised to use *P. sphacelatum* and *C. aethiopicus* perennial grass fodder crops resources under supplemental irrigation.

Keywords: Fodder, Grasses, Irrigation, Livestock, Perennial, Performance, Species, and Yield.

INTRODUCTION:

Livestock feed resources of Sub-Saharan Africa countries are mainly depends on natural grasses, forbs with some browse shrubs and trees (Abusuwar & Ahmed, 2010). Ethiopia has vast and substantial number of farm animals, but their productivity and economic contributions are low (Adugna, 2008). In the highlands of Ethiopia natural pasture and crop residues are the major sources of feed supply to livestock (Seyoum & Zinash, 1995; Zinash *et al.,* 1995; Zerihun, 2002). The amount and quality of feed obtained from such sources are very low and cannot satisfy the requirements and achieved the desired level of production (Adugna, 2007; Aklilu *et al.,* 2014; Fekede *et al.,* 2015; Alemayehu *et al.,* 2017). Feed availability and quality is the major bottle-neck challenges of livestock production which accounts 70% of production cost (Abd El-Hack *et al.,* 2015; Alam *et al.,* 2022).

In Ethiopia, shortage of feed both in quality and quantity resulted in low productivity of livestock (ILRI, 2009; Demeke *et al.,* 2017). According to CSA, (2021) report, the main feed resources in the country are green fodder or grazing is the primary one (54.54%) followed by crop residue (31.13%). Those major feed resources are available primarily during the rainy season and become severely scarce during the long dry period of the year. During this period crop residues are the main sources of feed for livestock with low nutritional profiling quality (Abegaz *et al.,* 2007). This situation of feed scarcity as well as low quality was challenging livestock producers to achieve the nutrient requirements of their animals (Yayneshet *et al.,* 2008). Bezabih *et al.* (2014), reported that the performance of livestock were influenced by periodic feed production patterns, that resulted in short supply of livestock products with high pricing (Kocho *et al.,* 2011). Furthermore the current government initiatives on irrigation scheme development projects have a paramount contribution for production of promising cultivated fodder crops under supplemental irrigation. So, cultivation of adapted and well performing fodder crops under suplemental irrigation can be used as a possible solution for addressing the animal feed deficit of the dry season (Mulisa *et al.,* 2022).

Using well performing and locally available or introduced forage species, which adapt the local environmental conditions, are critically important to address the problem of feed resource scarcity. According to Berhanu *et al.* (2003) enhancing the utilization and adoption of improved forage could considerably improve livestock productivity. Small holder farmers can possibility increase livestock production through evaluation of high quality forages with better yield advantage and potential adaptation to the existing environmental conditions (Tessema, 1999). Evaluation of promising cultivated perennial forage grass species like *B.mutica*_18659, *C. aethiopicus*, *P. sphacelatum*, *B. decumbense*, *C. gayana* and *B. mutica*_6964 under suplemental irrigation condition is one of the possible intervention strategies used to alleviate the prevailing feed scarcity challenge of the country.

Despite their significant importance as fodder crops, there is limited information on the relative advantage of producing Bracharia, Cynodon, Penisetum and Chloris species under supplemental irrigation conditions of the area. Since productivity of these species could vary and affected by area of origin, temperature, light intensity, rainfall, soil type, fertilizer level, and by stage of maturity. Therefore, this study was planned to evaluate the performance of *B. mutica*_18659, *C. aethiopicus*, *P. sphacelatum*, *B. decumbense*, *C. gayana cv. Masaba* and *B. mutica*_6964 perennial grass species and varieties under supplemental irrigation and advice the promising cultivated fodder for livestock producers.

MATERIALS AND METHODS:

Study area description

The experiment was undertaken collaborately at Wondogenet Agricultural Research center researcher and Bangladeshi researcher. The center found at 268 km far away to the South of Addis Ababa, capital city and 14 km South-East of Shashemene. It is located at 07°19.1' North latitude, 38°30’ East longitude with an altitude of 1780 meter above sea level. The average rainfall of the area is 1128 mm with 11 and 26°c of minimum and maximum temperature, respectively (Tekalegn *et al.,* 2017). The texture of the top soil (0-25cm) was sandy clay loam with PH 8.84 (1:2.5 soil water suspensions) and total nitrogen of 0.18.

Treatments and design

Randomized Complete Block Design of six treatment groups of perennial grass species with three replications were used for the experiment. The six perennial fodder crop grass species employed for the study were T1 (*B. mutica_18659*), T2 (*C. aethiopicus*), T3 (*P. sphacelatum*), T4 (*B. decumbense*), T5 (*C. gayana cv. Masaba*), and T6 (*B. mutica_6964*). A total of eighteen experimental plots of each with 12m^2 (4m*3m) areas were utilized for fodder establishment. The spacing used between plots and blocks was 1 m and 1.5 m, respectively.

The six perennial grass species were planted per plot with each of 0.25 and 0.5m space of intra- and inter-row spacing. Each treatment groups were assigned randomly and independently to each experimental block. DAP fertilizer was applied at the rate of 100 kg/ha to enhance sward consolidation. Management practices of hand-weeding, pest and disease monitoring or control were done uniformly.

Data collection

The collected data were includes agronomic performances (plot cover, stand vigor and height) and herbage yield using quadrat sampling. Incidence of disease and insect infestation were observed and recorded.

Height of the Plant

The height of harvested plant was taken from the ground to the tip of the plant. The average of five plant heights was taken randomly from each plot at the time of proper harvesting ages (about 50% flowering).

Estimation of Biomass Yield

The biomass yield of perennial grass species was harvested at proper harvesting stages of 10cm above the ground. Weight of fresh biomass yield was measured from each plot by using a meter square quadrat. Sub-sample of 200gm weights were taken from each plot to the laboratory, upon arrival at laboratory it was oven dried for 72 hours at temperature of 65°c. Total dry matter yield content was determined from oven-dried sample weight. Then the result was converted in to dry matter ton per hectare for comparison (Aklilu & Alemayehu, 2007).

Data Analysis

Quantitative data sets were analyzed by GLM of Statistical Analysis System (SAS, 2002) procedures of version 9.0. Least significant difference (LSD) test was employed for variables whose F-values declared a significant difference (P<0.05). The statistical model for data analysis was

$$Y_{ijk} = \mu + S_i + Y_j + SY_{ij} + B_k + e_{ijk}$$

Where,

Y_{ijk} = dependent variables;

μ = grand mean;

S_i = effect of perennial grass species i;

Y_j = effect of year j;

SY_{ij} = interaction effect of perennial grass species and year ij;

B_k = effect of block k; and

e_{ijk} = random error effect of species i, year j, interaction of year and species ij, and block k.

RESULTS AND DISCUSSION:

Overview performances of perennial fodder grass species

Analysis of variance for the variables used to measure the performances of perennial fodder grass was shown in **Table 1**. There were a variation on agronomic performance among perennial grass species (P<0.001) and also across years (P<0.05). Furthermore, the dry matter yield in ton per hectare as well as its contents were showed variation (P<0.001) between perennial grasses and also over years. There were also an effect (P<0.05) of species by years found on cover, vigor, height and dry matter contents of the perennial grass species.

Table 1: Overview performance evaluation of perennial fodder grass evaluated under supplemental irrigation condition.

Parameters	Species	Year	TxY	Mean	CV
Cover (%)	***	*	*	96	7.8
Vigour (%)	***	*	*	84.8	9.2
Height (cm)	***	***	***	170.9	12
DM Yield (ton ha^{-1})	***	***	ns	14.77	34.4
DM %	***	***	*	38.6	12

*, ***: Significant at P<0.05 and P<0.001 levels, respectively; ns= Non-significant; CV= Coefficient of variations; T*Y= Perennial grass species by Year interactions; ton ha^{-1}= ton per hectare.

Cover vigor and height of perennial grass species across treatments

The agronomic performance of cover, vigor and height were varied statistically (P<0.001) among perennial grass species (**Table 2**). The lowest (P<0.001) percentage values of cover and vigor were recorded by T5 (*Chloris gayana*) than the other perennial grass species. Regarding to the fodder grass species height, T3 (*Penicetum sphacelatum*) was the tallest (P<0.001) one while T4 (*Brachiaria decumbense*) measured the lowest (P<0.001) height. Similarly, the year by perennial grass species interaction effects of cover (P<0.05), vigor (P<0.05) and height (P<0.001) were showed variations over treatments.

Table 2: Cover vigour and height of perennial grass species across treatments.

Observations	Treatments Mean						Over all Mean	SEM (±)	CV %	Sig	T*Y
	T1	T2	T3	T4	T5	T6					
Cover (%)	100^{a}	95.6^{a}	100^{a}	98.9^{a}	81.7^{b}	100^{a}	96	0.25	7.8	***	*
Vigour (%)	98.3^{a}	91.1^{a}	96.7^{a}	95^{a}	75^{b}	97.8^{a}	84.8	0.28	9.2	***	*
Height (cm)	169.5^{bc}	172.7^{b}	208.1^{a}	142.2^{d}	150.7^{cd}	182.2^{b}	170.9	6.82	12	***	***

^{abcd} Means with different superscripts along the row differ significantly; *, ***: Significant at P<0.05 and P<0.001 levels, respectively; SEM= Standard Error of Means; CV= Coefficient of variations; Sig= Significant level; T*Y= Treatment by Year interactions; T= Treatments; T1= *B. mutica* 18659; T2= *C. aethiopicus*; T3= *P. sphacelatum*; T4= *B. decumbense*; T5= *C. gayana*; T6= *B. mutica* 6964.

Among the perennial grass species *P. sphacelatum*, *B. mutica*_6964 and *C. aethiopicus* recorded higher height of 208.1, 182.2 and 172.7 cm, respectively. The height of *B. decumbense* (142.2 cm) and *C. gayana* (150.7 cm) of the present study were found higher than that reported by Mulisa *et al.* (2022), who found 80.07 and 93.23 cm, respectively. The differences in agronomic performances of those perennial grass species might be resulted due to soil characteristics and environmental conditions of the area. More importantly the morphological and physiological growth habits of the *P. sphacelatum* and *C. aethiopicus* grass species had a vertical growth habit than the other grass species. So plant height can be attributed to the morphological and physiological differences among the cultivars (Akinyi Nguku, 2015).

Cover vigor and height of perennial fodder grass species over years

The agronomic performance of cover, vigor as well as height of perennial fodder grasses over years was showed in **Table 3**. The cover and vigor percent values of perennial grass species were revealed variations (P<0.05) over years of harvesting periods. Furthermore, the heights of those perennial grass species harvested during first year period (195.7cm) were higher (P<0.001) than the consecutive harvest years (174.7 and 142.3cm). There were also treatment by years interaction effects of cover (P<0.05), vigor (P<0.05) and height (P<0.001) of perennial grass species across years. This might be attributed due to environmental conditions of the area that can be suited for some of the perennial grass species.

Table 3: Cover vigour and height of perennial grass species over years.

Observations	Years			Mean	SEM (±)	CV %	Sig	T*Y
	1	2	3					
Cover (%)	91.7^{b}	98.1^{a}	98.3^{a}	96	0.18	7.8	*	*
Vigour (%)	88.3^{b}	95.6^{a}	93.1^{ab}	84.8	0.2	9.2	*	*
Height (cm)	195.7^{a}	174.7^{b}	142.3^{c}	170.9	4.82	12	***	***

^{abc}Means with various superscripts along the row differ significantly; *, ***: Significant at P<0.05 and P<0.001 levels, respectively; SEM= Standard Error of Means; CV= Coefficient of variations; Sig= Significant level; T*Y= Treatment by Year interactions.

Dry matter yield and content of perennial grass species across treatments

The average dry matter yield in ton per hectare and the associated percentage values was showed on **Table 4**. The result revealed that, the dry matter yield in ton per hectare and dry matter content of the perennial grass species were found vary statistically (P<0.001). The highest dry matter yield in ton per hectare were obtained by *P. sphacelatum* (22.85) followed by *B. decumbense* (16.86 ton ha^{-1}), *B. mutica*_6964 (12.94 ton ha^{-1}) and *C aethiopicus* (12.53 ton ha^{-1}). Mulisa *et al.* (2022) reported a lower average dry matter yield in ton per hectare for *B. decumbens* ILRI_10871 (12.58 ton ha^{-1}). However, the author was found a comparable dry matter yield in ton per hectare for *B. decumbens ILRI_13205* (17.15 ton ha^{-1}) accession with this report of *B. decumbense* (16.86 ton ha^{-1}).

Table 4: Dry matter yield and content of perennial grass species across treatments.

Parameters	Treatments Mean						Over all Mean	SEM (±)	CV %	Sig	T*Y
	T1	T2	T3	T4	T5	T6					
DM Yield (ton ha^{-1})	12.03^{bc}	12.53^{bc}	22.85^{a}	16.86^{b}	11.41^{c}	12.94^{bc}	14.77	1.7	34.5	***	ns
DM (%)	37.6^{bc}	40.6^{ab}	41.7^{ab}	33.2^{c}	43.2^{a}	35.3^{c}	38.6	1.55	12	***	*

^{abc}Means with various superscripts along the row differ significantly; *, ***: Significant at P<0.05 and P<0.001 levels, respectively; DM= Dry matter; ton ha^{-1}= ton per hectare; SEM= Standard Error of Means; CV= Coefficient of variations; Sig= Significant level; ns= Non-significant; T*Y= Treatment by Year interactions T= Treatments; T1= *B. mutica* 18659; T2= *C. aethiopicus*; T3= *P. sphacelatum*; T4= *B. decumbense*; T5= *C. gayana*; T6= *B. mutica* 6964.

The average dry matter yield of these perennial grass species (14.77 ton ha^{-1}) were lower as compared to Desho grass species (25.05 ton ha^{-1}) evaluated under similar environmental conditions (Tekalegn *et. al.,* 2017). Among the perennial grass species, *C. gayana, P. sphacelatum* and *C. aethiopicus* were provided higher (P<0.001) dry matter contents of 43.2, 41.7 and 40.6%, respectively. More importantly, there were an interaction effects (P<0.05) in dry matter contents of perennial grass species by years. Relatively, the dry matter yields and content of *P. sphacelatum* followed by *C. aethiopicus* perennial grass species were performed better than the other cultivated fodder grass species. Even though *B. decumbense* has produced good dry matter, its dry matter contents was founds to the lowest (P<0.001) than *P. sphacelatum* and *C. aethiopicus* perennial grasses. The variations in dry matter production potential and its content might be resulted due to variations in genotypes of the perennial fodder grass species.

Average dry matter production and contents of perennial grass species over years

The average dry matter production in ton per hectare was revealed that (**Table 5**), the highest (P<0.001) yield (20.3 ton ha^{-1}) were obtained at the second year of harvest than the first (12.65 ton ha^{-1}) and third (11.36 ton ha^{-1}) year harvests. The overall mean dry matter yield produced by those perennial fodder grass species were 14.77 ton ha^{-1}. Consequently, the highest (P<0.001) dry matter content of the perennial grass species was also found during the second year harvest (50.1%) than the first (25.8%) and third (40.0%) year harvests. Even though, the result showed that no effects (P>0.05) of treatment by year found on dry matter production ton per hectare, there was an interaction effects (P<0.05) of dry matter contents of the perennial grass species over years.

Table 5: Dry matter production and contents of perennial grass species over years.

Parameters	Years			Mean	SEM (±)	CV %	Sig	T*Y
	1	2	3					
DM Yield (ton ha^{-1})	12.65^{b}	20.3^{a}	11.36^{b}	14.77	1.2	34.4	***	ns
DM %	25.8^{c}	50.1^{a}	40.0^{b}	38.6	1.1	12	***	*

^{abc} Means with different superscripts along the row differ significantly; *, ***: Significant at P<0.05 and P<0.01 levels, respectively; ; DM= Dry Matter; ton ha^{-1}= ton per hectare; SEM= Standard Error of Means; CV= Coefficient of variations; Sig= Significant level; ns= Non-significant; T*Y= Treatment by Year interactions.

Dry matter production potential of perennial grass species over years

The dry matter production in ton per hectare of perennial grass species over years were indicated in **Fig. 1**. Across all harvesting years of the perennial grasses species, *P. sphacelatum* produced highest dry matter production in ton per hectare than other grasses. Moreover, at the second years of harvesting period most of the perennial grasses species were provided better dry matter production in ton per hectare than the first and third years of harvests. Majority of the perennial fodder crops were tend to increase their dry matter production to the maximum and start to declining then after. The lowest yield in ton per hectare was recorded by *C. gayana* at the first year (8.5 ton ha^{-1}) and third year (8 ton ha^{-1}) harvests. Similarly, *B. mutica_ 18659* provided the lowest yield (12.9 ton ha^{-1}) at the second harvest period. Mulisa *et al.* (2022) found lower dry matter yield in ton per hectare for *B. decumbens* ILRI_10871 (1.46 and 9.75 ton ha^{-1}) and *B. decumbens* ILRI_13205 (0.51 and 12.34 ton ha^{-1}) at both first and second year of harvest, than this study for *B. decumbens* (11.7 and 25.1 ton ha^{-1}). The dry matter production potential of *C. gayana* cv. Massaba at the first year (8.75ton ha^{-1}) and second year (17.71 ton ha^{-1}) harvest reported by Mulisa *et al.* (2022) were in agreement with this findings (8.5 and 17.8. ton ha^{-1}, respectively). However, the author reported a higher dry matter production in ton per for the above mentioned perennial grasses at the third year harvests. The variation in dry matter yields of perennial grass species might be attributed due to genotypes, soil characteristics and environmental conditions of the areas.

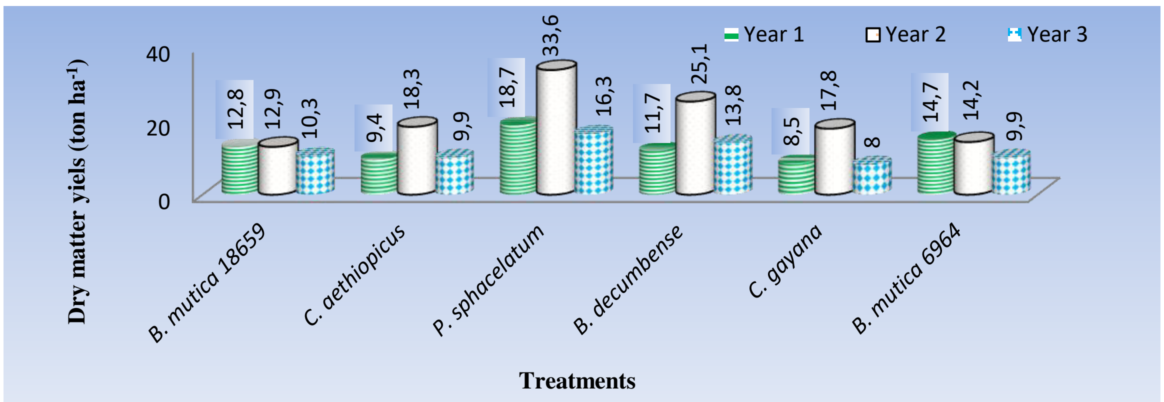
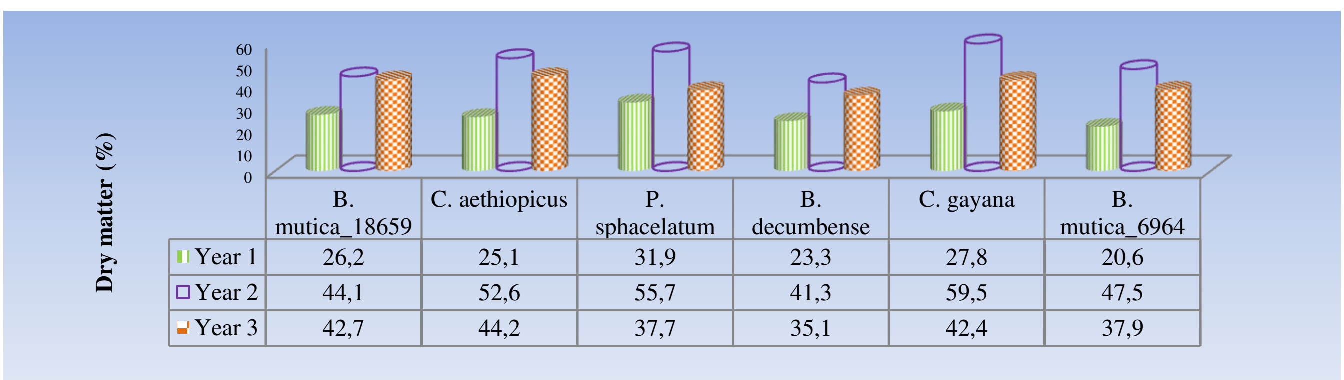


Fig. 1: Dry matter yield in ton per hectare of perennial grass species over years.

Dry matter content of perennial grass species over years

Dry matter contents of perennial grass species over years was indicated in **Fig. 2**. The result revealed that the average dry matter contents of the perennial grass species were higher at the second harvest than the first and third harvest. At the first, second and third harvests *P. sphacelatum, C. gayana and C. aethiopicus* have higher dry matter contents of 31.9, 59.5 and 424.2%, respectively.



	B. mutica_18659	C. aethiopicus	P. sphacelatum	B. decumbense	C. gayana	B. mutica_6964
Year 1	26,2	25,1	31,9	23,3	27,8	20,6
Year 2	44,1	52,6	55,7	41,3	59,5	47,5
Year 3	42,7	44,2	37,7	35,1	42,4	37,9

Fig. 2: Dry matter percent of perennial grass species across years.

CONCLUSION:

In Ethiopia feed resource availability and quality are the major challenges of livestock production. Identifying best performing perennial fodder crops under supplemental irrigation condition is critically important in addressing the bottle-neck problems of feed resources. The result of this study founds a variation on agronomic performances and dry matter yield in ton per hectare and its contents of perennial fodder grass species. At the period of the second years of harvest most of the perennial grasses species were provided better dry matter production in ton per hectare than the first and third years of harvests. Among the perennial grass species *P. sphacelatum* and *C. aethiopicus* was the best performing ones in dry matter yield (22.85 and 12.53 ton ha^{-1}) and associated contents (41.7 and

40.6%), respectively. Furthermore, there were also interaction effects of both agronomic and dry matter content performances of perennial grass species over years. Therefore, small holder farmers can preferably advised to use *P. sphacelatum* and *C. aethiopicus* perennial grass fodder crops as livestock feed resources under supplemental irrigation conditions.

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CONFLICTS OF INTEREST:

The authors declare no conflict of interest.

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