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Research Article

Comparative Evaluation of Selected Grass Species for Agronomic Performance, Forage Yield, and Chemical Composition in the Highlands of Ethiopia

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The study was conducted to determine the effect of different grass species (*Brachiaria mutica*, Desho, and Napier) and harvesting stages on agronomic performance, forage dry matter yield, and chemical composition. The grass species used were Desho (*Pennisetum pedicellatum*), *Brachiaria* (*Brachiaria mutica*), and Napier (*Pennisetum purpureum*), and the harvesting stages considered were 60, 90, and 120 days after establishment of grasses, respectively. The data collected included the following: percent plant survival (PS), plant height (PH), number of tillers per plant (NTPP), number of leaves per plant (NLPP), leaf length per plant (LLPP), leaf width per plant (LWPP), number of nodes per plant (NNPP), leaf-to-stem ratio (LSR), dry matter yield (DMY), and chemical composition of the grass species. Samples of grass species were harvested at different ages after establishment, weighed, and dried, and then, ground subsamples were taken for determination of dry matter (DM), ash, organic matter (OM), crude protein (CP), crude protein yield (CPY), acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL). Results showed that morphological characteristics, forage dry matter yield, and chemical composition of the forage grasses were significantly affected by interactions of species ($P < 0.001$) and harvesting dates. The highest mean PH (115.2 cm), DMY (11.8 t/ha), and %CP (11.6) were recorded from *Brachiaria mutica* grass which was followed by Napier grass with mean PH of 87.25 cm and mean DMY of 9.8 t/ha. The %CP content of Desho and Napier grasses declined by 24%, while %CP content of *Brachiaria* grass declined by 26% with increased harvesting stages. Therefore, among tested grass species, *Brachiaria mutica* grass was recommended followed by Napier and Desho grass for on-farm evaluation and demonstration in the study area at all harvesting ages. Farmers engaged in forage grass production could seriously consider the harvesting stage as the grasses responded differently to the chemical composition.

1. Introduction

In Ethiopia, the livestock sector is one of the main components of agriculture which is a contributor for food, income, and wealth accumulation. The sector also shares 15–17% of national gross domestic product (GDP), 35–47% of agricultural GDP, and 37–87% of the household income of the country [1]. It is evident that livestock perform agricultural economical (40%) and social and ecological functions both at the national and household level of our country. Apart from the above merits, livestock confer a certain degree of security during a time of crop production failure, as they are a "near-cash" capital stock. Livestock also provide benefits such as fuel and fertilizer from animal manure and draught power for farm production [2, 3]. Although the sector has such multifaceted contributions, the output from the sector is far below the expected potential both at macroeconomic and microeconomic levels. This is mainly contributed by the lack of sufficient feed supply in quality and quantity throughout the year [4]. In Ethiopia, livestock feed resources are natural pasture, crop residues, agroindustrial products, improved (cultivated) forages, and other nonconventional feeds. Among the listed feed resources, natural pasture and crop residues are dominantly available for livestock nutrition. But, these feed resources are mostly deficient in nutrients required for livestock production and even in the maintenance requirement, as they are critically deficient in protein, metabolizable energy, and micronutrients. This calls for exploring alternative sources of livestock feeds that compliment nutritionally and improve animals' productivity. One of the strategies is to introduce multipurpose improved forages which has been started for a long time in Ethiopia, although their contribution is very low. The reason might be lack of know-how, land shortage, and lack of planting materials (seeds, seedling, and root splits) which were the contribution factors for the lower adoption of improved forage in farmers' backyards. Among the introduced forage grasses, Napier grass is widely available in the smallholder production system, the majority in the backyard land use system. *Brachiaria* grass species has also been used in the production systems [5]. It has the potential of meeting the challenges of feed shortage since they provide more quality forage per unit area and ensure regular forage supply due to its multicut nature [6]. These grasses could provide forage biomass in the dry season as long as irrigation is accessible and serve against dry season green fodder scarcity. The crude protein content of Napier, *Brachiaria mutica*, and Desho grass grown in the production system ranges more than 8% although *Brachiaria* is taking the lead. Hence, they provide more protein than the maintenance requirement of ruminant animals. Protein is a critical nutrient mostly deficit in the major feed resources of the country. These improved forages have been well adapted in a wide range of soils. The biomass yield and nutritional attributes of *Brachiaria*, Desho, and Napier grass depend on plant management employed. Hence, we hypothesized that there would be differences in responses of grasses under the same management but different harvesting periods in the study area. The objective of this research, therefore, was to evaluate the harvesting stages on agronomic performance, dry matter yield, and chemical composition of the three grass species under rainfed condition in Ethiopia.

2. Materials and Methods

2.1. Description of the Study Area. The field experiment was conducted in Mecha District, Northwestern Ethiopia, in a special place called Kudmi kebele. Mecha district is located about 525 km Northwest of Addis Ababa and 34 km Southeast of Bahir Dar, the capital city of the Amhara region. It is also located at latitude 11°23′62″N and longitude 37°7′87″E. The location map of the study area is presented in Figure 1. The altitude of the study site is 1972 m.a.s.l. Most parts of the district have almost flat topography which accounts for more than 75% of the total area [7]. The minimum and maximum temperatures range between 10.25 and 27.67°C. Monthly rainfall and minimum and maximum temperatures of the study area in 2019 at the experimental site are presented in detail in Figure 1. The predominant soil type of the experimental site is red clay. Agriculture is the main economic sector in the study area.

2.1.1. Land and Seedbed Preparation. The experimental site was selected based on the available information suited to forage development and observation of different types of accessibility. Then, the land was cleared, ploughed, and harrowed by oxen to a fine tilth (three times) before laying out plots and planting material.

2.1.2. Experimental Layout, Design, and Treatments. Before planting, the experimental land was first cleared of weeds and unwanted debris like plastics, dried plants, and shrublike plants. Then, the land was ploughed by oxen, and the experimental land was leveled manually before subdividing it into blocks and plots. After proper land preparation, those different experimental grass species were planted using propagation methods in rows on a well-prepared area in the rainy season on the same day. The source of planting materials was from the university farm. The inter-row spacing and intraplant spacing was the same for all treatments (0.5 m). Weeds were removed manually on a two-week interval basis until the final harvesting was accomplished, to eliminate regrowth of undesirable plants and removal of the dry roots in order to promote fodder regrowth by increasing soil aeration. The data were collected from middle parts of the plot between four rows at 60, 90, and 120 days for each grass species [8].The experimental design used in the current study was the factorial arrangement of treatments in a randomized complete block design (RCBD) consisting of 2 factors (grass species and harvesting date) with 4 replications.

2.2. Methods of Data Collection

2.2.1. Plant Survival and Morphological Data Collection. Data on the morphological and yield parameters were recorded throughout the experimental period of four months. The morphological parameters such as plant height (PH), number of tillers per plant (NTPP), number of leaves per plant (NLPP), leaf length per plant (LLPP), leaf width per plant (LWPP), number of nodes per plant (NNPP), leaf-to-stem ratio (LSR), and dry matter yield (DMY) were computed as the mean of counts taken from 10 plants that were randomly selected from the middle rows of each plot at 60, 90, and 120 days after planting. Also, the number of survived plants per plot was counted. Harvesting was done by hand using a sickle, leaving a stubble height of 8–10 cm. Following each of the first harvesting days, follow-up studies were done to find out the status of the species. The fresh herbage yield of the grass was measured immediately after each harvest and weighed on the field soon after mowing using a field balance. Subsamples were taken from each plot to determine dry matter yield. Following harvesting, the adequate quantities of grass samples from each plot were weighed, labelled, and air-dried under shade and kept in separate perforated bags for laboratory chemical analysis of nutrient composition. The morphological yields of the first, second, and third harvests were compared at each different harvesting day intervals.

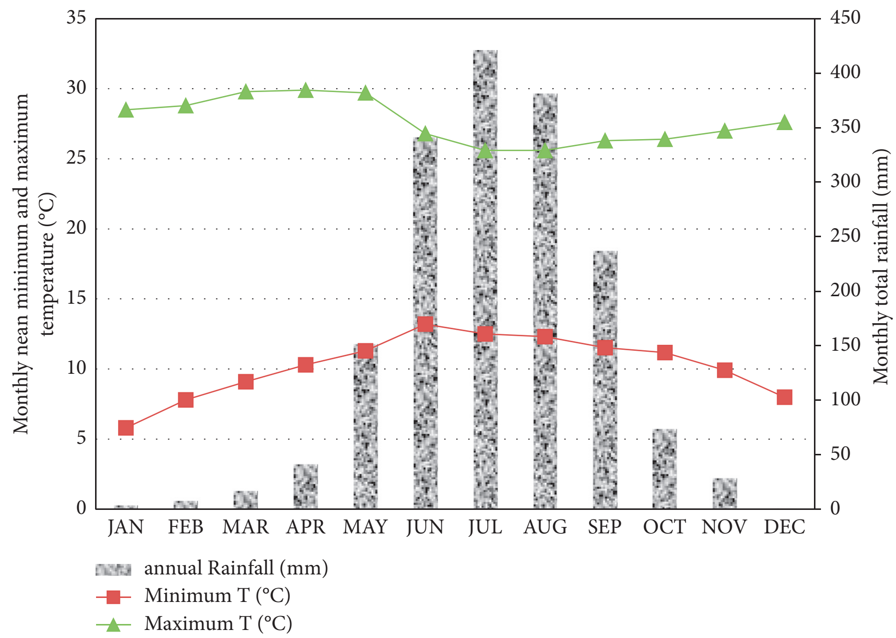

Figure 1: Monthly average rainfall and minimum and maximum temperatures of the study area in 2019.

2.2.2. Morphological Parameters

(1) Plant Height (PH). A measurement of plant height was done immediately before the time of biomass harvest, at the end of each of the three harvesting periods. From the total of six rows within each plot, four rows were selected by excluding the two border rows on each side to measure the plant height and then ten tillers were randomly selected for the measurement of the plant height at an interval of 30 days from the 60th day after transplanting up to 120 days, the final harvesting period, and then the average height was taken.

(2) Number of Tillers per Plant (NTPP). The number of tillers for the same tagged plants were counted and recorded. The number of tillers per plant was counted from the randomly selected sample of ten plants in the middle row of each plot from four rows at 60, 90, and 120 days after transplanting from the net plot area, and the mean was calculated.

(3) Number of Leaves per Plant (NLPP). The number of leaves per tiller was counted in ten randomly selected tillers at 60, 90, and 120 days of harvesting on an experimental plot area. The mean was calculated, and then, the total number of leaves per plant was estimated from the tiller number per plant and leaf number per tiller.

(4) Leaf Length and Width per Plant. Leaf length per plant was measured from the base of the collar region of the leaf to the tip of the leaf. It is measured in ten randomly selected plants from the four rows at each harvesting stage, and the mean was calculated. Leaf width per plant was also measured from the middle parts of the leaf region. It is measured from randomly selected plants from the four rows at each harvesting stage.

(5) Leaf-to-Stem Ratio (LSR). The leaf to stem ratio was determined by cutting plants from randomly selected four consecutive rows. The plants were cut from the middle parts of each plot and between four rows. Then, samples taken from each plot at each harvesting period were properly measured, and fresh stems and leaves of each harvested sample were separated and weighed after thoroughly mixing the net harvested plant. After measurements, stems and leaves were taken for DM analysis. Each sample of the leaf and stem was air-dried, and then, the leaf-to-stem ratio (LSR) was estimated by dividing leaf dry weight by stem dry weight.

(6) Dry Matter Yields (DMYs). The dry matter yield (DMY) was determined at the end of every harvesting days of each plot. At each harvest, the four rows at the middle of each plot were cut at eight to ten centimeters above the ground. Fresh biomass was measured using a sensitive balance; then, subsamples of about 500 g fresh plants were taken from the net harvested plant sample. Finally, these subsamples were air-dried to obtain dry weights. Leaf and stem dry weights are obtained by dividing the leaf and stem fresh weights and multiplied by 100 to determine DM% for each sample. On the basis of these, DM% and fresh biomass yield from the sample area of each plot were used to calculate total dry matter yields for each plot and thereafter converted to metric tons per hectare.

(7) Forage Quality Analysis. Materials that are harvested for biomass yield were subsampled for feed quality assessment and chemical analysis. These samples were dried by air and then ground to pass a 1 mm Wiley mill screen and stored in airtight containers for different preparations of the proximate chemical analysis method [9, 10] of feed analysis. Chemical analysis was performed to determine total dry

matter percentage, crude protein (Kjeldahl procedure), acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL), analyzed as per [11]. The protein content was calculated by multiplying the nitrogen content by 6.25. The total ash was determined by igniting the samples in a muffle furnace (FB1410M-33) at 550°C overnight. The total DM was determined by drying at 105°C. Dry matter (DM%) was multiplied with CP content of the feed samples to determine crude protein yield (CPY). Finally, all results were calculated on a dry matter basis.

2.3. Data Analysis. The collected data were subjected to ANOVA based on the general linear model designed for a randomized complete block design (RCBD) according to Gomez and Gomez [12]. To compare significant differences in response variables, ANOVA analysis was done using SAS package [13]. Mean comparison was carried out using Duncan's Multiple Range Test (DMRT). Differences were considered statistically significant at $P < 0.05$.

The model used for data analysis of experiment was

$$Y_{ijk} = \mu + Gs_i + H_j + Gs_i{}^{*}H_j + E_{ijk}, \quad (1)$$

where Y_{ijk} = overall dependent variables (morphological data, forage yield, and chemical composition); μ = overall mean; Gs_i = grass species effect (*Brachiaria*, Desho, and Napier grass); H_j = effect of harvesting days (60, 90, and 120); $Gs_i{}^{*}H_j$ = interaction effect (three grass species) and harvesting date; and E_{ijk} = residual error.

3. Results and Discussion

3.1. Effect of Harvesting Stages and Improved Grass Species on Morphological Characteristics and Dry Matter Yield. Significant interaction effects ($P < 0.001$) of grass species and harvesting stage on plant morphology and dry matter yield were recorded and are presented in Table 1. The longest plant height, number of tillers per plant, number of leaves per plant, leaf length, leaf width, number of nodes per plant, and dry matter yield increased with the maturity of the grass. The interaction of grass species and the harvesting stage had a significant effect on morphology and dry matter yield of different grass species.

3.1.1. Number of Plants Survived (NPS). The study on grass establishment performance is a very important consideration during forage crop cultivation due to its substantial effect on forage productivity. The interaction effect of grass species and harvesting stage on the number of plants survived showed significant difference ($P < 0.05$) among three grass species considered in this experiment. Harvesting stage had no significant ($P > 0.05$) effect on the survival rate of the grass, while grass species had shown ($P < 0.01$) significant difference on plant survivability. The highest average survival rate of 92.7% was shown by Desho grass followed by *Brachiaria* (87.9%) and Napier grass (83.3%). This difference might be due to species variation, fast growing nature of the grass, and season of planting [14]. On the other hand, the number of tillers during plantation increases the chance of survival and the available forage resource [5] as reported in *Brachiaria* grasses in Northwestern Ethiopia.

3.1.2. Plant Height (PH). The interaction between grass species and harvesting age had a very high significant ($P < 0.001$) effect on the plant height of the grass species. The tallest plant (57.25 cm, 117.8 cm, and 170.7 cm) was recorded for *Brachiaria* at 60, 90, and 120 days of harvesting stage, respectively. The shortest plant (38.3 cm, 42.83 cm, and 55.4 cm) was reported for Desho at 60, 90, and 120 days of the harvesting stage, respectively. The intermediate plant height (47.05 cm, 77.1 cm, and 137.6 cm) was recorded for Napier grass at 60, 90, and 120 days of harvesting stage, respectively. The plant height increases progressively with increase in plant maturity in all grass species which could be due to massive root, stem, and leaf development and efficient nutrient uptake, allowing the plant to continue to increase in height. A similar result has also been confirmed by other researchers for *Brachiaria mutica* grass [15].

The observed result of plant height increment at the late harvesting stage is in agreement with the findings of Tiruset [16] who observed that the mean plant height was low at 90 days of growth, but at harvesting period of 120 days, enhanced growth was observed in Desho grass. The current overall mean plant height (82.7 cm) was lower than that of Desho grass (91 cm) at the same age of harvesting as reported by Asmare et al. [17], and this difference comes from genetic variation of grass species, soil types, management, and climatic condition. Plant height increment was consistent with plant maturity. The differences in plant height could be attributed to species of the grass, soil, and climatic conditions. According to Mustaring et al. [18], *Brachiaria mutica* had the highest plant height (207.47 cm) than *B. brizantha* and *B. mulato* at 8 weeks of harvesting; also, our finding is less than this result. It might be due to different management systems, species differences, and agroecological variations.

The current result also indicated that the highest mean plant height was recorded for *Brachiaria mutica* (115.2 cm), while the minimum plant height was recorded for Napier grass (87.25 cm) and the least plant height was recorded for Desho (45.5 cm) among three grass species. This indicates that plant height was different among different species with the same management system. This difference might come from environmental factors, competition of species taking nutrients in the soil, a genetic variation of grasses, and genetic potential of species to extract minerals as reported by Beyadglign [19] for *Brachiaria* grass cultivar. Differences might also come from the genetics of the grass species, soil type and fertility, management system, and harvesting stage in the area where the experiments were conducted.

Moreover, the current study is in line with that of Kefyalew et al. [20] who indicated that plant height of Desho grass increased from a lower level of 37.19 cm at 90 days of age to a significantly higher value of 45.43 cm at the age of 150 days. This might be due to the well-established root development and nutrient uptake ability of the grasses which in turn could be manifested by the increment in plant height. The increase in herbage yield with an increase in harvesting

Table 1: Effect of harvesting stage and improved grass species on morphological characteristics and dry matter yield.

Factors		Parameter								
HD	SP	NPS	PH (cm)	NTPP	NLPP	LL (cm)	LW (cm)	LSR (kg)	NNPP	DMY (t/ha)
	Desho	45^{a}	38.3^{b}	16^{ab}	110.75^{ab}	23^{b}	1.045^{b}	1.36^{a}	3^{b}	1.79^{a}
60	*Brachiaria*	42.75^{a}	57.25^{a}	21 ^{a}	143.5^{a}	15.6^{c}	1.2225^{b}	1.05^{a}	6.25^{a}	1.87^{a}
	Napier	43^{a}	47.05^{ab}	10.25^{b}	69^{b}	45.03^{a}	2.1275^{a}	3.4^{a}	0^{c}	2.8^{a}
	Desho	43.25^{a}	42.83^{c}	45.70^{a}	389.8^{a}	21.5^{b}	1.2550^{b}	0.81^{b}	6.025^{b}	5.3^{a}
90	*Brachiaria*	43.75^{a}	117.8^{a}	36.45^{a}	412.9^{a}	20.6^{b}	1.4975^{b}	0.3^{c}	9.025^{a}	10.7^{a}
	Napier	39.25^{b}	77.1^{b}	16^{b}	145^{b}	60.3^{a}	2.4275^{a}	2.6^{a}	0^{c}	7.97^{a}
	Desho	45.3^{a}	55.4^{c}	77.65^{a}	854.87^{a}	26.2^{b}	1.2^{c}	1.03^{ab}	7.3^{b}	8.6^{b}
120	*Brachiaria*	40^{ab}	170.7^{a}	61^{b}	894.5^{a}	23.2^{b}	1.8^{b}	0.41^{b}	14.68^{a}	22.8^{a}
	Napier	37.8^{b}	137.6^{b}	17^{c}	197.76^{b}	82.6^{a}	2.99^{a}	1.6^{a}	4.96^{b}	18.57^{a}
	Overall mean	42.2	82.7	33.46	357.55	35.3	1.7	1.4	5.7	8.9
	SE	0.62	7.79	3.854	51.77	3.6698	0.1074	0.21	0.76	1.3
	CV	7.6	25.82	34.19	42.275	21.84	10.759	67.2	30.4	50.06
—	HD	Ns	***	***	***	***	***	*	***	***
Value	60	43.58^{a}	47.533^{c}	15.75^{c}	107.75^{c}	27.87^{b}	1.465^{c}	1.94^{a}	3.08^{c}	2.16^{c}
	90	42.08^{a}	79.233^{b}	32.72^{b}	316^{b}	34.1^{b}	1.73^{b}	1.25^{ab}	5.02^{b}	8^{b}
	120	41^{a}	121.3^{a}	51.91^{a}	649^{a}	44^{a}	1.99^{a}	1^{b}	8.98^{a}	16.65^{a}
	SPP	**	***	***	***	***	***	***	***	**
	Desho	44.5^{a}	45.5^{c}	46.45^{a}	451.799^{a}	23.516^{b}	1.1658^{c}	1.067^{b}	5.4^{b}	5.24^{b}
	Brachiaria	42.2^{ab}	115.2^{a}	39.48^{a}	483.614^{a}	19.783^{b}	1.5025^{b}	0.58^{b}	10^{a}	11.8^{a}
	Napier	40^{b}	87.25^{b}	14.45^{b}	137.245^{b}	62.64^{a}	2.513^{a}	2.5^{a}	1.65^{c}	9.8^{a}
	HD*×SPP	*	***	***	***	***	***	***	***	***

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, NPS = number of plants survived, HD = harvesting date, SP = grass species, PH = plant height, NTPP = number of tillers per plant, NLPP = number of leaves per plant, LLPP = leaf length per plant, LW = leaf width, LSR = leaf-to-stem ratio, NNPP = number of nodes per plant, DMY = dry matter yield ton per hectare, SE = standard error, and CV = coefficient of variation. ^{a,b,c}indicate significant differences of values for each parameter in a column at 60, 90, and 120 days of harvest of grass species.

days after planting could be attributed to the increase in the tiller number, leaf formation, leaf elongation, and stem development. The current mean plant height of different grasses (82.7 cm) indicates a higher value than in the findings of Asmare et al. [17] who reported that the mean value of Desho grass plant height (39.4 cm) under irrigation at Northern Ethiopia. This difference might be due to soil type and harvesting at different stages. On the other hand, the current result is in line with that of [21], which reported that the Napier grass plant height was relatively lower at early stages of growth, but after 60 days of harvesting, enhanced growth was observed.

3.1.3. Number of Tillers per Plant (NTPP). Tillering performance is an important morphological characteristic to be considered during selection of appropriate forage crop species for better improvement of production and productivity. There was a very high significant ($P < 0.001$) interaction effect between grass species and harvesting age on the number of tillers per plant in different grass species. The maximum number of tillers (77.65, 61, and 17) was reported during the late harvesting stage (120 days) followed by the intermediate number of tillers (45.7, 36.45, and 16) during intermediate harvesting (90 days) and the lowest number of tillers (16, 21, and 10.25) during the early harvesting stage (60 days) in all different grass species of Desho, *Brachiaria*, and Napier grass, respectively. The mean maximum number of tillers (52) was recorded at the late harvesting age (120 days), while the lowest mean number of tillers (15.75) was obtained at the early harvesting stage (60 days). At intermediate harvesting (90 days), the intermediate number of tillers was recorded (32.72). Therefore, the total number of tillers per plant increases linearly with increase in harvesting age. When the plants approached maturity, numerous fine branches appeared, growing out from the leaf axils of the main stems [15, 16].

The increment in the number of tillers per plant was in line with that of Kefyalew et al. [20] who reported that tiller number per plant was significantly ($P < 0.01$) affected by harvesting age in Desho grass. The highest number of tillers per plant (79.84) was recorded at the late harvesting stage (150 days), while the least tiller number (42.23) was recorded at the early harvesting stage (90 days); this result is significantly greater than that from our study. This difference might be due to management system, date of harvesting difference or maturity stage, and plant species competition. Similar findings also observed that there is a significant difference on the number of tillers per plant ($P < 0.05$) as the harvesting period increases the number of tillers per plant in all plant species [5] of *Brachiaria* grass. The number of tillers increases proportionally with increase in the harvesting period. In terms of tiller, the highest number of tillers (106.36) was recorded at 135 days of harvesting, whereas the values of 93.14 and 36.41 were recorded at 105 and 75 days of harvesting, as reported by Asmare et al. [17], respectively. This result is also significantly greater than our current finding (15.75, 32.7, and 52) at the harvesting stages of 60, 90, and 120 days, respectively. This difference might be due to altitude, different plant species, competition, maturity stage, weather condition, soil type, and agroecology. Also, the study in [22] reported that Napier grass shows an increase in the number of tillers with increase in maturity stages but the average number of tillers is much less (9.4–12.9) than from our result (15.75 to 52). It might be due to grass species variation and climatic and seasonal conditions.

Among species, the current result indicated that the mean maximum tiller number (46.45) was recorded in Desho grass, whereas the intermediate (39.48) and minimum (14.45) number of tillers were recorded in *Brachiaria mutica* and Napier grass, respectively. The difference might be due to genetic variability, compatibility, and ecosystem. Overall, the interaction mean number of tillers per plant was 33.46. This indicates that interaction between species and harvesting stage had a significant effect on different grass species and was a critical factor for the number of tillers per plant in the current study. This result is comparably in line with that of Beyadglign [19] who reported that fertilizers, cultivars, and soil type had a significant interaction which showed an overall mean number of tillers per plant (34.34) in *Brachiaria* grass cultivar. Also, different findings are in line with our findings. According to Mustaring et al. [18], the tiller number increased with maturity, that is, *B. mulato* had a higher ($P < 0.05$) tiller number than *B. brizantha* and *B. mutica* at a similar stage of harvesting. The tiller number is an important attribute of grasses, and it increases the chances of survival and the amount of available forage production as reported by Van Suan [23]. Increased tillering is probably an adaptive feature to tolerate frequent defoliation by reestablishing the lost photosynthetic area and maintaining the basal area.

3.1.4. Number of Leaves per Plant (NLPP). The interaction between grass species and harvesting age had a very high significant ($P < 0.001$) effect on the number of leaves per plant. *Brachiaria mutica* grass harvested at 60, 90, and 120 days had the highest leaf count per plant (143.5, 412.9, and 894.5 leaves) with mean 483.6, respectively. A moderate number of leaves (110.75, 389.8, and 854.87 leaves) with mean 451.8 were observed in Desho grass at the harvesting age of 60, 90, and 120 days. The lowest leaf count (69, 145, and 197.76 leaves) with mean 137.245 was observed in Napier grass at the harvesting age of 60, 90, and 120 days, respectively. This difference might be due to nature and growth of the grass species. However, in this study, we observed that with the increase in the stage of maturity, a greater number of leaves were produced which are important for the photosynthesis and transpiration surface for the newly emerging tillers.

This result is in agreement with the finding by Tilahun et al. [24] who reported that number of leaves per plant, which in part determines the photosynthetic capacity of the plants, was significantly ($P < 0.01$) affected by harvesting age. According to Zemene et al. [15], the mean number of leaves per plant increased from 232.2 leaves at 60 days to 1211.1 leaves at 120 days in *Brachiaria mutica* grass, but this result was greater than our finding, i.e., 107.75 leaves at the early harvesting stage (60 days) to 649 leaves/plant at the late harvesting stage (120 days). The difference might be due to genetic variation, soil fertility, season of the experiment being conducted, and long plant height of *Brachiaria mutica* grass, which might lead to a high number of leaves per tiller. The increasing tendency in the number of leaves per plant with the advanced stages of harvesting indicated that the time of harvesting had a significant influence on the number of leaves. This might be due to the extended growth; there was increment in plant height, the number of tillers, and the number of nodes that produce a comparable number of leaves.

The findings of [20] also reported the number of leaves per plant (593.47) was recorded at the late harvesting stage (150 days), while the least number of leaves (212.09) were recorded at the early harvesting age (90 days). This might be due to the full stage of growth which contributes to the number of leaves and total biomass of the plant. The highest number of leaves per plant (710.2) was observed at the late stage of harvesting (135 days), while the lowest number (249.3) was observed at the early stage (75 days) of harvesting [17], which was reported in the same grass species. The number of leaves per plant significantly increased ($P < 0.001$) as the age of the plant increased. This might be due to the full stage of growth which contributes to the number of leaves and total biomass of the plant. Hence, it could be concluded that the production of leaves from new tillers generally increased with an increase in the days of harvesting because the longer the vegetative phase and the taller the plant, the greater the number of leaves produced [25].

3.1.5. Leaf Length per Plant (LLPP). The interaction between grass species and harvesting age had a very high significant ($P < 0.001$) effect on the length of the leaf per plant (1). Napier grass had shown the longest leaf length per plant (45.03 cm, 60.3 cm, and 82.6 cm) with mean 62.64 cm at the harvesting stages of 60, 90, and 120 days, respectively. The intermediate leaf length per plant (23 cm, 21.5 cm, and 26.2 cm) with mean 23.5 cm was recorded in Desho grass at 60, 90, and 120 days of harvesting, respectively. The largest mean leaf length per plant (LLPP) (44 cm) was observed at the late stage of harvesting (120 days), but the early harvesting stage (60 days) resulted in the shortest leaf length per plant (27.8 cm) and the intermediate leaf length per plant (34.1 cm) was recorded at 90 days of harvesting in all grasses. The overall mean length of leaves per plant was 35.3 cm. The length of leaves increased progressively with increase in the age of harvesting. This is because the leaf length in grasses is greatly influenced by the developmental stage of the plant, either reproductive or vegetative. In the current result, the growth rate of leaf increases markedly following flower induction and before any visible stem elongation. This change in leaf growth rate seems to be due to an increase in cell division which could be related to environmental regulation of the gibberellins pathway [26]. Leaf length is a key factor determining the vegetative yield of forage grasses.

Similar findings were observed by Kefyalew et al. [20] who reported that leaf length increased from 20.91 cm to 23.38 cm as harvesting age increased from 90 days to 150 days. Similarly, Rambau et al. [22] reported that the leaf length per plant increased from 63.3 to 78.5 cm with maturity of Napier grass which is significantly greater than that of our finding (27.87 to 44 cm). This difference might be due to genetic makeup of the grass, grass competition, management, i.e., supply of nitrogen, soil type, and fertility. Also, variation might come from difference in their species type, season of experiments being conducted, maturity stage, and weather. The same authors also stated that late harvesting period (135 days) showed the largest leaf length, while the earliest period (75 days) showed the shortest leaf length as reported by Asmare et al. [17] which is in line with our finding. This is because the leaf length in forage grasses is greatly influenced by the developmental stages of the plant's reproductive or vegetative growth. Thus, the leaf growth rate increases prominently following flower induction and before any visible stem elongation [27].

3.1.6. Leaf Width (LW). The interaction between grass species and harvesting age had a very high significant effect ($P < 0.001$) on the leaf width of tested grass species increasing from the early harvesting stage (60 days) to late harvesting stage (120 days). Napier grass showed the wider leaf width per plant (2.13 cm, 2.4 cm, and 2.99 cm) with mean 2.5 cm at the harvesting stages of 60, 90, and 120 days, respectively. The shortest leaf width per plant (1.04 cm, 1.26 cm, and 1.2 cm) with mean 1.17 cm was recorded for Desho grass at 60, 90, and 120 days of harvesting, respectively. This might be due to the reason that leaf development has been most extensively described in grasses because different grasses have different leaf sizes and leaf attachments with the stem which showed variation in the leaf area index. The leaf's angle of attachment to the tiller of grass is important for its surface exposure on ground and solar radiation interception during growth and development [28]. The largest mean leaf width per plant (LWPP) (1.99 cm) was observed at the advanced stage of harvesting (120 days), but the early harvesting stage (60 days) resulted in the shortest leaf width per plant (1.465 cm) and the intermediate leaf width per plant (1.73 cm) was recorded at 90 days of harvesting stage. The overall mean of three successive harvest leaf widths per plant was 1.7 cm.

The current finding is in line with that of Msiza et al. [29], who reported that maximum leaves in *Panicum* had significantly higher leaf width value (12.53 mm) across all growth stages when compared to all other ranked grass species in the semi-arid region of South Africa. Grasses with broad leaves have a bigger surface area that enhances the photosynthetic activity, thereby producing more carbohydrates that stimulate regrowth of leaf width and length. This is due to cell division, elongation, and maturation zones occurring sequentially along the base of the developing leaf.

3.1.7. Leaf-to-Stem Ratio (LSR). The interaction between grass species and harvesting age had a very high significant ($P < 0.001$) effect on the leaf-to steam ratio of the tested grass species. The highest leaf-to-stem ratio was measured in Napier grass (3.4, 2.6, and 1.6) with mean 2.5, followed by Desho (1.36, 0.81, and 1.03) with mean 1.067 and *Brachiaria* (1.05, 0.3, and 0.41) with mean 0.58 at 60, 90, and 120 days of harvesting, respectively. The lowest leaf-to-stem ratio was seen in *Brachiaria mutica*. The overall mean leaf-to-stem ratio from all experimental groups was 1.4. However, the greater LSR (1.94) was measured at the early harvesting stage than in the two late harvesting stages (1.25 and 1) (90 and 120 days), respectively. One possible reason might be genetic variation of the grasses to produce a different leaf mass while the other could be the ability of all gas to produce more leaf (prolific tiller) at early stages before more nodes emerged. The leaf-to-stem ratio declined sharply as the harvesting days increased. Decrease in the leaf-to-stem ratio with increase in the harvesting interval might be attributed to the accumulation of more cell wall components in plant tissues as a result of stem development with advancing maturity.

Therefore, this result is in agreement with that of Zailan et al. [30] who reported that the LSR of Napier grasses decreased as the harvesting age increased. The decline in leaf-to-stem ratio with the advancement of age might be due to the loss of leaves especially from the bottom part of the plants and the accumulation of more structural materials on the stems which were assumed to be the causes for lower leaf-to-stem ratio. The current result is in line with the findings in [17] which found a higher leaf-to-stem ratio in Desho grass at the early harvesting stages (90 and 120 days) than at the later stage (150 days). A similar finding was also reported by Wangchuck et al. [21] who also reported a sharp decline in the value of leaf-to-stem ratio as the cutting intervals increased. The leaf-to-stem ratio, which varied depending on the number of cuts, harvest cycles, and harvest stage, is an important quality indicator during evaluation of herbage quality.

On the other hand, in our current study, the higher value of leaf-to-stem ratio was recorded in Napier grass (2.5), followed by Desho (1.067) and *Brachiaria* grass (0.58). The studies of different authors also confirm this result for different species of tropical grasses. 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. The current result agrees with the finding of Kefaylew et al. [20] who reported that the leaf-to-stem ratios declined from 1.76 to 0.79 in desho grass as age of plants increased. This could be due to the reason that old leaves fall down when a plant gets much older, thereby reducing the number of leaves.

3.1.8. Number of Nodes per Plant (NNPP). The interaction between grass species and harvesting age had a very high significant ($P < 0.001$) effect. Variation was observed among the tested grass species for the number of nodes per plant. The highest number of nodes (7.3, 14.68, and 4.96) was observed in the late harvesting stage (120 days), followed by the intermediate number of nodes (6.025, 9.025, and 0) at the intermediate stage (90 days) of harvesting and the lowest number of nodes (3, 6.25, and 0) at the early stage (60 days) of harvesting, in Desho, *Brachiaria*, and Napier grass species, respectively. In combined analysis, the mean number of nodes per plant ranged from 3.08 to 8.98 at the harvesting stage from 60 to 120 days. This might be because when the age of harvesting increases, the tiller or stem remains vegetative; the apical meristem is indeterminate and theoretically can produce an infinite number of new nodes and leaves. The highest mean number of nodes per plant (5.4 and 10 nodes) was recorded for the Desho grass and *Brachiaria* grass, respectively, while Napier grass produced the lowest (1.65) number of nodes. As other agronomic traits, stem elongation is also influenced by variation in soil type, temperature, amount and distribution of rainfall, genotypes, and harvesting stage interaction effects.

3.1.9. Dry Matter Yield. The interaction between grass species and harvesting age had a very high significant ($P < 0.001$) effect. Variation was observed among the tested grass species for DMY ton per hectare. The total DMY at the longest harvesting period (120 days) was recorded as 16.65 t/ha, followed by intermediate harvesting (90 days) and early harvesting (60 day) producing 8 t/ha and 2.16 t/ha, respectively. Among species, *Brachiaria mutica* grass provided the highest dry matter yield (11.8 t/ha), followed by moderate DMY of 9.8 t/ha and lowest DMY of 5.24 t/ha produced by Napier and Desho grass species, respectively. The overall mean DMY for different plant species was 8.9 t/ha. The DMY increased progressively with increase in harvesting age. This is due to the fact that as grass matures, herbage yield is increased due to the rapid increase in the tissues of the plant, development of additional tillers, and leaf formation, leaf elongation, and stem development with increase in plant age. DMY increased as plant density increased and with emergence of a high number of tillers.

The current result is in agreement with the report of Asmare et al. [17] who observed that the total dry matter at the longest harvesting period (150 d) was the highest (20.75 t/ha), whereas the lowest dry matter yield (12.71 t/ha) was produced in the shortest harvesting period (90 d). This finding is in line with our result, but the score is higher than in our finding at relatively different harvesting intervals. The difference might be due to the intensive management of nitrogen fertilizers, irrigation, and genetic makeup of the grass. On the other hand, harvesting at the age of 150 days gave the highest DMY (7.88 t/ha) compared to harvesting at 90 and 120 days. Kefyalew et al. [20] reported this finding to be lower than in our current study in Desho grass at relatively different plant harvesting stages. The variations might be due to percentage of plant survival rate, tillering performance, and plant height which are the causes of difference in DM yield.

Other reports of Tilahun et al. [24] also showed that at different days of harvesting (7.1 t/ha at 90 days, 15.7 t/ha at 120 days, and 25.5 t/ha at 150 at days), lower dry matter yields were produced than in the current finding. This difference might be due to line difference, agroecology, stage of harvesting, plant type, biomass yield difference, and rainfall. The total dry matter during the late harvesting stage (135 days) was the highest (25.4 t/ha), whereas the lowest dry matter yield (7.06 t/ha) was produced in the early harvesting stage (75 days) and an intermediate mean DMY (15.73 t/ha) was obtained at 105 days of harvesting. This indicated that DMY increased significantly as harvesting days increased. The increasing trend of DMY with advancement in the stage of maturity was due to increase in the structural carbohydrate and reduction in the moisture content of the grass. The present study is in line with the findings of different authors [31, 32] who reported that tiller density differed among the local range grasses in Kenya. Variations in DMY production across the ecotypes can be attributed to differences in growth rate and growth habit, which are mediated through the genotypic and phenotypic differences.

3.2. Effect of the Harvesting Stage and Improved Grass Species on Chemical Composition of the Grass Species. The interaction effects of harvesting stage and grass species on DM, ASH, OM, CP, CPY, NDF, ADF, and ADL are presented in Table 2. All quality parameters were significantly ($P < 0.001$) affected by the interaction effect of harvesting stage and grass species in the current study. The stages of harvesting and inherent type of species are important factors in altering the nature of forage nutritive value. The degree of response to chemical composition might be different within grass species and with the stage of cutting interval.

3.2.1. Dry Matter Content. The interaction effects between harvesting stage and grass species on the DM content of different grass species in the current study were significant ($P < 0.001$). The highest DM content (92.6, 92.61, and 93) with mean 92.76 was obtained from *Brachiaria* grass followed by the intermediate DM content (89.7, 90.6, and 91.3) with mean 90.5 from Napier grass and the lowest DM content (88.8, 90.2, and 90.5) with mean 89.84 from Desho grass at 60, 90, and 120 days of harvesting, respectively. In all grass species (Desho, *Brachiaria*, and Napier grass), late harvesting (120 days) resulted in higher DM content (91.6%) than 91.1% DM content during the intermediate harvesting (90 days), whereas the relatively lowest (90.4%) dry matter content was recorded at the early harvesting stage (60 days). Therefore, the result showed that DM content increases linearly with increasing harvesting age which might be due to an increase in DMY with maturity. The overall mean of dry matter content was 91%.

The current study is in in disagreement with results of Demlew et al. [33] who reported that forage species and harvesting time interaction had no significant effect ($P > 0.05$) on DM content of Buffel grass at different harvesting time periods. It might be due to the type of the grass or genetics of grasses, season, and management system in the area where the study was conducted. Also, an increase in the DM content with increasing maturity was in agreement with the findings of Rambau et al. [22] who showed the DM content increased as the grass matured and higher DM was observed at the late stage of maturity in Napier grass. The increment of dry matter content in the later harvesting stage could be due to decreased moisture content in the leaves as the plant gets matured and lignified. According to Asmare et al. [17], Desho grass harvested at 150 d after planting produced a significantly higher DM content than the grass harvested at 90 and 120 d. The increment of DM% with the

Table 2: Effect of harvesting stage and improved grass species on chemical composition of the grass.

Factor		Parameter							
Harvesting date	Grass species	DM (%)	ASH (%)	OM (%)	CP (%)	CPY (t/ha)	NDF (%)	ADF (%)	ADL (%)
	Desho	88.8^{c}	15.8^{c}	83.2^{a}	9.34^{b}	0.23^{a}	64.1^{a}	36.2^{a}	4.67^{b}
60	*Brachiaria*	92.6^{a}	16.93^{b}	83.07^{b}	12.2^{a}	0.224^{a}	55.4^{b}	35.6^{a}	4.2^{c}
	Napier	89.7^{b}	18.7^{a}	81.3^{c}	9.3^{b}	0.204^{a}	65.5^{a}	33.8^{b}	5^{a}
	Desho	90.2^{b}	15.6^{c}	84.1^{a}	7.1^{c}	0.37^{b}	65.7^{a}	36^{a}	4.81^{b}
90	*Brachiaria*	92.61^{a}	16.9^{b}	83.1^{b}	13.6^{a}	0.97^{a}	56.5^{b}	36.7^{a}	4.2^{c}
	Napier	90.6^{b}	18.3^{a}	81.7^{c}	9.7^{b}	1.15^{a}	66^{a}	33.8^{b}	5.3^{a}
	Desho	90.5^{c}	13.5^{b}	86.5^{a}	7^{b}	1^{a}	69.7^{b}	37.7^{b}	4.87^{b}
120	*Brachiaria*	93^{a}	15^{a}	85^{b}	9^{a}	1.8^{a}	59.6^{c}	39.1^{a}	4.77^{b}
	Napier	91.3^{b}	15.7^{a}	84.3^{b}	7^{b}	1.2^{a}	72.2^{a}	37^{b}	5.95^{a}
	Overall mean	91	16.3	83.7	9.4	0.8	63.8	36.2	4.86
	SE	0.24	0.265	0.265	0.39	0.112	0.92	0.3	0.1
	CV	2	2.5	2.52	5.5	0.45	30.3	3.2	0.3
PP value	Harvesting date	***	***	***	***	***	***	***	***
	60	90.4^{c}	17.14^{a}	82.9^{b}	10.3^{a}	0.22^{c}	61.7^{c}	35.2^{b}	4.6^{b}
	90	91.1^{b}	17^{a}	83^{b}	10.12^{a}	0.83^{b}	62.7^{b}	35.5^{b}	4.77^{b}
	120	91.6^{a}	14.7^{b}	85.3^{a}	7.7^{b}	1.32^{a}	67.14^{a}	38^{a}	5.2^{a}
	Grass species	***	***	***	***	*	***	***	***
	Desho	89.84^{c}	15^{c}	85^{a}	7.8^{b}	0.53^{b}	66.5^{b}	36.6^{a}	4.78^{b}
	Brachiaria	92.76^{a}	16.25^{b}	83.7^{b}	11.6^{a}	0.98^{a}	57.1^{c}	37.12^{a}	4.4^{c}
	Napier	90.5^{b}	17.6^{a}	82.4^{c}	8.7^{b}	0.85^{ba}	67.88^{a}	34.89^{b}	5.4^{a}
	Harvesting date*×grass species	***	***	***	***	***	***	***	***

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, DM = dry matter content, ASH = ash content, OM = organic matter, CP = crude protein, CPY = crude protein yield, NDF = neutral detergent fiber, ADF = acid detergent fiber, ADL = acid detergent lignin, SE = standard error, and CV = coefficient of variation.

advancement of age might be due to the decline in moisture content of the grass as harvesting age advanced.

On the other hand, the current study is in line with that of Tilahun et al. [24] who reported that harvesting age had shown minimum variation on the DM content of Desho grass with linear increase from 75 (88.2) to 105 (88.4) and 135 (89.1) days of harvesting. The current finding is supported by Kefyalew et al. [20], who found that Desho grass harvested at 150 days after planting produced a significantly higher DM content than the grass harvested at 90 and 120 days. This result reported a lower DM content than in the current result; this might be due to environment conditions, management system, and harvesting age differences in the area where the current experiment was conducted. The overall mean of dry matter content in the current result was 91%, lower than that of *B. mutica* grass as reported by Zemene et al. [15]. The studies reported that the DM content of grasses increased with an increase in growth and development of plants and longer time to harvesting.

3.2.2. Ash Content (%). The interaction between grass species and harvesting age had a very high significant ($P < 0.001$) effect on the ash content of different grass species. From all grass species (Desho, *Brachiaria*, and Napier grass), the early harvesting stage (60 days) resulted in higher ash content (15.8, 16.93, and 18.7) with mean 17.14, followed by intermediate (90 days) harvesting stage recording an intermediate ash content (15.6, 16.9, and 18.3) with mean 17 and late (120 days) harvesting stage recording the lowest ash content (13.5, 15, and 15.7) with mean 14.7 in all grass species, respectively. However, among all grass species, the highest ash content (17.6) was recorded in Napier grass, followed by *Brachiaria* (16.25), and the lowest mean (15) ash content was recorded in Desho grass. The overall mean of ash content was 16.3.

Our current result is in agreement with that of Zemene et al. [15] who reported that the mineral (ash) content of the *Brachiaria mutica* grass decreased with an increased stage of maturity. A finding indicated that decrease in ash content with a long harvesting interval is probably a normal phenomenon of maturity of Desho grass [20]. It might have been caused partly by the dilution effect of higher yields in the presence of a constant amount of available minerals in the soil. On the other hand, the concentration of minerals in forage grasses varies from species to species; this could be due to factors like morphological fractions, climatic conditions, and soil characteristics [19]. Linn and Martin [34] reported that most forage has an ash content ranging from 3% to 12%, but the current result has a greater value than this range. This difference could come from the variation of species type and cutting interval, higher biomass yield, better chemical composition, environmental conditions, and different management practices as well as their interaction effects in natural pasture.

3.2.3. Organic Matter Content (OM%). Grass species and harvesting stage had a very high significant ($P < 0.001$) interaction effect on organic matter content. Desho grass harvested at different harvesting periods (60, 90, and 120 days) showed a higher organic matter percentage (83.2, 84.1, and 86.5) than *Brachiaria* grass which showed intermediate organic matter percentage (83.07, 83.1, and 85) in line with 60, 90, and 120 days. Napier recorded the lowest organic matter percentage (81.3, 81.7, and 84.3) at 60, 90, and 120 days of harvesting stage, respectively. OM varied among species, and this might be associated with the genetic variation of grasses, environmental conditions, soil types, and soil fertility [19]. The overall mean of organic matter percentage was 83.7%. Hence, the result indicated that an increase in the concentration of organic matter (OM) is because of the advanced maturity stage of the grass.

The organic matter (OM%) content of the current study was similar with the findings of Zemene et al. [15] who noted that the rate of OM content of the *Brachiaria mutica* grass increased from 85.35 to 89.5% with increase in the stage of maturity (60 to 120 days). This is also conformed to the study in [24] which demonstrates that organic matter increased progressively ($P < 0.01$) with increasing harvesting days ($75 < 105 < 135$ days). This is because increase in the concentration of OM stems from the increased organic matter requirement of grass for their reproduction at the advanced maturity stage. Tiruset [16] showed that the Desho grass had shown relatively similar OM content with that of our study. On the other hand, the current result disagrees with that of Asmare et al. [17] who reported that harvesting age had no significant effect on OM content (%) of Desho grass at 90 (89.12), 120 (89.66), and 150 (90.57) days of harvesting. This might be due to the genetic variation of grasses, altitude differences, soil types, and fertility in the area where experiments were conducted.

3.2.4. Crude Protein Content (CP%). The interaction between grass species and harvesting age had a very high significant ($P < 0.001$) effect on crude protein content. *Brachiaria mutica* grass harvested at all three harvesting periods (60, 90, and 120 days) showed a higher crude protein content (12.2, 13.6, and 9), respectively. However, the intermediate crude protein content (9.3, 9.7, and 7) was recorded from Napier at 60, 90, and 120 days, and the lowest CP content (9.34, 7.1, and 7) was observed in Desho at 60, 90, and 120 days of harvesting, respectively. The highest crude protein content (10.3) was recorded during the early harvesting period (60 days), followed by the crude protein content of 10.12 during the intermediate harvesting stage (90 days) and CP content of 7.7 during the late harvesting stage (120 days). Therefore, the result indicated that the crude protein content significantly reduced with increase in the harvesting age. The decline in CP content with advancing stage of maturity is due to accretion of higher proportion of NDF corresponding to plant growth. CP was highest in the early stage compared with the intermediate stage and late stage. This could be attributed mainly to dilution of the CP contents of the forage crops by the rapid accumulation of cell wall carbohydrates at the later stages of growth [35]. Decreasing CP contents of grasses with increasing plant harvesting might be due to reduced leaf-to-stem ratio. Crude protein is one of the major criteria for determining the nutritional quality of a feed because as the level of CP increases, the DM intake by livestock and rumen microbial growth would also increase [36].

Grass species and harvesting stage had a significant effect on the CP content in line with Desho grass as reported by Asmare et al. [17] at 90 (9.38), 120 (8.75), and 150 (6.93) days and [24] at 75 (10.9), 105 (10.2), and 135 (9.3) days of harvesting in different agroecological and management systems. The finding is also in line with Asmare et al. [17] who reported that the harvesting period had a significant ($P < 0.001$) effect on CP content of Desho grass.

The current study showed that *Brachiaria mutica* grass harvested at all three harvesting stages had significantly ($P < 0.001$) higher CP content than other studied grass species. The difference might be due to nature of the grass species, different soil structures, management practices, and weather conditions which are the major factors that influence nutritional quality of grass species. Crude protein content from all the plant materials analyzed met the minimum requirements for ruminants (>7%), i.e., 6.9% for maintenance, 10.0% for beef production, and 11.9% for milk production [5]. All the studied grass species had a CP content which almost fulfiled the minimum requirement.

3.2.5. Crude Protein Yield (CPY). Grass species and harvesting age had a high significant ($P < 0.001$) interaction effect on CPY. The highest (1.32 t/ha and 0.83 t/ha) CPY was obtained at the later (120 days) and intermediate (90 days) stages of harvesting, respectively, while early harvesting (60 days) showed a relatively low (0.22 t/ha) CPY in all grass species. However, the crude protein yield increased when harvesting age increased. The CPY was highest when the grass was at the matured stage implying that the increase in DM yield was faster than the decline in CP with maturity. The CPY content varied among species at all harvesting stages, but the highest mean CPY of 0.98 ton/ha was recorded in *Brachiaria*, followed by Napier (0.85 ton/ha) and Desho (0.53 ton/ha). CPY difference among species might come from genetic variations, environmental conditions, soil types and fertility, altitude, and interaction effects [19].

The current result agrees with that of Zemene et al. [15] who reported that CPY increased according to the stage of maturity in *Brachiaria mutica* grass. The current result is also in line with that of Desho as reported by Tilahun et al. [24]. Harvesting age had a significant effect on CPY at 75 (0.8), 105 (1.6), and 135 (2.4) days of harvesting. This result was significantly higher than the CPY of the current result at 60 (0.22), 90 (0.83), and 120 (1.32) days. This might be due to planting systems, harvesting age, environment, altitude, and soil type and fertility in the area where the experiment was conducted. Obviously, decisions on the optimal time to harvest different grasses will depend on a compromise between yield and quality of forage. Similarly, our current study disagrees with that of Asmare et al. [17] who reported that harvesting age had no significant effect on CPY of Desho grass at 90 (1.21), 120 (1.21), and 150 (1.44) days of harvesting. This might be due to difference between harvesting date interval, different soil structures, management practices, and weather conditions which are the major factors that influence nutritional quality of grasses.

3.2.6. Neutral Detergent Fiber Content (NDF%). The interaction between grass species and harvesting age had a high significant ($P < 0.001$) effect on the content of neutral detergent fiber in grass species. Napier grass produced a higher content of neutral detergent fiber (65.5, 66, and 72.2), followed by Desho grass (64.1, 65.7, and 69.7) and *Brachiaria* grass (55.4, 56.5, and 59.6) at all harvesting periods (60, 90, and 120 days), respectively. The overall mean of neutral detergent fiber percentage was 63.8. All grass species harvested at the late harvesting period (120 days) produced a higher content (67.14) of neutral detergent fiber, whereas the intermediate (62.7) and lowest (61.7) neutral detergent fiber contents were observed at intermediate (90 days) and early (60 days) harvesting stages, respectively. The current result indicated that the content of NDF increased as the grass matured. The increasing trend of NDF concentration with increase in harvesting age agrees with the findings of Adnew et al. [5] in *Brachiaria* grass cultivar and Asmare et al. [17] in Desho grass, in which NDF concentration increased from 72.8 at 90 days to 77.7 at 150 days of harvesting. This might be due to more seeds being produced at the time of plant maturity; there is a translocation of protein from the leaf and stem to seeds, and therefore, high fiber remains on the plant. The reason might be due to environmental factors of temperature and water stress affecting the cell content and leading to accumulation of less carbohydrate. Similarly, harvesting age had a significant effect on the NDF content of grass species as reported by Tilahun et al. [24] at 75 (45.26), 105 (46.26), and 135 (51.7) days of harvesting of Desho grass. These current results also indicated that the NDF content increased with increase in the days of harvesting from 90 days to 150 days [33]. This might be due to an increase in fiber content accompanied with the decrease in CP content associated with an increase in the proportion of lignified structural tissue at the later stage of growth. On the other hand, contrary to our result, the study in [22] demonstrated that grass maturity had no effect ($P > 0.05$) on the NDF content of Napier grass. This might be due to the fact that as the plant matures, the cellulose, hemicelluloses, lignin, and silica which are found in the insoluble portion of the forage increase.

3.2.7. Acid Detergent Fiber. The interaction effects between grass species and harvesting age on ADF content of different grasses in the current study were highly significant ($P < 0.001$). The highest ADF content (38) was observed at the late harvesting stage (120 days). The intermediate (35.5) and the lowest (35.2) ADF contents were recorded during the intermediate (90 days) and early (60 days) harvesting stages, respectively. Among grass species, *Brachiaria* grass was showed a higher (37.12) ADF content than Desho grass (36.6) and Napier grass (34.89). The ADF content of grasses was affected by type and species of grass and soil types. The interaction effect in the current study is in line with that of [18, 19]. The ADF content is increased with the maturity of the plant.

Therefore, an increase in the ADF content with the increase in harvesting days of grass was in line with the results of [15]which reported that *Brachiaria mutica* grass harvested at 120 d after planting had a higher ADF (36.56). The results obtained also showed a linear increase in the ADF content with a corresponding increase in days of harvesting. According to [22], Napier grass showed a relatively similar ADF content (37.83) with that of our study (38). Similarly, harvesting age had a significant effect on the ADF content of Desho grass as reported by Asmare et al. [17] at 90 (40.27), 120 (42.15), and 150 (45.06) days. This difference might come from planting systems, environment, altitude, soil type, soil fertility, and harvesting age in the area where the current experiment was conducted.

3.2.8. Acid Detergent Lignin. The interaction between grass species and harvesting age had a significant ($P < 0.001$) effect on acid detergent lignin of different grasses. The highest acid detergent lignin content (5, 5.3, and 5.95) was recorded in Napier grass at harvesting age of 60, 90, and 120 days, followed by the intermediate content in Desho and the lowest content in *Brachiaria* grass recorded as (4.67, 4.81, and 4.87) and (4.2, 4.2, and 4.77), respectively, in line with 60, 90, and 120 days of harvesting stage. The highest ADL content (5.2) was recorded during late harvesting (120 days), whereas the intermediate (4.77) and the lowest (4.6) ADL contents were recorded during intermediate (90 days) and early (60 days) harvesting, respectively. This result was in conformity with that of other reports [37] which observed that ADL increased with progressive stages of maturity. The late stage had the highest lignin content which would bind the cellulose and hemicellulose and prevent them from being digested and are utilized efficiently by the rumen microbes.

Therefore, the current study indicated that harvesting age had a significant effect on the ADL content of the grass as reported by Asmare et al. [17] at 90 (4.68), 120 (5.53), and 150 (5.95) days of harvesting in Desho grass. This result was significantly higher than that of the current study of ADL content at 60 (4.6), 90 (4.77), and 120 (5.2) days of harvesting. These differences might come from planting system, harvesting age, environment, altitude, nature of grass type, soil type, and fertility in the area where the experiment was conducted. *Brachiaria mutica* grass performs better during feed digestion in the rumen than Napier and Desho grasses, and it can easily convert milk, meat, and other products.

4. Conclusion

In conclusion, in the current result based on all aspects of evaluations, *Brachiaria* grass was selected as adaptive and showed better productive performance to fulfil the optimum forage quantity and moderate quality to enhance the livestock production and productivity followed by Napier grass in the study area. Among the tested grass species, *Brachiaria* grass was recommended alternatively for high dry matter yield and better crude protein content depending on less fiber availability on farm evaluation and demonstration in the study area during the establishment phase. Regarding the harvesting ages, 90 to 120 days of harvesting are recommended for optimum dry matter yield and moderate nutritional quality of the grass in the study area and similar agroecologies. Further studies should be conducted at different locations with varying climatic conditions, soil types, and different fertilizer applications, and economic feasibility must be considered to investigate appropriate agronomic and management practices in order to maximize production and productivity of grass species at different study areas.

Data Availability

All data are included within the manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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