

Adaptation Trial of Alfalfa (*Medicago sativa* L.) Varieties for Midland Agro-Ecology of Kellem Wollega Zone, Oromia, Ethiopia

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To cite this article:

Yerosan Wekgari, Negasu Gamachu, Fikre Diriba. Adaptation Trial of Alfalfa (*Medicago sativa* L.) Varieties for Midland Agro-Ecology of Kellem Wollega Zone, Oromia, Ethiopia. *Computational Biology and Bioinformatics*. Vol. 10, No. 1, 2022, pp. 14-19.

doi: 10.11648/j.cbb.20221001.13

Received: December 29, 2021; **Accepted:** March 23, 2022; **Published:** March 31, 2022

Abstract: Alfalfa is important improved forage legume that solves feed shortages and has economic value for livestock production in Ethiopia. Six alfalfa varieties were evaluated to identify adaptable and high biomass yielder under rain fed condition of mid-altitude of Kellem Wollega Zone, Oromia, Ethiopia. The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. DAP fertilizer at the rate of 100 kg/ha was uniformly applied at sowing. Agronomic parameters and biomass yield were determined. Results revealed that the tested varieties were varied significantly ($P < 0.05$) for days to emergence, plant coverage, days to 50% flowering (forage harvest), plant height, and biomass yield. Accordingly, variety Hunter river was early emerged (8.33 days) and had maximum (68.33%) percentage of plot coverage though DZF-552 (9.08 days) was late emerged and had minimum (56.33%) percentage of plot coverage. Variety DZF-552 was late flowering while F-L-L-77 was early flowering. Hairy Peruvian (70.92 cm) gave the maximum plant height though DZF-552 (55.08 cm) gave a minimum height. The highest mean fresh biomass (6.46 t/ha) and dry matter yield (1.28 t/ha) were recorded from Segules-1359 variety. On the other hand, the lowest fresh biomass (4.79 t/ha) and dry matter yield (0.97 t/ha) were recorded from variety DZF-552. Based on the results, it could be concluded that variety segules-1359, F-L-L-77, Hunter river, and Hairy Peruvian could be recommended to grow under the midland ecological condition of Kellem Wollega zone and similar agro ecology for livestock producers as feed resources.

Keywords: Alfalfa, Agronomic Parameter, Biomass Yield, Variety

1. Introduction

Feed scarcity both in terms of quantity and quality is a major bottleneck for livestock production in Ethiopia. Improved forage crops play an important role in sustaining the livelihoods of small and medium scale farmers, mainly as a result of their positive effects on livestock production and contribution to economic and environmental sustainability. Many indigenous forage species in Ethiopia have low productivity, low nutritive value, and digestibility, which reduce their usefulness for livestock nutrition [1]. On the other hand, one way of improving livestock production and productivity is to introduce improved forage development and proper supplementation with leguminous forages [2].

Forage legumes have several advantages to mixed crop-livestock production systems especially in being protein source, which is usually the most limiting nutrients in tropical animal diets and can be grazed, harvested, and fed fresh or stored as hay or silage. One of such potential legume species for integration into existing livestock feeding system is alfalfa (*Medicago sativa* L.).

Alfalfa is one of the most important forage crops worldwide due to its high forage quality, yield, and adaptability to different climatic conditions [3] and it is a basic component in rations for all classes of domestic animals. It can be used directly for grazing or conserved as

silage or hay and is a reliable forage species that could represent a significant contribution to the livestock sector [4]. As a perennial legume, alfalfa may be used as a cover crop; its roots improve soil texture and its leaves add organic matter and nitrogen to the soil. The herbage DM yield and chemical composition of alfalfa depend on cutting cycles and cultivars, among others. Crude protein tends to be lower in aged alfalfa plants while the content of crude fibers increases [5].

In the western part of Oromia like anywhere in the country, livestock depends on natural pasture and crop residues. These feedstuffs are grossly low in quantity and quality to sustain production. Most legume forages are protein source in livestock nutrition and of which, those some grown feeds make farmers less dependent on the purchase of the other protein source. Research has identified high yielding and better quality forages adaptable to various agro-ecologies and production systems, improved forages are not yet adopted and developed by the farming community due to inadequate knowledge, poor extension service, and shortage of land and policy issues. So, to address the feed shortage problem in the areas, using available feeds efficiently, improving the nutritional quality of existing feeds by planting legume fodder crops like alfalfa. Therefore, the study was aimed to identify and select better adaptable and herbage yield performance of alfalfa variety grown at Kellem Wollega zone under rain fed condition.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted at Haro Sabu Agricultural Research Center (HSARC) in midland (altitude) agro-ecology of Kellem Wollega zone of Haro sabu (On station), Mata, Hawagalan and Kombo sub sites (locations) during 2018 and 2019 of the main cropping seasons. The center was located in Western Ethiopia in the Oromia region at 550 km from Addis Ababa. It has an altitude of 1515 m above sea level. It has a warm humid climate with an average annual minimum and maximum temperature of 14 and 30°C, respectively. The area receives an average annual rainfall of 1000 mm and its distribution pattern is uni-modal. The area is characterized by coffee based farming system and crop-livestock mixed farming system [6].

2.2. Treatments and Experimental Design

The six Alfalfa varieties (materials) were collected from Debre Ziet, Adami Tulu and Melka Werer Agricultural research centers and evaluated at Haro sabu Agricultural Research Center for the mid altitude of Kellem Wollega zone on four locations. The treatments used were DZF-552, F-L-L-77, Hairy Peruvian, Hunter river, Pioneer-1995, and Segules-1359. The design used was a randomized complete block design (RCBD) with three

replications with a plot size of 4m x 3m with 1.5 m, 1 m, and 0.2 m between replication, plot, and row respectively. The varieties were planted by seeds and the seed was sown drilling in a row with a seed rate of 10 kg/ha and fertilizer application of Di-ammonium phosphate (DAP) fertilizer at a rate of 100 kg/ha. Recommended management practices for herbaceous legumes were applied during the experimental periods.

2.3. Data Collected

Days to emergence, percentage of plot coverage and days to 50% flowering (forage harvest) of each alfalfa variety was recorded. Five plants were taken randomly from the middle rows and measured at the time of forage harvest for plant height parameter. Forage samples were taken from middle rows during 50% flowering and then dried in air until constant weight for dry matter yield determination.

2.4. Data Analysis

Differences among varieties were tested by using analysis of variance (ANOVA) procedures of SAS Version 9.0 [7] general linear model (GLM) to compare treatment means. The least significance difference at 5% significance level was used for comparison of means. The following model was used for combined analysis:

$$Y_{ij} = \mu + B_i + T_j + \epsilon_{ij}$$

Where,

Y_{ij} = measured response of variety i in block j ; μ = overall mean; B_i = i^{th} effect of block; T_j = j^{th} effect of treatment; ϵ_{ij} = random error effect of variety i in block j .

3. Results and Discussion

3.1. Agronomic Characteristics and Yield Performance

3.1.1. Days to Emergence and Plot Coverage

Days to emergence and percentage of plot coverage of alfalfa was presented in Table 1. The combined analysis of variance for days to emergence were significantly different ($p < 0.05$) among alfalfa varieties. Variety DZF-552 was had late days to emerge which was comparable with other varieties except Pioneer-1995 and Hunter river varieties (early emerged). This difference of days to emergence was attributed to variety, seed depth, and environmental condition (temperature, rainfall, moisture) disparities.

The combined analysis of variance for plot coverage percentage at the age of eight week were significantly different ($P < 0.05$) among alfalfa varieties. The combined analysis of variance showed that higher percentage of plot coverage was obtained from Hunter river which was insignificantly differed as compared to the rest varieties except DZF-552 that had the lowest percentage of plot coverage. This indicates that dues to forage genetic makeup difference.

Table 1. Mean days to emergence and plot coverage at eight weeks of alfalfa varieties.

Varieties	DE				Combined Mean	Plot coverage (%)				Combined Mean
	Haro sabu	kombo	Hawagalan	Mata		Haro sabu	Kombo	Hawagalan	Mata	
DZF- 552	8	8	8.33	12 ^{ab}	9.08 ^a	46.67	79.33	47.67	51.67 ^b	56.33 ^b
F-L-L-77	8	7.33	8.33	12.33 ^a	9 ^{ab}	51.67	82	51.67	79 ^a	66.08 ^a
Hairy Peruvian	7.67	8.67	8	11.67 ^{ab}	8.75 ^{abc}	51.67	81.67	50.67	69.33 ^a	63.33 ^a
Hunter river	7.33	7.33	7.67	11 ^b	8.33 ^c	55	83.33	56.67	78.33 ^a	68.33 ^a
Pioneer – 1995	7.33	7.33	7.67	11.33 ^{ab}	8.42 ^{bc}	53	82	53	76 ^a	66 ^a
Segules-1359	7.33	7.33	7	12 ^{ab}	8.50 ^{abc}	54	84	52.33	79.33 ^a	67.42 ^a
Mean	7.61	7.50	7.89	11.72	8.68	52	82.05	52	72.28	64.58
LSD (5%)	0.71	1.44	2.04	1.31	0.64	9.34	4.87	10.80	10.21	5.10
CV %	10.63	6.44	14.20	6.16	9.03	8.86	4.45	11.41	7.76	9.61
SEM	0.41	0.33	0.59	0.35	0.56	3.60	1.84	4.72	3.03	4.37
SL	ns	ns	ns	*	*	ns	ns	ns	**	**

^{a-c}Means with different letters in a column significantly different at (P>0.05). DE = days to emergence; LSD = least significance difference; CV = coefficient of variance; SE = standard error of mean; SL = significant level; * = significant at P<0.05; ** = significant at P<0.01; ns = non-significant.

3.1.2. Days to 50% Flowering (Forage Harvesting Stage)

Days to 50% flowering (forage harvest) for the tested varieties of alfalfa showed significant (P<0.05) differences at four locations (Table 2). Hairy Peruvian and Pioneer-1995 were early reached for forage harvesting (50% flowering) at Haro sabu and Hawagalan locations respectively, whereas F-L-L-77 was early reached for forage harvest at both Kombo and Mata locations and had comparable 50% flowering with other varieties, while DZF- 552 was significantly (P<0.05) late for forage harvesting stage for all locations of the study area. The result indicated that the overall mean of days to 50% flowering of the tested alfalfa varieties across locations were ranged from 106.83 to 112.33 with the mean of 108.45

days which was required after sowing of seedlings. Amongst the alfalfa varieties tested across locations, the DZF-552 variety was significantly required more days for the forage harvesting stage (112.33 days) followed by segules-1359 (108.17 days), while F-L-L-77 had the early days for 50% flowering (forage harvesting stage). The differences of days for 50 flowerings might be attributed to the genetic variability of the tested varieties. The significance of variety difference for days to 50% flowering of this finding is in agreement with finding that reported by [8], the mean 50% heading of different alfalfa accessions tested was observed significance difference grown on station of Jinka Agricultural Research Center under rainfed condition.

Table 2. Mean days to 50% flowering (forage harvest) Alfalfa Varieties tested per locations.

Varieties	Locations				Combined mean
	Haro sabu	Kombo	Hawagalan	Mata	
DZF- 552	116.33 ^a	104.33 ^a	112.67 ^a	116 ^a	112.33 ^a
F-L-L-77	114 ^{ab}	98.67 ^b	107.33 ^{ab}	107.33 ^b	106.83 ^c
Hairy Peruvian	112.67 ^b	100.33 ^b	108.33 ^{bc}	109.33 ^b	107.67 ^{bc}
Hunter river	113 ^b	101 ^b	108.33 ^{bc}	109.67 ^b	108 ^{bc}
Pioneer – 1995	114 ^{ab}	100.33 ^b	106.67 ^c	110 ^b	107.75 ^{bc}
Segules-1359	115 ^{ab}	99.67 ^b	109.67 ^b	108.33 ^b	108.17 ^b
Mean	114.17	100.72	108.83	110.11	108.45
LSD (5%)	2.57	2.65	2.51	2.77	1.19
CV (%)	1.24	1.45	1.25	1.38	1.33
SEM	0.82	0.84	0.79	0.88	0.42
SL	*	*	**	**	**

^{a-c}Means with different letters in a column significantly different at (P>0.05). LSD = least significance difference; CV = coefficient of variance; SE = standard error of mean; SL = significant level; * = significant at P<0.05; ** = significant at P<0.01.

3.1.3. Plant Height at Forage Harvesting Stage

Plant height was significantly differed (P<0.05) among the alfalfa varieties at the four locations (Table 3). The highest plant height was recorded from hairy Peruvian (67.33 and 69 cm) at Harosabu and Hawagalan, and Pioneer-1995 (81.40 cm) and F-L-L-77 (70.66 cm) at Kombo and Mata locations respectively. Whereas, the lowest plant height at forage harvest was recorded from the variety DZF-552 at all tested locations. The mean plant height of tested alfalfa varieties over locations was ranged

from 55.08 to 70.92 cm with a mean of 66.36 cm. The highest mean plant height was recorded from Hairy Peruvian followed by Hunter river, F-L-L-77, and pioneer-1995 respectively, while DZF-552 had the lowest plant height over locations. The differences in plant height among the tested variety were due to the fact that the genetic variability. The significance variety differences for plant height concur with that reported by different authors [8-10]. In addition to genetic variability, soil fertility could also contribute to the difference in height over locations. Generally, the presence of genetic variation among the

tested varieties, responses of varieties to environmental factors, and their interactions are the major reason for plant height variation in alfalfa. Ullah et al. [11] also reported differences in plant height to be linked to genotypic differences and explained this trait to be influenced by the differential response of genotypes to prevailing sites and crop management conditions. However, the current result

disagrees with the report of Turan et al. [3] who noted that the plant height of six alfalfa varieties tested in Eastern Turkey was not significantly different at the forage harvesting stage. The difference between our results could be attributed to such factors as the type of soil, climatic conditions, variety considered, date of flowering/heading for forage harvesting, and other management conditions.

Table 3. Mean plant height (cm) at forage harvesting of Alfalfa Varieties tested per locations.

Varieties	Locations				Combined mean
	Haro sabu	Kombo	Hawagalan	Mata	
DZF- 552	47.93 ^c	70.33 ^b	48.73 ^c	53.33 ^b	55.08 ^c
F-L-L-77	62.20 ^{ab}	79.26 ^a	62.33 ^{ab}	70.66 ^a	68.62 ^{ab}
Hairy Peruvian	67.33 ^a	79.73 ^a	69 ^a	67.60 ^a	70.92 ^a
Hunter river	63.27 ^{ab}	79.73 ^a	65.26 ^{ab}	68.93 ^a	69.30 ^{ab}
Pioneer - 1995	61.60 ^{ab}	81.40 ^a	62.26 ^{ab}	66.13 ^a	67.85 ^{ab}
Segules-1359	59.33 ^b	78.20 ^a	60.33 ^b	67.60 ^a	66.37 ^b
Mean	60.28	78.11	61.32	65.71	66.36
LSD _(5%)	6.49	4.77	7.72	9.21	3.26
CV (%)	5.92	3.54	6.93	7.70	5.97
SEM	2.06	1.51	2.45	2.92	1.14
SL	**	**	**	*	**

^{a-c}Means with different letters in a column significantly different at (P>0.05). LSD = least significance difference; CV = coefficient of variance; SE = standard error of mean; SL = significant level; * = significant at P<0.05; ** = significant at P<0.01.

3.2. Biomass Yield

Analysis of variance of mean values for biomass yields (fresh biomass and dry matter yield) of six alfalfa varieties at forage harvesting stage are presented in Table 4. The biomass yields (fresh biomass and dry matter yield) and the overall mean were showed significantly (P<0.05) vary among the alfalfa varieties over locations across years. The highest fresh biomass yield was obtained from Segules-1359, Hunter river, Hairy Peruvian, F-L-L-77 at Haro sabu, Kombo, Hawagalan and Mata locations, respectively though DZF-552 variety had

recorded lowest fresh biomass yield at all tested locations. The present result indicated that the fresh biomass yield of the evaluated varieties of alfalfa was significantly different across the tested locations. This might be due to the variations of genetic inheritance, soil and climate differences, and ages of cutting stages. The significant variety differences observed for fresh biomass yield in the present study in agreement with [8] who stated that the fresh herbage yield of different alfalfa accessions tested at Jinka Agricultural Research Center was significantly (P<0.05) varied.

Table 4. Mean biomass yield (t/ha) of Alfalfa varieties tested per locations across years (2018 and 2019).

Varieties	FBY					DMY				
	Haro sabu	Kombo	Hawagalan	Mata	Combined mean	Haro sabu	Kombo	Hawagalan	Mata	Combined mean
DZF-552	3.51 ^{bc}	9.07 ^b	3.06 ^c	3.51 ^d	4.79 ^b	0.66 ^b	1.91	0.63 ^{bc}	0.70 ^c	0.97 ^c
F-L-L-77	3.47 ^{bc}	10.91 ^{ab}	3 ^c	6.54 ^a	5.98 ^a	0.73 ^b	2.28	0.56 ^c	1.18 ^a	1.19 ^{ab}
Hairy Peruvian	3.10 ^{bc}	10.87 ^{ab}	4.79 ^a	5.40 ^c	6.04 ^a	0.69 ^b	2.245	0.87 ^a	0.91 ^b	1.18 ^{ab}
Hunter river	3.04 ^c	11.57 ^a	4.42 ^{ab}	6.16 ^{ab}	6.30 ^a	0.59 ^b	2.25	0.86 ^a	1.04 ^{ab}	1.18 ^{ab}
Pioneer-1995	3.62 ^b	9.80 ^{ab}	3.99 ^b	5.56 ^{bc}	5.74 ^a	0.75 ^b	2.08	0.85 ^{ab}	0.96 ^b	1.13 ^b
Segules-1359	4.65 ^a	11.07 ^{ab}	3.88 ^b	6.22 ^a	6.46 ^a	1.05 ^a	2.247	0.69 ^{bc}	1.15 ^a	1.28 ^a
Mean	3.57	10.54	3.86	5.56	5.88	0.74	2.17	0.72	0.99	1.16
LSD _(5%)	0.57	2.45	0.65	0.62	0.78	0.17	0.50	0.15	0.17	0.15
CV (%)	13.37	19.37	14.12	9.28	22.98	18.68	19.23	17.01	14.58	22.44
SE	0.19	0.83	0.22	0.21	0.276	0.056	0.17	0.05	0.06	0.053
SL	**	*	**	**	**	**	ns	**	**	**

^{a-c}Means with different letters in a column significantly different at (P>0.05). FBY = fresh biomass yield; DMY = dry matter yield; LSD = least significance difference; CV = coefficient of variance; SE = standard error of mean; SL = significant level; * = significant at P<0.05; ** = significant at P<0.01; ns = non-significant.

The overall mean of fresh biomass yield showed that fresh biomass yield was significantly (P<0.05) vary among the tested alfalfa varieties. The overall mean fresh biomass yield ranged from 4.79 to 6.46 t/ha with a mean of 5.88 t/ha. The mean indicated that the fresh biomass yield was significantly

higher (P<0.05) in Segules-1359 and non-significance difference with the rest varieties except DZF-552, whereas the lower was obtained from DZF-552. The alfalfa varieties in the present study had the lowest fresh biomass yield when compared with various reported literature values. For

instance, the fresh biomass yield values ranging from 16 to 44 t/ha [8] and from 29.22 to 43.57 t/ha was reported by [3], which were indeed much higher than those observed in the present study. The wide differences of the fresh biomass yield values observed in different research findings and our result could be attributed to varietal, environmental differences, harvesting stage, and other management factors.

Forage dry matter yield of alfalfa varieties were determined by environmental and genetic variability. Results from analysis of variance for DM yield of the tested alfalfa revealed that significant differences observed ($P < 0.05$) between the varieties at Haro sabu, Hawagalan and Mata, and mean values were recorded 0.74 t/ha, 0.72 t/ha and 0.99 t/ha, respectively, while non-significant results obtained at Kombo location with mean value of 2.17 t/ha. Accordingly, the higher dry matter yield was obtained from Kombo than other locations for the reason that might be due to soil fertility differences among the locations.

The overall mean of DM yield of Alfalfa varieties was 1.16 t/ha with values ranging from 0.97 t/ha for DZF-552 to 1.28 t/ha for Segules-1359. The present result indicated that DM yield was insignificantly ($P < 0.05$) higher in segules-1359 as compared to F-L-L-77, hairy Peruvian, and hunter river but significantly higher than pioneer-1995 and DZF-552. The presence of significant varietal differences for DM yield of alfalfa in this study concurs with reports of other researchers [12, 13]. Similarly, in evaluating five alfalfa genotypes, Gezahagn *et al.* [10] observed significant differences between genotypes for dry matter yield with an overall mean of around 6.46 t/ha. Unlike to this finding, Solomon and Tesfay [14] reported that the DM yield of selected alfalfa tested under the lowland of Raya valley, northern Ethiopia doesn't showed significant difference among cultivars. The result revealed that mean dry matter yield of alfalfa varieties tested in the present study was found within a range of dry matter yield values of alfalfa from 0.6 to 2.16 t/ha reported by Awad and Bakri [15]. However, other researchers reported respective DM yield values ranging from 4.22 to 4.77 t/ha [9] and from 1.78 to 3.23 t/ha [16] which was higher than those recorded for the alfalfa varieties in the present work. The wide range of DM yield values observed in different reports could be attributed to varietal differences, various soil fertility, and climate conditions, and agronomic activities of the experimental sites.

4. Conclusion and Recommendations

The tested alfalfa varieties were significantly ($P < 0.05$) varied in terms of days to forage harvest (50% flowering), plant height, fresh biomass, and dry matter yield. The mean result revealed that DZF-552 had late to reach 50% flowering while F-L-L-77 early reached. The highest mean plant height was recorded from Hair Peruvian though DZF-552 had a lower height. It was also concluded that from the tested alfalfa varieties, Segules-1359 was produced more fresh biomass and DM yield followed by F-L-L-77, Hunter-river and Hairy Peruvian. However, DZF-552 was less yielded than others which showed that low adaptability

to the study area. Therefore, based on high biomass yield potential four varieties: Segules-1359, F-L-L-77, Hunter-river and Hairy Peruvian were recommended to study area and it is important to trial vicinity. Moreover, the information obtained would benefit for promotion of forage species for demonstration and wider scaling out through scaling up program to the area and similar locations.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgements

The authors are grateful to Oromia Agricultural Research Institute for funding support to implement the study. The technical assistants of the Animal Feed Resources and Rangeland Management research team of the Haro Sabu Agricultural Research Center are also acknowledged for the support during the field research work.

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