EFFECTS OF VARIETY AND CUTTING INTERVAL ON AGRONOMIC PERFORMANCE AND CHEMICAL COMPOSITION OF ALFALFA (*Medicago sativa* L.) UNDER IRRIGATION IN CENTRAL GONDAR ZONE, ETHIOPIA †

[EFECTOS DE LA VARIEDAD E INTERVALO DE CORTE SOBRE EL DESEMPEÑO AGRONÓMICO Y LA COMPOSICIÓN QUÍMICA DE LA ALFALFA (*Medicago sativa* L.) BAJO RIEGO EN LA ZONA CENTRAL DE GONDAR, ETIOPÍA]

Alemu Tarekegn*, Desalegn Amsalu and Kifetew Adane

Gondar Agricultural Research Center, P. O. Box 1337, Gondar, Ethiopia. Email: mefetehiealemu@gmail.com, bementd2016@gmail.com, kifetewadane2008@gmail.com
**Corresponding author*

SUMMARY

Background: Understanding the relationship between dry matter yield production and forage quality throughout the growing season will help to optimize the cutting intervals between harvests in different alfalfa *(Medicago sativa* L.) varieties. **Objective:** To assess the effects of harvest frequency on forage yield and quality of 2 improved cultivars (ILRI-6984 and variety DzF-552) of alfalfa (*Medicago sativa* L.). **Methodology:** Two improved alfalfa (*Medicago sativa* L.) cultivars (ILRI-6984 and variety DzF-552) and four harvest frequencies (every 30, 40, 50, and 60 days) were combined and used for the study. A factorial experiment was laid down in a Randomized Complete Block Design (RCBD) with four replications**.** To assess their production potential plant height (cm), number of branches per plant, fresh biomass yield (t ha^{-1}), and dry matter yield (t ha^{-1}) of the forage and its nutrient content were recorded. The data collected were subjected to analysis of variance (ANOVA) by using the general linear model (GLM) procedure in Statistical Analysis System (SAS) (2003) version 9.1. **Results:** The highest forage dry matter yield was recorded for variety ILRI-6984 harvested every 40 d (26.8 t DM ha^{-1}) and for variety DzF-552 when harvested every 60 d (24.1 t DM ha^{-1}). While crude protein concentration tended to decline as age at harvest increased, there was little consistency in the pattern. Crude protein yields were also inconsistent across treatments but ILRI-6984 harvested every 40 d produced the highest yields (6.5 t ha^{-1}). **Implications:** The present study contributes to the understanding of the relationship between dry matter yield production and forage quality in optimizing the cutting intervals between harvests in different Alfalfa (*Medicago sativa* L.) varieties. **Conclusion:** These preliminary findings need to be confirmed under field conditions on a large scale along with longer-term studies to examine the longevity of the stands at these harvest frequencies. Irregular harvesting based on the stage of maturity should be compared with fixed inter-harvest intervals.

Key words: crude protein; dry matter yield; forage quality; harvest frequency.

RESUMEN

Antecedentes: Comprender la relación entre la producción de materia seca y la calidad del forraje a lo largo de la temporada de crecimiento ayudará a optimizar los intervalos de corte entre cosechas en diferentes variedades de alfalfa (*Medicago sativa* L.). **Objetivo:** Evaluar los efectos de la frecuencia de cosecha sobre el rendimiento y calidad del forraje de 2 cultivares mejorados (ILRI-6984 y variedad DzF-552) de alfalfa (*Medicago sativa* L.). **Metodología:** Se combinaron dos cultivares mejorados de alfalfa (*Medicago sativa* L.) (ILRI-6984 y variedad DzF-552) y se utilizaron cuatro frecuencias de cosecha (cada 30, 40, 50 y 60 días) para el estudio. Se empleó un experimento factorial con un Diseño de Bloques Completos al Azar (DBA) con cuatro réplicas. Para evaluar su potencial productivo, se registraron la altura de la planta (cm), el número de ramas por planta, el rendimiento de biomasa fresca (t ha^{-1}) y el rendimiento de materia seca (t ha^{-1}) del forraje, así como su contenido de nutrientes. Los datos recopilados se sometieron a un análisis de varianza (ANOVA) mediante el procedimiento del modelo lineal general (MLG) del Sistema de Análisis Estadístico (SAS) (2003), versión 9.1. **Resultados:** El mayor rendimiento de materia seca de forraje se registró para la variedad ILRI-6984 cosechada cada 40 días (26,8 t MS ha^{-1}) y para la

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variedad DzF-552 cosechada cada 60 días (24,1 t MS ha^{-1}). Si bien la concentración de proteína cruda tendió a disminuir con el aumento de la edad de cosecha, este patrón fue poco consistente. Los rendimientos de proteína cruda también fueron inconsistentes entre los tratamientos, pero ILRI-6984 cosechado cada 40 días produjo los mayores rendimientos (6,5 t ha^{-1}). **Implicaciones:** El presente estudio contribuye a la comprensión de la relación entre el rendimiento de producción de materia seca y la calidad del forraje en la optimización de los intervalos de corte entre cosechas en diferentes variedades de Alfalfa (*Medicago sativa* L.). **Conclusión:** Estos hallazgos preliminares deben confirmarse en condiciones de campo a gran escala, junto con estudios a largo plazo para examinar la longevidad de los rodales con estas frecuencias de cosecha. La cosecha irregular, basada en la etapa de madurez, debe compararse con intervalos fijos entre cosechas.
Palabras clave: proteína cruda; rendimiento de materia seca; calidad del forraje; frecuencia de cosecha.

INTRODUCTION

Ethiopia has the largest livestock population in Africa with an estimated 70.29 million heads of cattle, 42.92 million sheep, 52.46 million goats and 56.99 million poultry of meat producing animals (Central Statistical Agency, 2021). Livestock production is an integral part of the subsistence crop-livestock systems in the Ethiopian highlands, as livestock provide the major source of animal protein, power for crop cultivation, means of transportation, export commodities, manure for farmland and household energy, security in times of crop failure, and means of wealth accumulation. The sector contributed up to 45 percent of agricultural Gross Domestic Product (GDP), nearly 20 percent of total GDP, and 20 percent of national foreign exchange earnings (World Bank, 2017). Despite the large livestock population and its diversity in Ethiopia (Central Statistical Agency, 2021), the benefits obtained from the sector are low compared to other African countries and the world standard (Selamawit *et al.*, 2017), owing to the range of factors including the unavailability of sufficient and quality animal feed, the poor genetic potential of animals for productive traits, poor health care and poor management practices (Alemayehu, 2006). Of these factors, feed shortage both in terms of quantity and quality is a very crucial constraint for livestock production in the country and the study area in general (FAO, 2020; Alemu *et al*., 2021).

The major feed resources in the country are natural pasture (55.33%) and crop residues (31.29%) with agro-industrial by-products and manufactured feed contributing much less (Berhanu *et al*., 2009, Central Statistical Agency, 2021). Thus far, the contribution of improved forage in Ethiopia is very less significant; lower than one percent (Central Statistical Agency, 2021). Because of the severe feed shortage problem in the area, farmers are completely dependent on the crop residue for the long dry season to feed their livestock which is poor in protein and vitamin content and digestibility. Nevertheless, to enhance livestock production in the country, the integration of productive and highly nutritious improved forages in the farming system is mandatory (FAO, 2016). To improve this situation more productive forages with better nutritional value like alfalfa are needed.

Alfalfa (*Medicago sativa* L.) is an important and broadly adapted forage crop, most often harvested as hay and can be made into silage, grazed, or fed as green chop and primarily used as feed for high-producing animals (cattle, horses, sheep, goats and poultry). Alfalfa's adaptability to diverse environments underscores its success as a high-yielding and nutritionally valuable livestock feed crop, cultivated in more than 80 countries and currently across approximately 45 million hectares worldwide (Mielmann, 2013; Boe *et al.*, 2020). Alfalfa has thrived across a multitude of ecological contexts, showcasing its exceptional adaptive capabilities (Bagavathiannan and Van Acker, 2009; Small, 2011). The process of its global spread provides an opportunity to study the adaptation of alfalfa to different environments, as it transitioned from its origins in eastern Turkey and central Iran to reach North and South America within 300 years (Small, 2011; Prosperi *et al.*, 2014). Because of its high biomass yield and CP digestible energy, vitamin A, and 10 other vitamins concentration alfalfa is often considered 'The King or Queen' of forages (USDA Census of Agriculture, 2012). In poultry diets, dehydrated alfalfa and alfalfa leaf concentrates are used for pigmenting eggs and meat, because of their high content of carotenoids, which are efficient for coloring egg yolk and body lipids. Supplementation of cattle on a diet containing 30:70 alfalfa and roughage ration has a significant effect in improving nutrient intake and digestibility as compared to cattle fed on other forage grasses (Neal *et al.*, 2014; Zhang *et al.*, 2024). Alfalfa besides its fodder uses its deep taproot allows it to use water that is stored deep in the soil profile, giving it tolerance to drought. As a legume, it also contributes to enhancing soil fertility and its perennial growth habit helps protect the soil from erosion, improves soil structure and acts as a carbon sink.

In addition, alfalfa is cut three to four times a month and it can be harvested up to 12 times per year with total yields which are ranging from 5-11 t ha^{-1} (Teshale *et al.*, 2021; Xu *et al.*, 2021). But under irrigated conditions, yields have been ranging from 25 to 27 t ha^{-1} (Denbela and Sintayehu, 2021; Xu *et al.*, 2021), and protein content in alfalfa hay varies from 18 to 25% depending on the growth stage, cutting cycle, cultivar difference and other factors (Denbela and Sintayehu, 2021; Gezahegn *et al.*, 2022). Although alfalfa is known for its quality biomass production and other important traits in adaptation and soil improvement, the biomass productivity and nutritional quality of alfalfa are believed to be significantly affected by varietal differences, agronomic and management practices. Besides variety proper harvest management, e.g. cutting interval between harvests is essential to obtain optimal alfalfa production, particularly in terms of forage quality and yield. However, with this promising potential, the alfalfa varieties with cutting management practices have not been evaluated for dry matter yield and their chemical composition in the study area under irrigation conditions. Since irrigation is available, this study was conducted to determine the performance of 2 new alfalfa cultivars at 4 different harvest frequencies under irrigation.

MATERIALS AND METHODS

Description of the study area

The study was conducted at Melkam wuha village of West Dembia district (12º 17’ 42.18’’ N, 37º 13’ 25.39’’ E; 1,856 m.a.sl.) for about 20 months. The soil texture of the study area is sandy loam with good water-holding capacity and the 0–40 cm horizon has an average pH of 7.5, 3.96% organic matter, 6.4 ppm available P, and 2.16 cmol (+) K/kg (Nigus *et al.*, 2016). The area has a moist tropical climate and the mean monthly maximum temperature is 26.2 ºC, while the mean monthly minimum temperature is 12.6 ºC. Based on 10 years of (2009-2018) data, annual rainfall ranges between 665 and 1,524 mm (mean 1,095 mm). Rainfalls during the study and medium-term data are shown in Figure 1.

Treatments and experimental design

Two improved alfalfa cultivars (ILRI-6984 and var. DzF-552) developed at the International Livestock Research Institute (ILRI) were used for the experiment. Besides the two improved alfalfa cultivars, four harvest frequencies (every 30, 40, 50, and 60 days) were compared in a randomized complete block design with 4 replications. The plot size was 2.8 x 2.4 m with spacing of 40 cm between rows and 20 cm between plants within rows. To ensure the effective establishment, N:P:S (19:38:7)

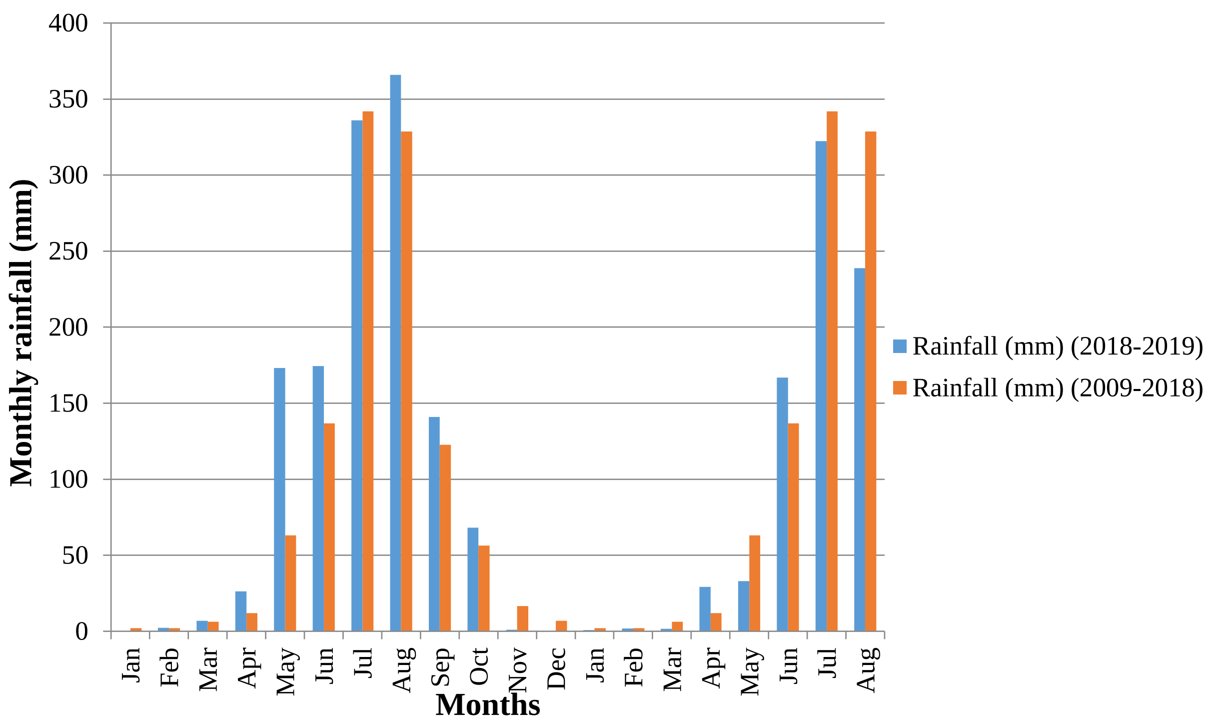

Figure 1. Monthly rainfall data over 10 years (2009-2018) representing the medium-term average and study period average (2018-2019) for the study area.

fertilizer was applied at the rate of 100 kg ha^{-1} at the time of planting. Sowing was done by hand-drilling into fully tilled soil with approximately ½ inch soil depth in January 2017. To ensure good seed-to-soil contact, the soil onto the seedbed was pressed by hand. Immediately after sowing irrigation water was applied, with a second irrigation after a further 7 days. After the emergence of seedlings, irrigation was applied through furrows at about 10-day intervals throughout the study. A total of 39 irrigations were applied for the entire study period (20 months) without measuring the water amount. Two weeks after planting, seedlings were thinned to produce 20 cm plant spacing within rows. Uniform trial management such as hand weeding was done on average every 2 months during the study, but more frequently at the beginning of the experiment and hoeing between rows was carried out during the establishment year and after every harvest to facilitate the regrowth of healthy and productive stand (Kay, 2004).

Data collection and processing

In this experiment, after planting in the field their performance was evaluated concerning plant height, number of branches per plant, fresh biomass yield (t ha^{-1}), dry matter percent (DM%), and Dry matter yield (t ha^{-1}). On the appropriate dates plants were harvested with a handheld sickle at 3-5 cm above the soil surface. Cutting and sampling procedures were executed on the remaining 5 rows of 2.8 m length (2.8 × 2.4= 6.72 m^2) after the side effect was eliminated. The first harvest was performed 60 d after planting for all treatments and subsequent harvests were applied at 10% blooming stage for 30 d cutting interval whereas for 40, 50, and 60 d intervals were arranged as 10, 20 and 30 d after 10 % blooming. Plant height above ground was measured from the ground level to the tip of 10 randomly selected plants per plot using a steel tape and their mean was recorded for statistical analysis. The main branch number was an average of primary branches on the stem of ten plants per plot. Alfalfa forage harvested for herbage and dry matter yield was following each cutting interval. The yield from each cut for each year was computed and the combined data was also used to calculate total herbage and dry matter yield. In each cutting, interval sampling was done from the middle eight rows excluding the guard rows. At each harvest in the field, the green forage was weighed immediately by using a salter balance having a sensitivity of 0.1kg. Immediately after green forage sampling a minimum of 500 g individual samples of alfalfa forage were taken, manually chopped into small pieces using a sickle, and dried in a forced-draft oven at 65 ºC for 72 hours until constant weight was obtained to determine dry matter concentration.

Dry matter yield was determined using the following formula described by Mutegi *et al.* (2008).

$$\text{Dry Matter Yield (t/ha)} = TFW\ X\ \left(\frac{\text{DWss}}{\text{HA}}\ \text{X FWss}\right) X\ 10;$$

Where TFW = total fresh weight kg/plot; DWss = dry weight of sub-sample in grams; FWss = fresh weight of sub-sample in grams, HA=Harvest plot area in square meters and 10 is a constant for conversion of yields in kg/m^2 to t ha^{-1}.

Forage quality analysis

Chemical analyses of the leaf and stem parts of pasture hay samples were carried out by taking representative samples from different harvests. The feed samples were dried in a forced air draft oven at 60 ºC for 72 hrs for partial dry matter (DM) determination. Dried samples of feeds were milled using a laboratory mill to pass through a 1 mm screen. Milled samples of feeds were taken to Debere Birhan Agricultural Research Centre and stored at room temperature pending chemical analysis. DM, CP and ash in the feed samples were determined according to the procedure of (AOAC, 2000). Nitrogen (N) concentration was measured using the micro-Kjeldahl procedure and CP was determined by multiplying N concentration by 6.25. Ash percentage was determined by placing a feed sample (2 g) in a temperature-controlled furnace heated to 600 ºC for 2 hours while Organic matter (OM) was determined as 100 minus ash. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were analyzed according to the procedures of Van Soest *et al*. (1991).

Data analysis

The data collected were subjected to analysis of variance (ANOVA) by using the general linear model (GLM) procedure of Statistical Analysis System (SAS) (2003) version 9.1. When the difference was significant among treatments, LSD (least significant difference) test at a 5% probability level was used to locate differences between the treatment means.

The statistical model was:

Yijkl=μ+Bi+VJ+Ck+(V*C)l+Eijkl

Where:
Yijkl=the response variable
μ=overall mean
Bi=effect of block
Vj=effect of variety
Ck=effect of cutting interval

(V*C)l=interaction between variety and cutting interval
Eijkl=random error.

RESULTS

Biomass yield and related components

For the full study period (20 months) dry matter yields (DMY) for the various treatments varied from 16.7 to 26.8 t DM ha^{-1} with a mean of 20.5 t DM ha^{-1} (Table 1). There was a highly significant (P<0.001) interaction between variety and cutting interval in terms of green and dry biomass yield (Table 1). However, there was no statistically significant (p<0.05) interaction effect between variety and cutting interval on plant height (cm), number of branches per plant, and DM percentage (Table 1).

Total crude protein production

For the 20 months study period total CP produced (t ha^{-1}) for the various treatments varied from 3.6 to 6.5 t CP ha^{-1} with a mean of 4.6 t CP ha^{-1} (Table 1). The highest CP yield was obtained from alfalfa variety ILRI-6984 at a 40-day harvest interval and the lowest from var. DzF-552 at a 40-day harvest interval and ILRI-6984 harvested every 30 or 50 d (P<0.001). The significant (P<0.001) interaction between variety and harvest frequency in terms of CP production was of interest. While CP yield of ILRI-6984 was largely in line with DM yields since CP% did not differ significantly between harvest frequencies, variation in CP% for var. DzF-552 at different harvest frequencies meant that CP yield did not reflect DM yields.

Forage quality

There were differences in the stage of maturity of alfalfa at the different harvest intervals, e.g. no flowering at 30-day intervals; 10% flowering at 40-day intervals; 50% flowering at 50-day intervals; and 90% flowering at 60-day intervals, with no marked differences between the 2 cultivars. The mean response for nutritive values to variety and cutting interval is shown in Table 2. The interaction of variety and cutting interval effect was not significant (P>0.05) for DM, NDF, ADF, and ADL which is in agreement with the findings of Ji-Shan *et al*. (2012) and in disparity with that of others (Katić *et al*., 2008, Diriba *et al*., 2014). Though not statically significant, all cultivars when harvested at 30, 40, 50, and 60 d interval had greater than 91, 51, 31, and 6% DM, NDF, ADF and ADL, respectively which agrees with the findings of Mekuanint *et al*. (2015).

Ash content was significantly (p<0.001) higher when alfalfa variety ILRI- 6984 and variety DzF-552 harvested at 30 and 40 d intervals. The interaction of variety and cutting interval effect was significantly (P<0.001) higher in CP production when alfalfa variety ILRI- 6984 was harvested at 40 d interval and when variety DzF-552 harvested at 30 and 50 d intervals. Therefore, crude protein CP concentration in harvested forage of ILRI-6984 varied from 20.5 to 24.2% (P>0.05), while that for var. DzF-552 varied from 18.5 to 29.1% (P<0.05) (Table 2).

Table 1. Effects of variety and cutting interval on biomass yield, yield components, and total crude protein production of alfalfa (*Medicago sativa*) over 20 months in 2018 and 2019 growing seasons.

Treatment	Plant height (cm)	Number of branches per plant	Green Biomass Yield (t ha^{-1})	Dry matter percentage	Dry biomass yield (t ha^{-1})	Total CP yield (t ha^{-1})
ILRI- 6984*30 DCI	55.19	41.54	72.59^{bc}	23.12	16.73^{c}	3.90^{c}
ILRI- 6984*40 DCI	56.24	43.94	106.80^{a}	25.09	26.76^{a}	6.50^{a}
ILRI- 6984*50 DCI	58.16	48.63	75.32^{bc}	25.82	19.42^{bc}	3.90^{c}
ILRI- 6984*60 DCI	53.66	52.11	74.30^{bc}	27.27	20.20^{b}	4.30^{bc}
Var.DzF-552*30 DCI	42.76	34.27	69.84^{c}	25.82	17.65^{bc}	5.20^{b}
Var.DzF-552*40 DCI	45.22	34.12	71.44^{c}	26.55	18.97^{bc}	3.60^{c}
Var.DzF-552*50 DCI	53.28	38.12	71.79^{c}	27.67	19.83^{b}	4.80^{b}
Var.DzF-552*60 DCI	56.35	40.02	83.19^{b}	29.01	24.14^{a}	4.50^{bc}
Mean	52.61	41.59	78.16	26.29	20.46	4.60
CV (%)	12.92	5.89	9.64	3.86	9.32	12.03
LSD (0.05)	**ns**	**ns**	**11.08**	**ns**	**2.81**	**2.24**
LS	ns	ns	***	ns	***	***

Note: CP= crude protein; CV= coefficient of variation; DCI= days cutting interval; ILRI= international livestock research institute; LS= level of significance; LSD= least significant difference.
[abc] Means within columns having different superscript letters are significantly different at ***= P<0.001; ns= non-significant at (P>0.05) by LSD test.

Table 2. The interaction effect of variety and cutting interval on the proximate composition of alfalfa (*Medicago Sativa*) in the 2018 and 2019 growing seasons.

Treatment	Chemical Composition of Feeds (%)					
	DM	Ash	CP	NDF	ADF	ADL
ILRI- 6984*30 DCI	91.00	12.01[a]	23.32[bc]	57.76	39.58	9.82
ILRI- 6984*40 DCI	91.67	12.00[a]	24.18[ab]	53.09	33.47	6.89
ILRI- 6984*50 DCI	91.67	8.73[de]	20.48[bc]	67.06	44.31	10.99
ILRI- 6984*60 DCI	91.33	9.47[cd]	21.38[bc]	63.32	41.49	9.58
Var.DzF-552*30 DCI	91.33	10.95[ab]	29.10[a]	51.39	31.37	6.56
Var.DzF-552*40 DCI	91.67	10.91[ab]	18.87[bc]	65.06	43.65	10.64
Var.DzF-552*50 DCI	91.33	10.59[bc]	24.22[a]	61.03	37.25	9.03
Var.DzF-552*60 DCI	91.33	8.00[e]	18.50[c]	72.08	49.47	13.25
Mean	91.46	1o.34	22.37	61.35	40.07	9.60
CV (%)	1.06	6.98	4.37	13.47	9.30	19.59
LSD (0.05)	ns	0.79	2.64	ns	ns	ns
LS	ns	***	*	ns	ns	ns

Note: ADF= acid detergent fiber; ADL= acid detergent lignin; CP= crude protein; CV= coefficient of variation; DCI= days cutting interval; DM= dry matter; ILRI= international livestock research institute; LS= level of significance; LSD= least significant difference; NDF= neutral detergent fiber.

[abc] Means within columns having different superscript letters are significantly different at ***= P<0.001; *= P<0.05; ns= non-significant at (P>0.05) by LSD test.

DISCUSSION

Biomass yield and related components

Maximum green biomass yield (t ha^{-1}) was recorded when alfalfa variety ILRI- 6984 was harvested within 40 d intervals, while the lowest green biomass yield was recorded when alfalfa variety DzF-552 harvested at 30 d intervals. For ILRI-6984 highest DMY occurred with a 40-day harvest interval and the lowest with a 30-day harvest interval, while for var. DzF-552 highest yield occurred at a 60-day harvest interval. Except for these 3 treatments, DMY did not vary between cutting frequencies or between cultivars (20.8 vs. 20.1 t DM ha^{-1}).

This study suggests that harvesting alfalfa ILRI-6984 at 40-day intervals in this environment will give maximum productivity in terms of both DM and CP yields of the forage while delaying harvesting of var. DzF-552 until every 60 d gives the highest DM yields but not the highest CP yields. The data for ILRI-6984 suggest that delaying harvesting beyond 40 d might result in DM loss through leaf fall with increasing maturity. These data were similar to those reported by Kallenbach *et al*. (2002) in Missouri, who reported that dry hay yields for cv. Nimet and Alsancak peaked at 42-day harvest intervals. This result was also similar to those reported by Ibrahim *et al.* (2019), who reported green biomass and dry hay yields at 40 d cutting interval were higher than 20 and 30 d cutting intervals when evaluated in combined with the alfalfa variety cv. Nimet at Hatay province of Turkey. In contrast with this study, Solomon and Tesfay (2019) reported a dry biomass yield of 21.1 t ha^{-1} year^{-1} from alfalfa cvv. FG-10-09(F), FG-9-09(F), Magna-801-FG (F), Magna-788, and Hairy Peruvian, when harvested at 57-day intervals without compromising forage quality at Wargiba research site, Raya-Azebo district. Mekuanint *et al*. (2015) also reported a 21.0 t ha^{-1} year^{-1} dry biomass yield from the same cultivars harvested every 45 d at Debre Zeit Agricultural Research Center in the East Shewa Zone of Oromia Regional State, Ethiopia. This could be due to differences in the response of different cultivars to various cutting frequencies.

Total crude protein production

The most frequent harvesting produced lower DM yields than the least frequent harvesting but equal CP yields because of significantly higher CP%. Since forage must provide both energy and protein to livestock, the combination of high DM yield and high CP% is ideal for forage. Total CP production continuously tended to decrease depending on delayed cutting intervals. Similar results were reported for forage alfalfa cultivars harvested at 42 d interval by Palmonari *et al.* (2014) and Ahmad *et al.* (2016). Total CP production decreases depending on advancement in plant maturity through reducing the leaf ratio and increasing plant cell wall components (Faridullah *et al.,* 2009; Palmonari *et al.,* 2014). In contrast, with the current results, Azizza and Babo (2013) reported a 2.23 t ha^{-1} total CP yield when Berseem alfalfa was harvested every 30 d in Khartoum North (EL Selate project) in a farmer's field. This could be due to differences in alfalfa variety and cutting intervals used and also variations in agroecology and edaphic conditions in different locations.

Forage quality

The observed higher ash content when alfalfa variety ILRI- 6984 and variety DzF-552 harvested at 30 and 40 d intervals might be due to the much biomass produced and less organic matter accumulated at this stage for the two verities. This result was per the findings of Mekuanint *et al*. (2015) who reported the ash content of alfalfa variety FG10-09(F) when harvested at 45 d intervals may reach 10.47%. The overall trend was for ash concentration in forage to decline with increasing age at harvest. This is not surprising as mineral concentrations in forage conventionally decline with increasing maturity.

Unlike ILRI-6984 a serious shattering of leaves followed by immediate regeneration was observed for var. DzF-552, which caused a serious reduction in CP% when the variety was harvested every 40 and 60 days. CP% for alfalfa variety DzF-552 harvested every 30 or 50 d exceeded that of all other treatments except ILRI-6984 harvested every 40 days. While normally CP% of forage declines with increasing maturity (Kallenbach *et al*., 2002; Faridullah *et al.*, 2009; Palmonari *et al.*, 2014), there was no consistent pattern of higher CP% for more frequent harvests in this study. Overall, forage quality increased as cutting frequency optimized, which was consistent with other findings Kallenbach *et al*. (2002) and Ibrahim *et al.* (2019).

CONCLUSION

This study result suggests that alfalfa varieties ILRI-6984 harvested at 40-day intervals and DzF-552 harvested at 60-day intervals under irrigation provide high DM yields of high-quality forage especially CP with low fiber content. Further studies are needed under wider field conditions to determine if these preliminary data are reflected in a commercial situation and importantly, what is the longevity of the stands under these cutting regimes. In some countries of the world, e.g. Australia, farmers harvest alfalfa at times reflecting the stage of maturity of the plants, e.g. early blooming. This would vary with the time of year and probably should be investigated relative to a predetermined inter-harvest interval.

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Compliance with ethical standards. The authors confirm that the research was carried out and managed under ethical standards.

Data availability. Data are available with the corresponding author (mefetehiealemu@gmail.com) upon request.

Author contribution statement (CRediT). A. Tarekegn– Conceptualization; Investigation; Methodology; Data curation; Formal analysis; Writing - original draft; final of the manuscript; Writing review and editing, **D. Amsalu**– Data curation; Investigation, **K. Adane** –Writing – review and editing.

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