Evaluation of alfalfa (Medicago sativa L.) varieties for biomass yield and herbage quality under irrigation at Bakelo, north Shewa

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ABSTRACT

Four alfalfa varieties were evaluated for herbage yield potential and nutritional quality under irrigation conditions at Basonawerana Wereda, Bakelo Kebele during the 2017 and 2018 dry seasons. The experiment was conducted in a randomized complete block design with three replications. The Alfalfa varieties used in the current study were DZ554, DZ406, DZ409, and DZ552. Each variety was seeded in a single plot area of 3 m x 4 m = 12 m0. NPS (Nitrogen, phosphorus, sulfur) fertilizer at the rate of 126 kg/ha was uniformly applied at sowing to assess the production potential plant height (cm) and dry matter yield (t ha^{-1}) of the forge and its nutrient content. The data collected were subjected to analysis of variance (ANOVA) using the general linear model procedure of the Statistical Analysis System (SAS, 9.4). The result revealed that there is no significant difference ($p > 0.05$) in plant height potential among varieties at 50% flowering in the current study. Plant height ranged from 67.75 to 72.73 cm with a mean value of 70.05cm. The herbage dry matter yield per hectare obtained in this study revealed that there is no significant difference ($p > 0.05$) among varieties. The overall DM yield ranged from 6.23 to 7.77 t/ha with a mean value of 7.3 t/ha. All the forage quality traits (dry matter, Crude protein, Ash, NDF, ADF, and ADL) showed non-significant ($P>0.05$) differences between varieties. Generally, the alfalfa varieties showed no variations in terms of plant height, biomass yield potential, and nutritional quality under irrigation conditions in the study area. Hence, all tested varieties of alfalfa could be interchangeably used in the study area and similar to other conditions.

Keywords: Alfalfa, Dry matter yield, Forage quality, Plant height, Variety

INTRODUCTION

The main Livestock feed resources in Ethiopia are natural pasture, crop residues, improved pastures, forage crops, and agro-industrial by-products (Alemayehu 2004). At present, the human population in Ethiopia has tripled, necessitating the expansion of arable crops at the expense of available grazing land to meet food demand. In addition, the expansion of urbanization and the use of arable lands for housing, recreation, and industrial development is displacing a considerable area of grazing land. As a result, in the highlands alone grazing lands have dwindled to about 5.7 million hectares (Abera 2006). These remaining grazing lands constitute marginal lands-highly fragmented and limited to areas where conditions are adverse for cropping due to topographic, edaphic, and climatic limitations. Improvement in livestock production and productivity requires a concomitant intensification in feed production using improved and or cultivated forage crops in addition to efficient utilization of the natural pasture and crop residues. The present understanding in the ongoing economic growth and transformation plan concerning the livestock sector is to reorient the smallholder production system into specialized and market-oriented production system that includes high-quality cultivated forage production along with other livestock production packages. In line with this, evaluation of different alternative forage species and cultivars under existing production conditions is vital.

Alfalfa (Medicago sativa L.) is one of the best leguminous feed crops bet for livestock especially for dairy and poultry production in Ethiopia, due to its superior herbage yield, palatability, nutritional value, a wide range of adaptation and suitability for irrigated production systems. Its agronomic merits such as fast growth, persistence in prolonged dry condition, and versatility in its soil requirements have made it a popular fodder crop for intensive livestock production systems such as dairy production (Alemayehu 2002). In Ethiopia alfalfa has an excellent performance in a wide range of altitudes from cool temperate highland to warm low land and in a range of soil types. Alemayehu (2002) noted that because of its very high feed value, alfalfa should be used as a supplement for crop residues and natural hay in a mixture of 30 percent alfalfa and 70 percent other roughages. Alfalfa produces more protein per hectare than other legumes (for instance, cowpea, lablab, desmodium) and grasses; therefore, it is widely used for hay production and as pasture for livestock, especially for ruminants (Monteros and Bouton 2009). According to the Central statistical agency CSA (2019), the estimated livestock population of the north shewa zone is 1,323,720 cattle, 1,644,881 sheep, 732,433 goats, 410,378 equines, 1,679,373 chickens and 54,314 beehives. Ruminants fed alfalfa have higher nutrient intake and digestibility than when fed on other legumes and grasses (Frame 2005).

According to the BoARD (2004) report, Debre Birhan is identified and categorized as a potential dairy area in milk shed areas; milk shed is aimed at concentrating the rapidly growing urban population and the growing demands for milk and milk products. To improve the availability of livestock feed in terms of quantity and quality, it is better to cultivate alfalfa forage that has better biomass yield and nutritional quality. Therefore, the objective of the present study was to evaluate the adaptability, biomass yield potential, and nutritional quality of alfalfa varieties under irrigation conditions.

MATERIALS AND METHODS

Description of the Study Sites

The experiment was conducted at Basonawarana Wereda, Bekelo Kebele under irrigation conditions. The experimental site is located 10 km northeast of Debre Birhan town. The area is situated at 9.70 N and 39.660 E with an altitude of 2837 m.a.s.l. The soil in the area is deep and very dark grayish brown when dry and very dark gray when moist. The texture is clay strong coarse sub angular blocky structure. These soils have a consistency that is hard when dry, friable when moist and sticky, and plastic when wet. The area has an annual average rainfall of 91 mm with maximum and minimum temperatures of 19.030c and 3.220c, respectively (NSRC 2006).

Experimental Design and Treatment

The experimental materials (seeds) of each variety were collected from the Debrezeit Agricultural Research Center. For this trial, a 0.0209-hectare land was prepared and divided into 12 plots with 3 replications per treatment. The spacing between the plot and the block was 1 m. The selected varieties DZ554, DZ406, and DZ409& DZ552 were planted in a plot area of 3 m x 4 m = 12 m2 using a randomized complete block design (RCBD) with three replications. The seed of the four alfalfa varieties was sown on well-prepared seedbeds in rows spaced 30 cm apart using a seed rate of 20 kg ha 1. The plots were hand-weeded during the establishment and subsequent years. NPS fertilizer was applied uniformly at a rate of 126 kg/ha was uniformly applied at sowing. The plots were uniformly irrigated at field capacity every 7 days during the dry season of the year (Orloff et al 2001).

Crop Management and Data Collection

The management activities such as hoeing, weeding, diseases, and pest inspection were carried out continuously. The agronomic data like sowing date data of emergence, plant height, and days to 50 % flowering and yield data like fresh and dry matter yield were collected. To measure the height of the plant per each treatment at 50% flowering, five plants from middle rows per plot were randomly taken for the height of plant measurement and the average height of the plant was considered for their height growth potential of each treatment.

Each alfalfa variety was harvested to determine fresh herbage and dry matter yield at the 50% flowering stage, described as a stage when open flowers emerge on average of 2 or more nodes and there are no seed pods present (Ball 1998). Eight interior rows were clipped at 5cm above the ground level to determine the biomass yield. The weight of the total fresh biomass yield was recorded from each plot in the field and the estimated 300 g sample was taken from each plot to the laboratory. The sample taken from each plot was weighed to know the total fresh weight using Salter balance and oven dried for 24 hours at a temperature of 650C for 72 hours for herbage DM yield determination at Debre Birhan Agricultural Research Center, animal feed and nutrition laboratory.

Chemical Analysis

The dried samples were grounded to pass a 1mm sieve and used for laboratory analysis.

Analysis was carried out for the nutritional parameters of ash, CP, NDF, ADF and ADL nutritional parameters. The total ash content was determined by oven drying the samples at 105 0C overnight and by burning the samples in a muffle furnace at 550oC for 6 hours (AOAC 1990). Nitrogen (N) content was determined following the micro-Kjeldahl digestion, distillation, and titration procedures (AOAC 1995), and the crude protein (CP) content was estimated by multiplying the N content by 6.25. The structural plant components (NDF, ADF, and ADL) were determined according to the procedures of (Van Soest and Robertson 1985).

Statistical Analysis

The analysis of agronomic and yield data was performed using the GLM procedure of SAS statistical software version 9.1. Mean separation was done by using Duncan's multiple range (DMR) test with the following model.

Yij = a + ßi + tj + eij

Where:

Yij = dry matter yield,

a = General mean of the treatments,

ßi = block effects,

tj = treatment effects

eij = experimental (random) error.

RESULTS AND DISCUSSION

Plant Height at Forage Harvesting Stage

The mean plant height of alfalfa varieties is presented in Table 1. There were no significant differences ($p > 0.05$) among the varieties for plant height at 50% flowering in both years. The overall mean plant height ranges from 67.75-to 72.73 cm with a mean of 70.05cm. The results of this study agree with the results of Gezahagn *et al* (2017) who found no significant difference ($P>0.05$) between the plant height of the alfalfa variety for the first two consecutive years. And also the non-significant CP content in the present study was in agreement with Alemu *et al* (2020) who found no statistically significant ($P>0.05$) interaction effect between variety and cutting interval on plant height (cm), the number of branches per plant and dry matter percentage. This study result also is in line with the result of Solomon et al (2018) who reported that there was a non-significant ($P>0.05$) difference between varieties on stand height. However, this result is inconsistent with the finding of Hidosa (2015) who reported that there was a significant difference ($p<0.05$) between alfalfa varieties in plant height. This might be the difference in agro-ecology and rainfall distribution, and also the variety difference.

Table 1: Mean plant height (cm) of alfalfa varieties evaluated for biomass yield and herbage quality under irrigation

Varieties	Plant height (cm)		
	2017	2018	Average
DZ554	69.05	66.46	67.75
DZ406	66.28	76.04	71.16
DZ409	69.93	75.54	72.73
DZ552	69.25	67.93	68.59
CV	3.8	10.46	3.2
Mean	68.62	71.49	70.05
LS	ns	ns	ns

CV= coefficient of variation, ns=non-significant, LS= Level of Significance

Dry Matter Yield

The dry matter yield of the alfalfa varieties evaluated under irrigation was presented in table 2. The result indicated that there were no significant difference (P>0.05) among varieties in the dry matter yield. The mean DM yield ranged from 7.33 to 7.25 t ha^{-1} in the years 2017 and 2018 respectively. The result was higher than the finding of (Afsharmanesh 2009 and Awad and Bakeri 2009), they reported that DM yield values ranged from 1.78-3.23 t ha^{-1} () and from 0.67-2.16 t ha^{-1} respectively. This study result is in line with the result of Solomon et al (2018) who reported that there was a non-significant (P>0.05) difference between varieties on stand height and DM yield at Debrezeit under irrigation. The wide range of herbage DM yield values observed in different research findings could be attributed to varietal and environmental differences and their interactions. Growth stage, number of cuts per year/frequency of cutting, leaf to stem ratio, moisture conditions at harvest, and processing method are the most important causes of variation in the yield of alfalfa (Veronesi et al 2010). However, the result of this study disagreed with the result reported by Gezahagn *et al. (2017)* who reported that there was a significant difference (P<0.05) between genotypes on herbage dry matter yield.

Table 2: Mean dry matter yields of alfalfa varieties (t ha^{-1}) evaluated under irrigation

Varieties	Dry matter yield		
	2017	2018	Average
DZ554	7.6	7.83	7.7
DZ406	7.39	8.16	7.77
DZ409	6.01	6.45	6.23
DZ552	8.32	6.58	7.5
Mean	7.33	7.25	
CV	19.17	20.66	11.27
sig	ns	ns	ns

CV= coefficient of variation, sig= significant level, ns= non-significant t ha^{-1} = ton per hectare

Chemical Composition

Herbage quality traits of alfalfa varieties are presented in Table 5. All forage quality traits showed non-significant (P>0.05) differences among varieties. The ash content of the alfalfa varieties ranged from 6.8 to 10.66 with a mean value of 8.63%. The mineral content is affected by the stage of maturity and the leaf-to-stem ratio, since alfalfa leaves contain more P, Ca, Mg, Cu, Zn, Fe and Mn while stems contain more K (Markovic et al., 2009). Since the concentration of minerals in forages is affected by the stage of maturity and climatic and seasonal changes (Minson, 1990), regular analysis has been recommended for formulating appropriate mineral supplementation schedules (Spears, 1994). Other studies also indicated that the concentration of minerals in forage varies due to factors like plant developmental stage, morphological fractions, climatic conditions, soil characteristics, and fertilization regime (McDowell and Valle 2000; Jukenvicius and Sabiene 2007). Differences in both the proportion and composition of the different morphological fractions could explain varietal differences in ash content. Alfalfa is a highly valued animal feed. It is a rich source of proteins, fibers, minerals, and vitamins used in the diet of livestock, especially ruminants. The content of minerals in alfalfa fully meets the livestock requirements while the content of fats is low (averaging 3.8 g kg^{-1}), and it varies slightly among cultivars (Katić et al 2009).

The CP content of alfalfa varieties ranged from 18.3 to 22.9% with a mean value of 21.3%. The nonsignificant CP content in the present study was in agreement with Mekuanint et al (2015) and disparity with Diriba et al (2014). The CP content reported in the present study was higher compared with other research findings (Diriba et al 2014; Mekuanint et al 2015). High-quality alfalfa was reported to contain >19% CP (Redfearn and Zhang, 2011). On the other hand, alfalfa forage quality values at the full bloom stage contain CP >16% (Dunham, 1998). In this study, all alfalfa genotypes except DZ552 had a CP content greater than the threshold value >19% indicated by other researchers (Redfearn and Zhang 2011). Alfalfa nutritive value is identified with protein content which depends on the share of leaves in dry matter yield which in its turn is positively correlated with protein content (Julier et al 2001 and Katic et al 2005).

Protein content in alfalfa dry matter varies from18 to 25% depending on the growth stage, cultivar, and storage method (Katic et al 2006). Harvesting at earlier development stages produces more crude protein and less crude cellulose (Katic et al 2003). The result showed that alfalfa produces more protein per hectare than other legumes and grasses. Therefore, it is widely used for hay production and as pasture for livestock, especially for ruminants (Monteros and Bouton 2009). In fact, all varieties had CP values of above 15%, a level suggested for a protein source supplement to be considered optimal to support lactation and growth in dairy cattle. The result indicates that alfalfa had an optimal crude protein content, so it was used as an alternative protein source feed for livestock production.

The non-significant ($P>0.05$) differences for NDF and ADF content of alfalfa varieties are indicated in Table 3. Mekuanint et al (2015) and Gezahegn et al (2017) also reported nonsignificant differences in NDF and ADF contents of alfalfa varieties. High-quality alfalfa was reported to contain NDF <400 g/kg DM and ADF <310 g/kg DM (Ball et al 1997; Redfearn and Zhang 2011; Kazemi et al 2012). On the other hand, alfalfa forage quality values at the full bloom stage contain NDF <530 g kg^{-1} DM and ADF <410 g/kg DM reported as better quality (Dunham 1998). The NDF content of the varieties DZ554 and DZ406 were below the critical level (530 g kg^{-1} DM) reported in alfalfa (Dunham, 1998) could indicate that it has better digestibility. However, the NDF values of the varieties DZ409 and DZ 552 were higher than the critical level (530 g kg^{-1} DM) reported in alfalfa (Dunham, 1998). The ADF values reported in the present study were higher than the threshold level (<410 g kg^{-1} DM) reported by Dunham (1998) and also much higher than the threshold level (<310 g kg^{-1} DM) reported by Ball et al (1997); Redfearn and Zhang (2011) and Kazemi et al (2012).

The ADL content showed a non-significant (P>0.05) difference among the tested alfalfa varieties, and this was also reported by other researchers (Gezahegn et al 2017; Diriba et al 2014; Mekuanint et al 2015) on other alfalfa varieties. The ADL content ranged from 6.42% to 9.77% with a mean value of 8.46%. The highest ADL content was recorded for DZ409, indicating a low quality compared with the other varieties. The lignin component contributes to erective strength and resistance to plant tissue, thereby limiting the ability of rumen microbes to digest cell wall polysaccharides, cellulose, and hemicellulose (Reed et al 1988). Hence, alfalfa varieties with a lower lignin content should have better digestibility. The high lignin content in alfalfa plants increases their resistance to lodging. However, lignin is a major factor that limits cell wall digestibility because it inhibits the digestibility of polysaccharides (Katic et al 2008).

Table 3: Mean Chemical composition of alfalfa varieties evaluated under irrigation

Varieties	**Herbage quality traits (% DM)**					
	DM %	Ash	CP	NDF	ADF	ADL
DZ554	85.33	9.39	20.89	60.59	44.7	6.42
DZ406	84.66	10.66	22.6	67.56	51.95	8.31
DZ409	86.66	7.7	22.9	75.02	58.12	9.77
DZ552	87.66	6.8	18.83	74.87	56.06	9.36
Mean	87.07	8.63	21.3	69.51	52.7	8.46
SEM	2.6	1.44	3.5	9.5	6.2	1.21
CV	3.1	3.5	16.86	13.8	11.88	14.3
LS	NS	NS	NS	NS	NS	NS

DM=Dry matter CP=Crude Protein NDF =Neutral detergent fiber ADF =Acid detergent fiber ADL =Acid detergent lignin SEM= Standard error of mean CV=Coefficient of variation LS=Level of significance

CONCLUSION AND RECOMMENDATION

From this study, it can be concluded that the tested four alfalfa varieties showed non-significant differences in plant height, DM yield, and quality (Ash, CP, ADF, NDF, and ADL). Based on the study result all tested alfalfa varieties were well-adapted and performed well in terms of forage yield and quality in the study area. Therefore, these selected alfalfa varieties should be further demonstrated and scaled up in the study area and at similar agro-ecologies of north the zones.

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