Acta Scientific Veterinary Sciences (ISSN: 2582-3183)

Volume 3 Issue 4 April 2021

Research Article

Dry Matter Yield and Chemical Composition of Alfalfa (*Medicago sativa*) Varieties as Animal Feed in the South Omo Zone of South-western Ethiopia

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Received: March 04, 2021

Published: March 25, 2021

Abstract

Alfalfa (*Medicago sativa*) species is leguminous herbaceous forage primarily used as feed for livestock due to high protein content and digestible fibers. This study was initiated to evaluate dry matter yield and chemical composition of four Alfalfa varieties grown under rain fed condition in a randomized completed block design in factorial arrangement having three locations (On-station of Jinka Agricultural Research Center, Shama-Bulket and Chali) and four varieties(DZ409, DZ407, DZ local and D5533) with three replications per variety. Data on dry matter yield, cutting height above ground, leaf to stem ratio and chemical compositions were analyzed using the Generalized Linear Model (GLM) procedures of SAS. The higher ($P > 0.05$) dry matter yield (5.20 t ha^{-1}) was recorded for DZ local variety and whereas, the lowest dry matter yield (3.74 t ha^{-1}) was recorded for DZ5533 variety. The higher ($P < 0.001$) Crude Protein (220.98 g/Kg, DM) obtained from DZ409 variety and whereas, the lowest ($P < 0.001$) Crude protein (180 g/Kg, DM) obtained from DZ local variety. Based on the result from this study we concluded that farmers and agro-pastoralists could enhance the feed availability for increased livestock production in the study area by planting DZ local alfalfa variety and DZ409 variety for higher dry matter yield and Crude Protein respectively.

Keywords: Dry Matter Yield; Chemical Composition; Location and Varieties

Introduction

Ethiopia has largest livestock population in Africa possessing 60.39 million cattle, 31.30 million sheep, 32.74 million goats, 2.01 million horses, 8.85 million donkeys, 0.46 million mules, 1.42 million camels and 56.06 million poultry [1]. However, the overall productive and reproductive of livestock in Ethiopia are generally low due to various factors [2]. The poor feed quality and inadequate feed supply is one of the nutritional impediments that have been affecting the livestock production in Ethiopia [2]. However, currently the demands toward the livestock products like meat and milk by consumers in Ethiopia have been increasing at alarming rate. This is recalling that immediate action in improving availability of feeds and feeding systems. Conversely, in the study areas, the livestock feeding system is based on natural pasture and native range forage [3-6]. It is obvious that the natural pasture based feeding system is greatly influenced by feed supply and nutritional dynamics of range forages [5,7]. Likewise, natural pasture are characterized by high fiber (>55%) and low crude protein (CP) (<7%) contents especially during dry seasons [8,9] and their feed intake level by animal is limited and animal barely satisfy even the high mortality, longer calving interval and substantial weight loss. Therefore, the identifying locally adaptable and promising forages

species to supplement pasture based feeding system is only way to overwhelm the feed shortage problem in the study area [3,10]. Among the promising improved herbaceous legume forage species, Alfalfa (*Medicago sativa*) is widely grown throughout the world as forage for cattle, horses, sheep and goats. It is most often harvested as hay and can be made into silage, grazed, or fed as green chop and primary used as feed for high-producing animal, because of its high protein content and highly digestible fibers [11]. Moreover, Alfalfa hay used in poultry diets and alfalfa leaf concentrates are used for pigmenting eggs and meat, due to high content in carotenoids, which are efficient for colorings egg yolk and body lipids [12]. The other studies reported by [13,14] attested that cattle supplemented with diet contained the 30:70 alfalfa and roughage ration had shown higher nutrient intake and digestibility as compared to cattle fed on other forage grasses. In addition, alfalfa is cut three to four times in a month and it can harvest up to 12 times per year with total yields which are ranging from 5-11 tha^{-1} [15,16]. But under irrigated condition yields have been ranging from 25 to 27 tha^{-1} [17-19] and protein content in alfalfa dry matter varies from 18 to 25% depending on the growth stage, cutting cycle, cultivar difference and other factors [16,20]. However, with this promising potential, the alfalfa varieties have not evaluated for dry matter yield and their chemical composition in the study area under rain fed condition. Therefore, this study was initiated to evaluate the dry matter yield production potential and chemical composition of Alfalfa variety for study areas.

Material and Methods

Description of study site

The field experiment was conducted in South Omo Zone at On-station of Jinka Agricultural Research Center, Shama-Bulket and Chali Kebeles in 2018 main cropping year. The Jinka On-station is located 729kms South-west of Addis Ababa at coordinate of 36° 33' 02.7" East Longitude and 05° 46' 52.0" N Latitude with an altitude of 1383 above sea level and the maximum and minimum monthly average temperature is 27.55 and 16.55°C, respectively while the mean annual rainfall of the area is 1274.67mm [21]. The soil of the Jinka on-station site is loam in texture with organic matter content of 5.88%, total nitrogen content of 0.24%, cat ion exchange capacity of 32.40cmol kg^{-1}, available phosphorus content of 3.41 mg kg $soil^{-1}$ and soil pH of 6.41 [22]. The Chali Kebele has mean annual temperature of 33°C during the early dry season (December-February) and 18°C and during main rainy season of the year (Mid-March - end of June) and short rainy seasons Mid July – November and annual rainfall ranges 350 to 1500 mm with altitude of 550-1550m above sea level [23]**.** Moreover, Shama-Bulket has suited at altitude of 06°11'35.95'' N and 036°39'07.95'' E and has soil PH 5.84, Organic Matter (%OM) 4.96 and Altitude 2558m above sea level with clay loam soil textural class.

Experimental design and treatments

Four alfalfa varieties namely DZ407, DZ409, D5533 and DZ local were collected from Debire Zeit Agricultural Research Center and were planted on plot area of 4mx3m=12m^2 under rain fed condition. In this study a randomized completed block design in factorial arrangement having three locations (On-station Jinka Agricultural Research Center, Shama-Bulket and Chali) and four alfalfa varieties level with three replications per variety. The detachment between plots and replication were 1m and plots in each block were randomly assigned to each alfalfa variety. The seed was sown on well-prepared seed-bed in rows spaced 20cm apart using a seed rate of 20kg per hectare [16].

Data collection and experimental site management

The experimental plots were kept nearly weed-free by hand hoeing. The agronomic data such as cutting height above ground and leaf to stem ratio (LTSR) were recorded at the age of 90 days after planting by harvesting the two middle rows using sickle. Fresh samples were recorded in the field immediately after harvest using spring balance. Five hundred-gram sample per plot was brought to Jinka Agricultural Research Center. Samples were chopped into pieces and 300g sub-sample was taken to be dried in an oven set at a temperature of 105°C for 24 hours. Dry matter yield was determined using the following formula described by [24]:

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

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. Cutting height above ground was measured from the ground level to the tip of five randomly selected plants per plot using a steel tape. To determine the fresh weight of leaf to stem ratios, samples were categorized into leaf and stem first and then the weights of each component was measured separately. The samples were oven dried for 24 hours at a

temperature of 105°C and separately weighed to estimate the proportions of these parts. Accordingly, the Leaf to Stem Ratio (LTSR) was estimated based on the dry matter of each component.

Chemical composition analysis

The chemical composition analysis was conducted at Debre Birehan Agricultural Research Center, Debre Birehan, Ethiopia. Previously harvested forage samples were oven dried at 65°C for overnight (12hrs) and ground to pass through 1mm sieve size. The DM, CP and Ash were analyzed according to procedures of [25]. The Neutral Detergent Fiber (NDF) values were calculated using the procedure of [26] and whereas the Acid Detergent Fiber (ADF) value was analyzed using the procedures described by [27].

Data analysis

The data such as plant height, leaf to stem ratio, dry matter yield and chemical composition were subjected to analysis of variances (ANOVA) using the Generalized Linear Model (GLM) procedure of statistical analysis System (SAS) software [28]. The significant differences among the means of varieties were declared at $P \leq 0.05$ and means were separated using Least Significant Difference (LSD) test with model of

$$Yijk = Y_{ijk} = \mu + R_i + V_j + L_k + (VL)_{jk} + e_{ijk}$$

Where; yijk = is the dependent variables; μ = overall mean; R= replication; Vi = the effect of variety; Lj = the effect of Locations; Vi*Lj = the interaction effects of variety by locations and eijk = random error.

Results and Discussion

Effects of variety on dry matter yield, cutting height and leaf to stem ratio

The dry matter yield, cutting height above ground and leaf to stem ratio are presented in table 1. The result revealed that the higher ($P < 0.05$) dry matter yield and taller cutting height above the ground were obtained for DZ local variety than DZ5533 variety but, dry matter yield and cutting height above the ground were comparable ($P > 0.05$) among DZ407, DZ409 and DZ5533 varieties. However, the leaf to stem ratio (LTSR) was insignificantly ($P > 0.05$) varied among all tested alfalfa varieties. The higher dry matter yield and taller cutting height above aground for DZ local variety from the present study is associated to high genetic potential of variety to adapt tested agro-ecology. The previous studies reported by different scholars were demonstrated that the wider range of dry matter yield difference between forage species could be attributed due to differences in genetic potential of forage species to adapt in given environment [7,29,30]. The dry matter yield obtained from our study for all tested alfalfa varieties lower than previously reported values by different Scholars. Accordingly, Hayek T., *et al*. [31] reported 12 tha^{-1} for 16 alfalfa cultivars, Zeinab MAE., *et al*. [32] reported 11 tha^{-1} for three alfalfa cultivars; Gezahagn Kebede., *et al*. [16] reported dry matter yield ranged from 5.5 - 8.7 tha^{-1} from the Ethiopia. However, dry matter yield from this study for DZ local and DZ5533 varieties were similar to reported values of 5.67 and 3.50 t ha^{-1} respectively for DZ local and DZ410 varieties under rain fed condition by Hidosa Denbela., [7] but it lower than reported value of 10.88 tha^{-1} for DZ220 by same author. Moreover, the dry matter yield from our study was higher than previously reported values by different researchers under different agro-ecologies for different alfalfa genotypes. Accordingly, Colombari G., *et al.* [33] reported 1.320 - 1.68 t ha^{-1}, Afsharmanesh G., [34] reported 1.78 - 3.23 t ha^{-1} and Awad OA and Bakri E. [35] reported 0.67 - 2.16 tha^{-1} dry matter yield. The result from our study for plant height was agreed to previously reported values which ranged from 55 - 92 cm by Hidosa Denbela., [7] for four alfalfa varieties, 52.7 - 77.74 cm by Gezahagn Kebede., *et al*. [16] for five alfalfa varieties from the Ethiopia.

Alfalfa Variety	Parameters Measured		
	Dry Matter Yield (t ha^{-1})	Cutting Height (cm)	Leaf to stem ratio
DZ407	4.27^{ab}	74.81^{b}	0.78
DZ409	4.26^{ab}	76.24^{b}	0.83
DZ5533	3.74^{b}	76.60^{b}	0.86
DZ local	5.20^{a}	84.88^{a}	0.87
LSD	0.97	8.14	0.10

Table 1: Dry matter yield, cutting height above ground and leaf to stem ratio of alfalfa variety grown under rain fed in South Omo Zone in 2018 main cropping year.

[a, b]: (Means with the different letters in column for dry matter yield, plant height and leaf to stem ratio at 50% flowering stage are significantly different at $P < 0.05$; LSD= least significant difference).

Effect of location on dry matter yield, plant height and leaf to stem ratio

The effects of location on dry matter yield, leaf to stem ratio and cutting height above ground are presented in table 2. The result revealed that higher ($P < 0.05$) dry matter yield was obtained from Jinka On-station than Chali and Shama-Bulke while the lowest dry matter yield was obtained from Shama-Bulket. However, taller ($P < 0.05$) cutting height above ground was obtained from Chali than Shama-Bulke and Jinka On-station while, the shorter cutting height above the ground was recorded from the Shama-Bulke. The higher ($P < 0.05$) LTSR was obtained from Shama-Bulket but lowest LTSR was obtained from Chali. The higher dry matter yield from Jinka on-station than Chali and Shama-Bulket is might be sufficient amount of rainfall, suitable temperature and favorable soil parameters which make faster plant growth and triggering more leaves per plats. In supports to the current result, the previous study reported by different scholars were showed that the dry matter yield of forage species greatly influenced by weather conditions such as rainfall, temperature and precipitations [36,37]. Also, Veronesi F., *et al*. [38] and Gezahagn Kebede., *et al*. [16] were reported that the dry matter yield may be variable for alfalfa genotype due to variation in agro ecological factors (moisture, temperature and soil parameters) which agreed to result from present study. The taller cutting height above ground for Chali is might be due to ecological variation. Gezahagn Kebede., *et al*. [16] and Tucak M., *et al.* [39] reports showed that in addition to genetic variability, the soil fertility and environmental conditions could be also contributed to the differences in height over year which concurs to results from our study.

Parameters measured	Testing locations				
	Shama-Bulket	On-station	Chali	Average	LSD
Dry Matter Yield (t ha^{-1})	2.12^{c}	6.02^{a}	4.97^{b}	4.40	0.84
Leaf to Stem Ratio	1.03^{a}	0.88^{b}	0.59^{c}	0.83	0.08
Cutting height (cm)	67.62^{b}	68.5^{b}	98.3^{a}	78.14	7.05

Table 2: Effects of location on dry matter yield, cutting height above ground and leaf to stem ration for alfalfa variety in South Omo Zone in 2018 main cropping year.

$^{a, b, c}$: (Means with the same letters in across row for dry matter yield, cutting height and leaf to stem ratio at 50% flowering stage are not significantly different at $P > 0.05$. LSD: Least Significance difference).

Effect of location by variety on dry matter yield, cutting height and leaf to stem ratio

Effect of location by variety on dry matter yield, cutting height above ground and leaf to stem ratio of alfalfa varieties are presented in table 3. The result on location by variety revealed that higher ($P < 0.05$) dry matter yield, cutting height above ground and leaf to stem ratio were observed among the three locations by keeping variety constant and however, dry matter yield, cutting height above ground and leaf to stem ratio were insignificant ($P > 0.05$) among the tested alfalfa varieties by keeping testing location constant. Accordingly, better dry matter yield observed for DZ local variety followed by DZ407, DZ5355 and DZ409 at Jinka on-station and Shama-Bulket. Likewise, better dry matter yield obtained for DZ local variety followed by DZ5355, DZ407 and DZ409 at Chali. However, the significantly ($P < 0.05$) the lowest dry matter yield obtained from Shama-Bulket for all tested alfalfa varieties. The result from this study shown that the taller ($P < 0.05$) cutting height above the ground was observed at Chali than Jinak On-station and Shama-Bulket for DZ local alfalfa variety than DZ5355, DZ409 and DZ406, while it was insignificant ($P > 0.05$) among DZ5355, DZ409 and DZ406 varieties. The leaf to stem ratio of forage species is stands an important factors have been affecting diet selection and forage intake in ruminant. The result from this study for LTSR showed that more leaf to stem ratio was obtained from Chali for DZ local alfalfa variety than other alfalfa varieties. However, higher leaf to stem ratio obtained from Shama-Bulket for DZ5355, DZ409 and DZ406 than DZ local alfalfa variety. Pertaining to the Jinka On-station, the more leaf to stem ratio obtained for DZ5533 variety than DZ local, DZ409 and DZ407. Generally, from this study we observed that effect of variety by location demonstrated to us that one variety performs better in one location but it is not better in other location. This is might be due to variability in climatic and soil condition which shows to us different alfalfa variety has differently responded to different planting location. The previous study reported by Adjei AI., *et al*. [40] was validated that variety by environment interaction is the result of changes in cultivar's relative performance across environments due to differential responses of the genotypes to various edaphic, climatic and biotic factors and this is help to identifying suitable genotype for specific location.

Chemical composition of alfalfa varieties

The chemical compositions of tested alfalfa varieties are presented in table 4. The higher ($P < 0.01$) ash content was obtained for DZ5533 variety than DZ407 and DZ local varieties but compa-

Tested Variety	Locations	Parameters Measured		
		Dry Matter Yield(t ha^{-1})	Cutting Height (cm)	Leaf to Stem Ratio
DZ407	Jinka	6.44^{abc}	69.67^{cd}	0.79^{de}
	Chali	4.26^{def}	92.83^{ab}	0.59^{f}
	Shama-B	2.12^{g}	61.93^{d}	0.97^{abc}
DZ409	Jinka	5.92^{abcd}	70.67^{cd}	0.84^{cde}
	Chali	3.84^{ef}	94.00^{ab}	0.60^{f}
	Shama-B	1.45^{g}	64.07^{d}	1.06^{ab}
DZ5533	Jinka	6.24^{abc}	68.83^{d}	1.05^{ab}
	Chali	4.60^{cdef}	96.50^{abc}	0.65^{ef}
	Shama-B	1.95^{g}	64.47^{d}	0.86^{cd}
DZ local	Jinka	7.19^{a}	61.33^{d}	0.87^{cd}
	Chali	5.45^{bcde}	109.83^{a}	1.21^{ab}
	Shama-B	2.95^{fg}	83.47^{bc}	0.52^{ef}
LSD (%5)			14.11	0.17

Table 3: Effect of location by variety on dry matter yield, cutting height and leaf to stem ratio for alfalfa varieties in Jinka on -station, Shama-Bulket and Chali in 2018 main cropping year.

$^{a, b, c, d, e, f, g}$: (Means with the same letters in across column for dry matter yield, cutting height and LTSR at 50% flowering stage are not significantly different at P > 0.05. LSD: Least Significance difference).

rable (P > 0.01) to DZ407 variety. The alfalfa variety DZ409 had higher (P < 0.001) crude protein (CP) than alfalfa variety DZ5533 but comparable (P > 0.001) to alfalfa variety DZ407. Moreover, alfalfa variety DZ409 had higher (P < 0.001) NDF than alfalfa variety DZ409 but similar (P > 0.05) to alfalfa variety DZ5533. Likewise, ADF content was lower (P < 0.001) for alfalfa variety DZ409 as compared to alfalfa DZ local but it was similar (P > 0.001) to alfalfa variety DZ407 and DZ5533. The higher CP for alfalfa DZ409 variety than other varieties from this study is might be due to differences in genetic make-up of variety to accumulate higher nitrogen contents from soil in a given environment. Furthermore, the variation among the alfalfa variety for CP can be attributed to various factors such as cultivar and climatic or their interactions (Diriba G., *et al.* [41]; Gezehagne Kebede, *et al.* [16]). The previously reported studies were shown that the CP content in alfalfa cultivars varied from 18 to 25% depending on the growth stage, cultivar and storage methods which are in agreement to result from our study for all tested alfalfa varieties [16,42]. However, the CP content reported from our study was higher when compared with others research results reported by different scholars [19,41,43]. Generally, the high quality alfalfa was reported to have >19% CP [44]. Based on this the results from our study, average CP alfalfa varieties gave CP content greater than reported threshold value (>19%) by Redfearn D., and Zhang H. [44]. Conversely, the higher ash content for DZ5533, DZ407 and DZ409 varieties as compared to DZ local variety from this study might be due to variation stage of maturity, climatic and seasonal changes, genetic make-up of the variety and leaf to stem fraction. The differences in both proportion and composition of the different morphological fractions (leaf and stem) could explain varietal differences in ash content [45]. The ash content reported in the present study was higher when compared with others research reports [19,41] and slightly lower than values reported by Gezahagn Kebede, *et al.* [16] which ranged from 10.26 to 11.5%.

Tested Variety	DM%	Ash%	CP	NDF	ADF
DZ407	89.62	9.21^{ab}	20.86^{a}	53.37^{b}	35.18^{b}
DZ5533	90.22	10.27^{a}	18.45^{b}	52.86^{b}	39.57^{ab}
DZ409	89.09	9.19^{ab}	22.98^{a}	49.42^{b}	36.19^{b}
DZ Local	90.00	8.29^{b}	18.08^{b}	59.03^{a}	43.18^{a}
SEM	0.87	0.53	1.12	2.02	3.04
LSD	1.82	1.09	2.32	4.18	6.31

Table 4: Chemical compositions of alfalfa variety at Jinka on-station, Shama-Bulket and Chali in South Omo Zone in 2018 main cropping year.

$^{a, b}$: (Means with the same letters in across column for DM%= Dry matter percent, CP= Crude protein, NDF= Neutral detergent fiber, ADF= Acid detergent fiber at 50% flowering stage are not significantly different at P > 0.05. SEM= Standard error of mean; LSD: Least significance difference).

Effects of locations on chemical composition of alfalfa variety

The effects of location on ash, CP, NDF and ADF content are illustrated in table 5. Higher (P < 0.05) ash content was obtained from Shama-Bulket than Jinka On-station and Chali but it was insignificantly (P > 0.05) varied for Jinka On-station and Chali. However, the CP, NDF and ADF contents were not significantly (P > 0.05) affected by the three testing locations. However, the better CP and lower NDF and ADF content were obtained from Shama-Bulket than Jinka

On-station and Chali. The similarity and differences among the alfalfa varieties to tested location could be attributed to the large differences and similarity between the three test location in altitude, physic-chemical properties of the soil, temperature and differences in both amount and distribution of annual rainfall. In supports to current result from our study the previous study reported by different scholars had confirmed that the quality parameters of alfalfa species greatly influenced by weather conditions and environmental factors [46-48].

Parameters measured	Tested Locations					
	Shama-Bulket	Jinka on-station	Chali	Average	SEM	LSD
DM%	89.25	89.51	90.44	89.73	0.76	1.57
Ash	10.07[a]	8.85[b]	8.81[b]	9.24	0.46	0.95
CP	21.34	19.38	19.56	20.09	0.97	2.01
NDF	52.79	53.09	55.13	53.67	1.75	3.62
ADF	38.24	38.31	39.03	38.53	2.63	5.46

Table 5: Effects of locations on chemical composition of alfalfa varieties at Jinka on-station, Shama-Bulket and Chali locations in 2018 main cropping year.

[a, b] (Means with the same letters in across row for DM%, Ash, CP, NDF and ADF at 50% flowering stage are not significantly different at P > 0.05. CP= Crude protein, NDF= Neutral detergent fiber, ADF= Acid detergent fiber, SEM= Standard error of mean; LSD= Least significance difference).

Conclusion

The higher (P < 0.05) dry matter yield was observed for DZ local alfalfa variety than DZ5533 but it was not significantly (P > 0.05) varied to DZ420 and DZ409. Pertaining to location effects on dry matter yield for alfalfa varieties, higher dry matter yield was observed at Jinka On-station than Shama-Bulket and Chali and whereas, the lowest was for Shama Bulket and intimidate dry matter yield was for Chali. Moreover, the DZ409 variety had higher (P < 0.05) CP than DZ5533 variety but comparable (P > 0.05) to DZ407 variety but the lower CP content was for DZ local variety. Based on the result from this study we concluded that farmers, pastoralist and agro-pastoralists could enhance the feed availability for increased livestock production in the study area by planting DZ local alfalfa variety and DZ409 variety for higher dry matter yield and crude protein respectively.

Acknowledgements

This study was made possible with funds from Regional Agricultural Growth Program II (AGPII) to Jinka Agricultural Research Centre for the enhancing the farmer, agro-pastoral and pastoral livelihoods in South Omo Zone through improving livestock feeds and feeding system. Therefore, we are extremely thankful the AGPII for providing fully fund support for research activity and the Jinka Agricultural Research Center at Jinka for providing logistical supports. Finally, we are grateful to acknowledge the laboratory technician Mr Ashenafi kebede Hailemariam from Debre Birehan Agricultural Research Center for his wonderful cooperation for laboratory forage sample chemical composition analysis.

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