Participatory Evaluation of Some Selected Forage Species in Afar Regional State, Ethiopia: In the Case of Koneba and Telalak Districts

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Abstract

This experiment was conducted with the objective of evaluating the on-farm productivity of the selected improved forage species and assessing pastoralists’ perception on the selected forage species and assessing pastoralist criteria for selecting forage species as livestock feed. Accordingly, the biomass yield of Sudan grass (Sorghum sudanense) was significantly higher than all the grass species in both Koneba (8.24 t/ha) and Telalak (7.79 t/ha) districts followed by Chloris gayana. The number of tillers/plant for C. gayana were significantly higher than the other species in both Koneba (27.45 tillers/plant) and Telalak (20.41 tillers/plant). C. gayana and S. sudanense showed significantly higher vigor score than the other grass types. C. gayana (5.00), Panicum coloratum (4.75) and Panicum antidotale (4.25) showed significantly higher (0.05) plot cover sore. C. gayana, S. sudanense and P. antidotale were reached their 50% flowering stage earlier than the other grasses. According to the pastoralist perception C. gayana was selected first followed by P. antidotale for their palatability, early maturity, drought tolerance and regeneration capacity. C. gayana and P. antidotale showed higher vegetational and perceptual performance; therefore, these grasses should be tested in different areas and disseminated to the community by creating awareness about proper management system.

Keywords: Biomass; Koneba; Telalak; Forage species; C. gayana; P. coloratum; S. sudanense

Introduction

Ethiopia has a large livestock population and diverse agro-ecological zones suitable for livestock production and for growing diverse types of fodder plants. However, livestock production has mostly been subsistence oriented and characterized by very low reproductive and production performance [1].

The primary constraint limiting livestock production and productivity in Ethiopia is shortages of quality and quantity of animal feed [1,2]. It is often cited as the main constraint in pastoral and agro-pastoral areas of the country [3]. Livestock are fed almost entirely on natural pasture, fallow land and cropland after harvest which is characterized by poor nutritive value to meet the nutrient requirement of livestock. This is aggravated with undernourishment, slow growth rate, low daily body weight gain, loss of body condition and prolonged time to reach marketable weight which makes less benefit of the pastoral communities [4]. This short supply and unimproved feed is also reflected in the low supply of meat, milk, drought power and other animal products [2].

Native forage species in natural pastures are in danger of extinction due to invasion of rangelands by invasive plant species, bush encroachment, recurrent drought, overgrazing and expansion of state farms. Forage production and quality of degraded rangelands need to be improved for enhancing livestock production to meet the ever-increasing demand of growing human population for animal protein and other products. Therefore, cultivation and production of improve is mandatory to fill the feed gap. Over the past years several forages have been tested to grow in different ecological zones Ethiopia, and considerable efforts have been made to test the adaptability of different species of pasture and forage crops under varying agro-ecological conditions. As a result, quite a number of useful forages have been selected for different zones [5].

Chloris gayana is a variable species of diploid and tetraploid genotypes that has been very successful in the sub tropics. Rhodes grass stems can extend from 0.5 to 2 m high. It is a perennial, stoloniferous, sometimes tufted grass. Rhodes grass can survive dry seasons of up to about 6 months yet can tolerate periodic flooding or water logging. Also, it is tolerant of fire, tolerates high saline conditions [6]. It has a good balance between crude protein (CP) and digestibility, with CP up to about 18 to 20% and digestibility up to above 70%. Its regrowth potential is faster than other warm season perennial grasses. Seed production, seedling vigor, and seedling recruitment characteristics are good. Under farm conditions, production can be 5 to 8 t/ha dry matter (DM) [7].

Cenchrus ciliaris is another important grass that can survive in a range of harsh environmental conditions but has the highest yields in arid areas [8]. It tolerates a variety of moisture regimes, from dry sandy areas to tropical forests. It can grow in shallow or heavy clay soils of low fertility and may occur at elevations ranging from sea level to 2000 m. C. ciliaris is an important pasture grass in many parts of the tropics, mainly because of its low cost of establishment, high yields and high level of nutrients, tolerance to drought conditions and crop pests, and its ability to withstand heavy grazing and trampling by livestock [9].

Panicum coloratum is tufted perennial grass with variable habit, up to 150 cm high. It is adapted to drier (400 mm) low land alluvial flood plains at an altitude range of 500 to 2000 m.a.s.l. Yields are usually
around 12 t/ha DM but ranges of 5.8 to 18 t/ha DM has been reported [7]. *P. coloratum* is palatable, high quality forage when green, tolerant of temporary water logging and flooding, drought tolerant, tolerant to soil salinity, very persistent, even in heavy soils with low soil N [10].

*Panicum antidotale* is palatable deep-rooted perennial drought resistant grass spece with short rhizomes [11]. It is a tall, much branched and tussock forming grass. This grass is resistant to abiotic and biotic stresses, thus reported to be grown with promising forage production. It has a considerable agrarian potential to be used as cattle feed and it can be grown with saline water irrigation of salinized and/or waste land [12].

However, the on-farm evaluation of different forage species has not been tested in the study area under farmers’ management level to see the adaptability and preference of the community. This might be due to the remoteness and low awareness of the community for adaptation and experiment. Hence, introducing and cultivating; and extension of relatively adaptable, drought tolerant and improved forage species in participatory way should be practiced in the areas to cope up with the above listed problems and to increase livestock productivity. Therefore, this research was conducted to evaluate the productivity and pastoralists’ preference of the selected drought tolerant forage species.

**Materials and Methods**

**Description of study areas**

The two years (2014/2015 and 2015/2016) study was conducted in Koneba and Telalak districts in the Afar Regional State, Ethiopia. Koneba is one of the districts in the Afar Region of Ethiopia. A triangle-shaped district in the Administrative Zone 2. It is located near the base of the eastern escarpment of the Ethiopian highlands and bordered on the west by the Tigray Region, on the north by Dallol and on the east by Berhale. The average elevation in this district is 1150 m.a.s.l. Based on the 2007 Census conducted by CSA, the district has a total population of 54,198 of whom 29,355 are men and 24,843 women; with an area of 483.16 km², Koneba has a population density of 112.17. While 3,031 or 5.59% are urban inhabitants, a further 366 or 0.68% are pastoralists. A total of 5,447 households were counted in this district, which results in an average of 7.0 persons to a household, and 5,732 housing units.

Telalak is also one of the districts in the Afar Region of Ethiopia. Part of the Administrative Zone 5. It is located near the base of the eastern escarpment of the Ethiopian highlands, and bordered on the south by Dewe, on the west by the Amhara Region, on the north by the Administrative Zone 1 and on the east by the Administrative Zone 3. The average elevation in this district is 720 m.a.s.l. Based on the 2007 Census conducted by CSA, this district has a total population of 37,970, of whom 22,395 are men and 15,575 women; with an area of 1,261.84 km², Telalak has a population density of 30.09. While 1,950 or 5.37% are urban inhabitants, a further 1,950 or 5.37% are pastoralists. A total of 7,698 households were counted in this district, which results in an average of 7.0 persons to a household, and 7,875 housing units.

**Farmer selection and site and land preparation**

Based on the results of reconnaissance survey selection of target pastoralists was carried out. Target groups was selected purposively based on their interests to be included in the study activities; engaged mainly on livestock production and having potential role to share findings to other pastoralists and agro-pastoralists. The target group may include experienced livestock keepers and pastoral and agro pastoral community leaders. Hence, ten farmers from each district (i.e., a total of twenty farmers) were included in this study. Then forage sites were selected purposively based on proximity to infrastructure and irrigation water sources. Experimental land was cleared, ploughed, softened and made to be suitable for cultivation (Figure 1).

![Figure 1: Experimental site.](image)

**Participatory research group (PRG) establishment**

In order to improve the linkage among research, extension and pastoralist, there was a need to promote group action and formation of participatory research group (PRG). The objective was to empower pastoralist so that they take part in the research process. This was designed to increase their participation in the research system. The entire task contained 10 pastoralist members and 1 developmental agent (DA) from each experiment areas and 4 researchers to conduct participatory improved forage research. The PRG was organized by researchers and facilitated by the DAs. DAs were deeply involved on guiding and organizing the task. The establishment of the PRG was used for the pastoralist to work with researchers and development agents and discuss on which forage was better for their livestock on their management scheme.

**Roles of each actor**

- **Pastoralists**: keep records, prepare required materials, execute recommended practices, and control, arrange and hold meetings and visits by members, mobilize group members to participate in the activity.
- **DAs**: keep records, arrange and encourage visit to PRG member farmers’ trial site by non PRG member farmers, help researchers in arranging visits and field days, follow up the trial.
- **Researchers**: monitor proper implementation of the trial, confirm participation of all stakeholders in the activity, organize training farmers, DAs and others, collect data, analyze and communicate ongoing results to farmers and concerned actors.

**Experimental Design and Treatments**

For evaluation of the five-forage species, a series of trials was used and conducted at two locations (Koneba and Telalak). Twenty plots, each measuring 3 m × 2 m (6 m²), with 1 m spacing between plots, 1.5 m between blocks and 25 cm spacing between rows were prepared for sowing. Seed of *C. ciliaris*, *C. gayana*, *P. coloratum*, *P. antidotale* and *S. sudanese* was sown into rows on a well-prepared seedbed. The
experiment consisted of five treatments (forage species) arranged in a Randomized Complete Block Design with four replications. The treatments were *C. ciliaris*, *C. gayana*, *P. coloratum*, *P. antidotale* and *S. sudanense*. All agronomic activities were implemented by the pastoralists with the strict supervision of the researchers and development agents at each location. Hand weeding was applied during the entire experiment to control weed competition against the experimental grasses. Watering frequency was 4 days up to the middle of the growth while it became weekly after. Irrigation water was utilized throughout the entire growth season.

### Methods of data collection

**Vegetation data:** The study was conducted in two years and the major information about seedling and tiller count, plant height, growth vigor, plot cover, disease and pest resistance, flowering, maturity and biomass yield was measured on plot and plant basis.

**Seeding count:** Was made after planting to give an estimation of emergence. This was done by counting the total number of seedlings in the row to determine plant density per square meter. The average number of seedlings was determined from randomly selected sampling areas in the central rows of each plot for each species at 2, 3 and 4 weeks after sowing.

The major phonological and growth parameters thought to be associated with growth, biomass yield and drought tolerance were recorded on plot and plant basis by using standard procedures.

These include:

- **Days to 50% flowering (DF):** Number of days from planting to the date on which 50% of plants on the two middle rows produce at least their first flower.

- **Biomass yield (Biological yield) (BY):** Determined by weighing the total air dried above ground biomass yield of plants in the two middle rows.

- **Plant height:** The height of ten randomly taken plants from each of the two middle rows was measured from the ground level to the tip of the plant at maturity and expressed as an average of ten plants per plot.

- **Number of effective tillers per plant:** Number of basal tillers which bear mature ears of ten randomly taken plants from each experimental unit was counted and the mean was recorded as effective tillers per plant and expressed as average of ten plants per plot.

- **Plot cover and growth vigor:** Plot cover was estimated by dividing the 1 m² quadrat into 252, each of 20 cm × 20 cm (400 cm²), using string. Growth vigor was a subjective measurement of plant vigor. Plot cover and vigour (growth, competitive ability, seedlings) of establishment were recorded on a scale of 1 to 5 where 1 stands for very poor while 5 stands for very good.

- **Disease and pest incidence:** Was also the subjective measurement of plans attack by disease and pest that mainly hinders growth performance of the forage. This was recorded on a scale of 1 to 10 where 1 stands for severely attacked while 10 stands for no symptom of disease or pests incidence.

- **Perceptional data:** A total of 20 pastoralists were participated in the trial for the species selection in each district. The trials were managed by pastoralists and developmental agents and frequent visit was made by researchers to monitor, evaluate and collect data on the trial. The pastoralists were made to set criteria to select productive, drought tolerant palatable forage grasses. Accordingly, biomass yield, palatability, vigorosity, early maturity, seed production, drought tolerance, disease and pest resistance, easy of management, easy of seed collection and regeneration capacity were set as the main criteria to select the best performing forage varieties at the close supervision and recommendation of the researchers. The trials were managed by the pastoralists and frequent visit and serious follow-up of the researchers and DAs to evaluate and collect data.

Observation and pastoralists’ preference ranking data was taken using pair wise ranking matrix. The pastoralists used a score (1 to 5) for ranking the grass and (1 to 10) to rank their selection criteria, where 1 is best and 5 is worst in the case of the species and 1 is best and 10 is the worst in the case of the selection criteria [13].

**Statistical analysis:** All measured parameters were subjected to Analysis of variance (ANOVA) on the model designed for a randomized complete block design (RCBD) following the standard procedure given by Gomez and Gomez [14] using statistical analysis system (SAS) software package to estimate the prevalent variation among the tested experimental materials. Test of mean separation was employed depending on the significance of analysis of variance. Mean separation was done using Duncan’s Multiple Range Test to discriminate the forage grass species and identify superior ones based on the collected parameters and trait of interest.

### Results and Discussion

#### Biomass yield

The biomass yield of Sudan grass (*S. sudanense*) was significantly higher (P<0.05) than all the grass species in both Koneba (8.24 t/ha) and Telalak (7.79 t/ha). The biomass of *S. sudanense* is similar to the production (8.97 t/ha) shown in Pakistan (25). This could be due to the growth nature of the grass where it has longer height and high stem weight. *C. gayana* was performing second with the value of 7.24 t/ha and 6.04 t/ha for Koneba and Telalak respectively which is higher than the result (4.72 t/ha) reported by Arshadullah et al. [15] in Pakistan but lower than the reported by Yisehak [16] and Hidosa [4] at Alemaya University (10.60 t/ha) and Jinka Agriculture Research Centre (15 t/ha) which might be due to the application of fertilizer and relatively better agro-ecology and controlled management since the research has been conducted on station. Similar result has been reported in northern Kenya which *C. gayana* has shown higher biomass than *C. ciliaris*, which is supported by Hidosa [4]. Yields in the second year may be double that of the establishment year, but this also depends on management and environmental conditions [17]. Yields of 35 to 60 t/ha DM are reported [18]. The biomass of *P. coloratum* (5.62 t/ha) and *P. antidotale* (5.46 t/ha) showed statistically similar result in Koneba site which is significantly higher than the result of *C. ciliaris* (4.14 t/ha) while *P. antidotale* (5.51 t/ha) produced significantly higher biomass than *P. coloratum* (4.38 t/ha) and *C. ciliaris* (4.38 t/ha) in Telalak site (Table 1).

| Species   | Location | Konoba | Telalak |
|----------|----------|--------|---------|
| **FBM**  |          |        |         |
| *C. ciliaris* | 17.01d  | 16.26d | 16.26d  |
| *C. gayana*  | 26.63b  | 21.97b | 6.04b   |

| **DMB**  |          |        |         |
|----------|----------|--------|---------|
| *C. ciliaris* | 4.14d  | 4.38d  | 4.38d   |
| *C. gayana*  | 7.24b   | 6.04b  | 6.04b   |

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The result of *P. antidotale* in this study is lower than the result (6.47 t/ha at the spring to 12.93 t/ha at the monsoon) reported by Koech et al. [20] in Kenya but lower than the result (7.4 t/ha) due to the favorable climate of that area. This indicates that there is a potential to increase the productivity of *P. antidotale* by improving the agronomic practices. The result of *C. ciliaris* (4.14 t/ha to 4.38 t/ha) in both sites of this study was higher than the result (3.73 t/ha) reported by Koech et al. [20] in Kenya but lower than the result (7.4 t/ha) reported from Tanzania [21]. This implies that *C. ciliaris* can improve its productivity through application of better management measures.

### Growth attributes

**Plant counts:** The mean seeding count of *C. gayana* (364.00) and *P. antidotale* (345.00) was significantly higher (P<0.05) than the other forage species in Koneba while in Telalak site *C. gayana* (448.75) is significantly higher than the other species followed by *P. antidotale* (390.00) (Table 3). *C. ciliaris* and *S. sudanense* showed the lowest seeding count in both experimental sites. The number of seeds/kg of the experimental grasses is expected to be 703,000 [22], 906,000, 962,000 [23], 962,000 [22], 1,299,000 [22] and 150,000 [24] for *C. ciliaris*, *C. gayana*, *P. coloratum*, *P. antidotale* and *S. sudanense* respectively. The number of seedlings of *C. gayana* and *P. antidotale* signifies for their higher number of seeds/kg than *S. sudanense*. Accordingly, as per the seeding rate of each grass, *S. sudanense* showed the highest germination percentage than the other experimental grasses in both Koneba (86%) and Telalak (78%) due to the higher germination and low dormancy behavior of the grass. *C. gayana* emerged second followed by *P. antidotale* while *C. ciliaris* showed the lowest percentage germination which might be due to the fluffy nature of the seed that was easy to be taken by wind and water and was also difficult to be covered by soil to desired depth.

**Plant height and growth vigor:** Plant height has the principal contribution for biomass productivity of herbaceous forage plants. The mean height difference among the five-grass species was significant (P<0.05) (Table 3) in both sites but there was no statistical difference between *C. gayana* and *P. antidotale* in Koneba site. Generally, *S. sudanense* gave the highest plant height (225 cm) in both sites, which was followed by *C. gayana* (151.60 cm) and *P. antidotale* (158.23 cm) in Koneba while *C. ciliaris* (79.50 cm) showed the lowest plant height in both sites (Table 4). The longer height of *S. sudanense* might be due to the morphological property of the plant in which it has always more than 200 cm long which is similar to the report (224 cm) by Habib et al. [25] in Pakistan (Figure 2). The result of *C. gayana* is higher than that of shown in Pothower Plateau of Pakistan (117 cm) at rain fed conditions [15]. However, *S. sudanense* has lower number of tillers/plant in which it contributes to the lower stand count of the grass. This behavior may contribute to the longer height since nutrient competition/tiller is minimized. In Telalak site, the height of *P. antidotale* (136.53 cm) was longer than the other species which was next to *S. sudanense* (227.85 cm). The result of *C. gayana* is similar to the report by Onyeonagu and and Asiegbu [26] in Nigeria.

In the case of growth vigor, the score given for *C. gayana* (5) and *S. sudanense* (5) was significantly higher (P<0.05) than the score for *C. ciliaris* in both Koneba and Telalak. This might be related to the general lower performance of *C. ciliaris* in all aspects except drought tolerance. The result of *C. gayana* is similar to the result reported by Yisehak [16] at Alemaya University Research Station. *P. antidotale* also showed similar vigorsity with *C. gayana* and *S. sudanense* in Telalak.

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**Table 1:** Mean comparison among results of different grass species on fresh biomass (FBM) and dry matter biomass (DMB) (t/ha) in Koneba and Telalake sites over two years. Means of the same letter in a column are not significantly different. a,b,c,d=Mean located values.

| Species      | Location | Seeding Count | Germination percentage | Tillers/plant | Seedling Count | Germination percentage | Tillers/plant |
|--------------|----------|---------------|------------------------|---------------|----------------|------------------------|---------------|
|              | Koneba   |               |                        |               |               |                        |               |
| *C. ciliaris*| 200.00²  | 24            | 11.30²                 | 214.50²       | 25            | 6.94²                  |               |
| *C. gayana*  | 364.00⁴  | 57            | 27.95⁴                 | 337.00⁴       | 53            | 20.41³                 |               |
| *P. coloratum*| 248.00³ | 37            | 22.00³                 | 262.25³       | 39            | 14.51⁶                 |               |
| *P. antidotale*| 345.00⁵ | 53            | 21.05⁵                 | 292.75³       | 45            | 13.89⁹                 |               |
| *S. sudanense*| 193.25⁴ | 86            | 4.02⁴                  | 179.50²       | 79            | 2.31⁶                  |               |

**Table 2:** Mean comparison among results of the five-grass species on seedling count/m², germination percentage and tillers/plant in Koneba and Telalak experimental sites over two years. Means of the same letter in a column are not significantly different. a,b,c,d=Mean located Values.

| Species      | Location | Seedling Count | Germination percentage | Tillers/plant |
|--------------|----------|---------------|------------------------|---------------|
|              | Koneba   |               |                        |               |
| *C. ciliaris*| 200.00²  | 24            | 11.30²                 | 214.50²       |
| *C. gayana*  | 364.00⁴  | 57            | 27.95⁴                 | 337.00⁴       |
| *P. coloratum*| 248.00³ | 37            | 22.00³                 | 262.25³       |
| *P. antidotale*| 345.00⁵ | 53            | 21.05⁵                 | 292.75³       |
| *S. sudanense*| 193.25⁴ | 86            | 4.02⁴                  | 179.50²       |

There was a significant difference (P<0.05) on number of tillers/plant among the different forage grass species. The number of tillers/plant for *C. gayana* was significantly higher than the other species in both Koneba (27.45 tillers/plant) and Telalak (20.41 tillers/plant) (Table 2). This result was smaller as compared to the result reported by Yisehak [16] at Alemaya University Research Station (81.3 tillers/plant) which might be due to the application of fertilizer but is higher than the result shown in Pakistan (12 tillers/plant) Rainfed Conditions [15] which might be due to relative availability of water. Next to *C. gayana*, *P. coloratum* and *P. antidotale* were producing higher number of tillers followed by *C. ciliaris* in both research areas. The number of tillers/plant of Panicum species was higher in Pakistan, which might be due to better control of the experiment. The result of *C. ciliaris* was higher compared to the result which was reported by Kizima et al. [21] in Tanzania (25.594 tillers/plant).
experimental site. *P. coloratum* (4) also showed lower vigoreity next to *C. ciliaris* (2.25) (Table 3).

![Figure 2: A=Sorghum sudanense (Sudan Grass); B=Cenchrus ciliaris (Buffel grass) Plant height and growth vigor.](image)

Table 3: Mean comparison among results of five grass species on plant height and growth vigor score in Koneba and Telalak experimental sites over two years. a,b,c,d,e=Mean located values.

| Species | Location | Koneba | Telalak |
|---------|----------|--------|---------|
|         | Plant Height | Growth Vigor | Plant Height | Growth Vigor |
| *C. ciliaris* | 79.50<sup>b</sup> | 3.25<sup>b</sup> | 63.15<sup>a</sup> | 2.25<sup<c| |
| *C. gayana* | 151.60<sup>b</sup> | 5.00<sup>b</sup> | 113.95<sup>c</sup> | 5.00<sup>b</sup> |
| *P. coloratum* | 98.80<sup>c</sup> | 4.25<sup>c</sup> | 90.96<sup>d</sup> | 4.00<sup>d</sup> |
| *P. antidotale* | 158.23<sup>b</sup> | 4.25<sup>b</sup> | 136.53<sup>b</sup> | 5.00<sup>a</sup> |
| *S. sudanense* | 225.00<sup>a</sup> | 5.00<sup>a</sup> | 227.85<sup>a</sup> | 5.00<sup>a</sup> |

Plot cover and disease and pest incidence: Species difference has significant effect on plot cover scores in both Koneba (P<0.05) and Telalak experimental sites. In Koneba, the higher plot cover score was observed on *C. gayana* (5.00), *P. coloratum* (4.75) and *P. antidotale* (50 days) but, *P. coloratum* took more than 13 days for its germination (Table 4). In Telalak site, *C. gayana* (5.00) indicated the highest plot cover to the other species. This might be due to the higher emerging and maturity of the species in both sites. Similar result was reported by Yisehak [16] at Alemaya University Research Station. Diseases were not observed as a problem in both experimental sites though some unidentified pests were observed attacking some species of experiment plants. Among the grass species, *C. ciliaris* and *P. coloratum* were relatively resistant (Figure 3).

![Figure 3: A=Panicum coloratum; B=Panicum antidotal.](image)

Emerging and maturity: *S. sudanense* was germinated early in the seventh and eighth day in Koneba and Telalak sites respectively followed by *C. gayana* which was emerged on the eighth day in both sites while *P. coloratum* took more than 13 days for its germination (Table 5). The late germination of *P. coloratum* affects its time of growth and maturity. The date of initial flowering for *C. gayana* was 40 days which is shorter than the other species followed by *P. antidotale* (50 days) but, *P. coloratum* still took longer time (about 60 days) to bloom its first flower. Similar to its germination and initial flowering *C. gayana* reached it's 50% flowering stage (55 days) earlier than the other grasses followed by *P. antidotale* (63 days) and *S. sudanense* (62 days) while *P. coloratum* (77 days) showed the longer period to reach 50% flowering. The 50% flowering period of *C. gayana* was shorter than the result shown in Sudan (about 70 days) [27] and at Alemaya University (89 days) [16] which might be due to the higher temperature of Afar Region which increases the growth rate of plants.

![Table 4: Mean comparison among scores of the five-grass species on plot cover and disease and pest incidence in Koneba and Telalak experimental sites over two years. Means of the same letter in a column are not significantly different. a,b,c,d=Mean located values.](image)

| Species          | Koneba | Telalak |
|------------------|--------|---------|
|                  | Plot Cover | Disease Incidence | Plot Cover | Disease Incidence |
| *C. ciliaris*    | 3.50<sup>c</sup> | 8.00<sup>b</sup> | 2.75<sup>c</sup> | 7.25<sup>d</sup> |
| *C. gayana*     | 5.00<sup>a</sup> | 10.00<sup>a</sup> | 5.00<sup>a</sup> | 9.50<sup>ab</sup> |
| *P. coloratum* | 4.75<sup>ab</sup> | 9.50<sup>ab</sup> | 3.25<sup>bc</sup> | 8.00<sup>cd</sup> |

![Table 5: Germination date, Date of initial flowering, Date of 50% flowering of the five-grass species in Koneba and Telalak. GD=Germination date; DIF=Date of initial flowering; FD=Flowering date.](image)

| Species          | Koneba | Telalak |
|------------------|--------|---------|
|                  | GD | DIF | 50% FD | 100% FD | GD | DIF | 50% FD | 100% FD |
| *C. ciliaris* | 12 | 55 | 70 | 87 | 11 | 57 | 76 | 93 |
| *C. gayana* | 8 | 40 | 55 | 70 | 8 | 43 | 55 | 75 |
| *P. coloratum* | 15 | 60 | 77 | 91 | 13 | 59 | 75 | 97 |
| *P. antidotale* | 10 | 50 | 63 | 75 | 11 | 48 | 67 | 79 |
| *S. sudanense* | 7 | 46 | 62 | 84 | 8 | 55 | 68 | 91 |

Correlation of growth attributes with biomass yield: Biomass yield of all grass species is positively correlated with all growth attributes. Biomass production of *C. gayana* was significantly (P<0.05) correlated with seedling count (r=0.847) number of tillers/plant (r=0.847) and...
plant height \((r=0.935)\) which is supported by Arshad et al. [28]. In the case of \(P. \) coloratum, number of tillers/plant \((r=0.942)\) and plot cover \((r=0.933)\) were significantly \((P<0.05)\) correlated with the biomass yield. Biomass production yield of \(P. \) antidotale was positively correlated with disease and pest incidence score \((r=0.915)\), growth vigor \((r=0.767)\) and plot cove \((r=0.767)\). This result is similar to the result reported by Munyasi et al. [29]. Number of tillers/plant \((r=0.986)\) and plot cover \((r=0.864)\) showed significant correlation with biomass of \(S. \) sudanense (Table 6).

| Grass Species | Plant Height | Seedling Count | No. of tiller/plant | Growth Vigor | Plot Cover | Disease and Pest Incidence |
|---------------|--------------|----------------|---------------------|--------------|------------|--------------------------|
| C. ciliaris   | 0.427        | 0.291          | 0.383               | 0.349        | 0.492      | 0.258 0.536 0.464 0.246 |
| C. gayana    | 0.935        | 0.001          | 0.847               | 0.008        | 0.000      | 0.000 0.000 0.689 0.058 |
| P. coloratum | 0.458        | 0.253          | 0.384               | 0.942        | 0.001      | 0.369 0.369 0.933 0.001 |
| P. antidotale| 0.299        | 0.472          | 0.297               | 0.349        | 0.767      | 0.742 0.035 0.915 0.001 |
| S. sudanense | 0.225        | 0.592          | 0.574               | 0.986        | 0.001      | 0.000 0.864 0.005 0.000 |

Table 6: Correlation of biomass yield with plant height, seedling number, number of tillers per plant, growth vigor, plot cover and disease incidence.

Community perception towards the experimental grasses

Species preference for individual selection criteria: All pastoralist member of the research group was participated in selecting better forage species. Hence, according to the amount of forage product they produce in both areas, \(S. \) sudanense and \(C. \) gayana were ranked as first and second by all pastoralists, respectively [30]. In terms of palatability \(C. \) gayana ranked first in both sites while \(P. \) coloratum ranked second in Konobo experimental site and \(P. \) antidotale ranked second in Telalak site followed by \(P. \) coloratum. Based on early maturity, pastoralist also ranked \(S. \) sudanense as first since it reached livestock consumption level within not more than a month. Next to \(S. \) sudanense, \(C. \) gayana was ranked second according to the number of days it reached the consumable level while \(P. \) coloratum is ranked fifth for its low growth rate in both sites. All the pastoralists also set ranks for all grass according to their tolerance for drought [30]. Hence, \(C. \) ciliaris ranked first since it stay green for a longer period of without water followed by \(P. \) antidotale in Konobo and \(C. \) gayana in Telalak experimental sites. Regeneration capacity was also used to rank the grass species to evaluate the potential to regrow after harvesting and long dry period; hence, \(P. \) antidotale take the first rank to restore its growth in which it reached second harvest with in twenty days followed by \(P. \) coloratum and \(C. \) gayana. The participants ranked \(S. \) sudanense fifth for the reason the grass failed to regenerate after long dry season though it showed fast growth at the first harvest in progressive watering. Seed production, disease and pest resistance, easy of management and easy of seed collection were also another selection criteria to range the forage grasses.

Pastoralists’ preference ranking: The pastoralist’ selection criteria for the forage grass species were beyond the biomass yield of each species. They generally gave priority to qualitative and drought tolerance traits for livestock feed [31] such as palatability, drought tolerance, early maturity followed by biomass yield and regeneration capacity in order of importance in both sites, but other traits like easy of management, seed production, disease and pest resistance, and easy of seed collection were also given emphasis in ranking the grass species. Aberra et al. [32] has used these criteria to evaluate the positive attributes of some selected forage plants.

| Species   | Pastoralists’ preference | Average | Rate |
|-----------|--------------------------|---------|------|
|           | P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 |         |      |
| C. ciliaris| 2 4 2 3 4 5 3 4 3 3            | 3.3     | 3    |
| C. gayana | 1 2 1 2 1 2 2 1 1 1            | 1.4     | 1    |
| P. coloratum| 4 3 4 1 3 4 5 5 4 4          | 3.7     | 4    |
| P. antidotale| 3 1 3 2 3 4 2 3 2 2        | 2.5     | 2    |
| S. sudanense| 5 5 5 5 5 1 4 5 1 4        | 4.1     | 5    |

Table 7: Pastoralists’ preference ranking of different grass species for different selection criteria in Konobo Woreda. P1=pastoralist 1, P2=pastoralist 3 ……...P10=pastoralist 10.

Note: The qualitative traits were biomass yield, palatability, early maturity, seed production, drought tolerance, disease and pest resistance, easy of management, easy of seed collection and regeneration capacity.
Based on these criteria, all pastoralists who participated in the selection process preferred *C. gayana* as a number one grass due to its collective performance on palatability, early maturity, biomass yield and disease and pest resistance in both Koneba and Telalak sites. The *P. antidotale* ranked second for its regeneration capacity, drought tolerance, ease of management and seed production (Tables 7 and 8). *S. sudanense* ranked at last in Koneba for its low palatability, drought tolerance and regeneration capacity though it produced higher biomass than any of the experimental grasses while *P. coloratum* ranked fifth in Telalak for its slow maturity, low drought tolerance, difficulty of management, less disease and pest resistance and seed production (Table 8).

| Species         | Pastoralists’ preference | Average | Rate |
|-----------------|--------------------------|---------|------|
|                 | P1  | P2  | P3  | P4  | P5  | P6  | P7  | P8  | P9  | P10 |
| *C. ciliaris*   | 5   | 4   | 4   | 4   | 4   | 4   | 1   | 1   | 3   | 3   | 3.3 | 3   |
| *C. gayana*     | 2   | 1   | 2   | 1   | 2   | 3   | 3   | 1   | 1   | 1   | 1.7 | 1   |
| *P. coloratum*  | 4   | 5   | 5   | 2   | 3   | 3   | 5   | 5   | 4   | 4   | 4   | 5   |
| *P. antidotale* | 3   | 2   | 3   | 3   | 2   | 1   | 2   | 2   | 2   | 2   | 2.2 | 2   |
| *S. sudanense*  | 1   | 3   | 1   | 5   | 5   | 5   | 4   | 4   | 5   | 5   | 3.4 | 4   |

**Table 8: Pastoralists’ preference ranking of different grass species for different selection criteria in Telalak Woreda. P1=pastoralist 1, P2=pastoralist 2, …….. P10=pastoralist 10.**

**Note:** The qualitative traits were biomass yield, palatability, early maturity, seed production, drought tolerance, disease and pest resistance, easy of management, easy of seed collection and regeneration capacity.

**Pair-wise ranking matrix for selection criteria:** Pair-wise ranking of the pastoralists’ selection criteria was made to rank the selection criteria and to identify the most important trait for the community for future forage improvement. The pastoralists were voluntary to compare the criteria and rank them in order of importance. In the pair-wise comparison similar result was shown in both experimental sites (Table 9). Accordingly, the selection criteria were compared and palatability ranked first against all criteria while drought tolerance led all criteria except palatability which is supported by Mganga et al. [31] and Aberra et al. [32]. Early maturity and biomass yield ranked the third and fourth respectively followed by regeneration capacity.

| Species | BY  | Pal | Matu | SP  | DT  | DPR | EM  | ESC | RC  | Points | Rank |
|---------|-----|-----|------|-----|-----|-----|-----|-----|-----|--------|------|
| BY      | Pal | Matu| Pal  | Pal | DT  | BY  | BY  | BY  | BY  | 5      | 4    |
| Pal     | Pal | Pal | Pal  | Pal | Pal | Pal | Pal | Pal | Pal | 8      | 1    |
| Matu    | Matu| DT  | Matu | Matu| Matu| Matu| Matu| Matu| Matu| 6      | 3    |
| SP      | DT  | SP  | SP   | SP  | SP  | RC  | 3   | 6   | 9   |        |      |
| DT      | DT  | EM  | ESC  | RC  | 0   | 9   |     |     |     |        |      |
| DPR     | EM  | RC  | 2    | 7   | 4   | 5   |     |     |     |        |      |
| EM      |    | RC  | 8    | 7   | 4   | 5   |     |     |     |        |      |

**Table 9: Pair-wise ranking matrix of pastoralists’ selection criteria for different forage grasses. BY=Biomass yield, Pal=Palatability, Matu=Early maturity, SP=Seed production, DT=Drought tolerance, DPR=Disease and pest resistance, EM=Easy of management, ESC=Easy of seed collection and RC=Regeneration capacity.**

Participatory evaluation of forage grasses is important to understand traits or combinations of traits of interest to pastoralists, which are in a wider interest than researcher thought [33]. Through the approach of participatory evaluation of grasses, the researchers have got the chance to well understand the pastoralists’ preferences and their indigenous knowledge in setting criteria and comparing and prioritizing the criteria through discussion. A similar report was showed by Gurmu [13] to assess farmers’ criteria for common bean variety selection in Sidama Zone. It was also able to verify that it is important to involve pastoralists in the animal feed improvement program starting from research activities. Utilization of their knowledge and criteria for animal feed selection is also very important to develop livestock-preferred grass species that can be simply adapted by pastoralists.
**Pair-wise ranking of grass species:** As the result observed in Table 8, *C. gayana* ranked first in compare to the other grass species in both sites which is followed by *P. antidotale*. *C. ciliaris* ranked first in compare to *P. coloratum* and *S. sudanense* while *P. coloratum* preferred against to *S. sudanense* in Koneba site (Table 10) which might be due to its better palatability of *P. coloratum* but the reverse is true in Telalak which might be due to the late growth of *P. coloratum* (Table 11).

| Species          | C. ciliaris | C. gayana | P. coloratum | P. antidotale | S. sudanense | Points | Rank |
|------------------|-------------|-----------|--------------|---------------|--------------|--------|------|
| C. ciliaris      | C. ciliaris | C. gayana | *P. antidotale* | *C. ciliaris* | 2 | 3 |
| C. gayana       | C. gayana  | C. gayana | *C. gayana*  | *C. gayana*  | 4 | 1 |
| *P. coloratum*  | *P. antidotale* | *P. coloratum* | *P. coloratum* | *P. coloratum* | 1 | 4 |
| *P. antidotale* | *P. antidotale* | *P. coloratum* | *P. coloratum* | *P. coloratum* | 3 | 2 |
| *S. sudanense*  | *S. sudanense* | *S. sudanense* | *S. sudanense* | *S. sudanense* | 0 | 5 |

**Table 10:** Pair-wise ranking of grass forage species by pastoralists for different traits in Koneba.

| Species          | C. ciliaris | C. gayana | P. coloratum | P. antidotale | S. sudanense | Points | Rank |
|------------------|-------------|-----------|--------------|---------------|--------------|--------|------|
| C. ciliaris      | C. gayana  | C. ciliaris | *P. antidotale* | *C. ciliaris* | 2 | 3 |
| C. gayana       | C. gayana  | C. gayana | *C. gayana*  | *C. gayana*  | 4 | 1 |
| *P. coloratum*  | *P. antidotale* | *P. coloratum* | *P. coloratum* | *P. coloratum* | 0 | 5 |
| *P. antidotale* | *P. antidotale* | *P. coloratum* | *P. coloratum* | *P. coloratum* | 3 | 2 |
| *S. sudanense*  | *S. sudanense* | *S. sudanense* | *S. sudanense* | *S. sudanense* | 1 | 4 |

**Table 11:** Pair-wise ranking of grass forage species by pastoralists for different traits in Telalak.

**Conclusion**

Base on the experimental result, the pastoralists select *C. gayana* as the first choice for their livestock due to its productivity, palatability and early maturity. This grass showed higher performance in its growth potential and the community perceived that the grass is important for milking cows. *P. antidotale* ranked second for its regeneration capacity, drought tolerance, early maturity and palatability. However, *P. coloratum* ranked fourth in Koneba and fifth Telalak for its slow growth which resulted for its late maturity. The community perceived that this grass could take huge amount of water and longer time for maturity which is difficult to maintain in areas of low precipitation and scarce moisture. Though *S. sudanense* ranked first for its biomass yield, cumulatively it ranked fifth in Koneba and fourth in Telalak. The main reason draw *S. sudanense* to the last rank is its low palatability by the animals.

*S. sudanense* showed high biomass production due to its growth nature even though it is failed to be selected by the pastoralist since it did not match with their selection criteria. *C. gayana* showed the second production potential followed by *P. antidotale* which they also matched with pastoralists' interest.

Accordingly, *C. gayana* and *P. antidotale* showed higher vegetational and perceptual performance, therefore, this grass should be tested in different areas and disseminated to the community by creating awareness about proper management system. *S. sudanense* can be also produced in huge amount in wider area so it is used for silage making by introducing the pastoralists with modern feed conservation systems. Generally, we observed that the community has low awareness about intensive forage production; hence, pastoralists should be trained and aware of intensive animals feed production by proper agronomic management.

**Conflicts of Interest**

The authors declare that they have no conflicts of interest.

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