Adaptation Trial of Alfalfa (*Medicago sativa*) Varieties/Cultivars in Selected districts of West Hararghe Zone, Oromia, Ethiopia

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Abstract

Ethiopia has the largest livestock population in Africa. The sector supports a million people in the country. But, the sector is primarily challenged by animal feed in terms of quality and quantity. So, it is important to introduce different improved forage at the smallholder farmer level. The experiment was conducted in West Hararghe Zone, Oromia, Ethiopia. The trial was conducted at mid to highland agro-ecologies for two consecutive major cropping seasons, 2021 to 2022 years aimed to evaluate, identify and recommend the best adaptable, high biomass yielders and drought tolerance alfalfa varieties for the study area. Five alfalfa varieties were used as experimental treatments in a randomized complete block design (RCBD) with four replications. All agronomic and yield parameters showed statistically significant ($p<0.05$) variation among varieties except plot cover. The highest mean dry matter yield was recorded for Arba Rakate FTC (5.51 t/ha), Kuni Segeria (3.62 t/ha), and on station (3.42 t/ha) with a combined mean of 4.18t/ha. The highest combined mean dry matter was recorded from the variety Hair Peruvian (4.82 t/ha) followed by Magna#788 (4.16 t/ha) and the lowest dry matter was recorded from Magna#801 (3.9 t/ha) and the fresh biomass yield varied from 14.02 to 17.34 t/ha with the average of 15.16 t/ha that the highest mean fresh biomass yield recorded from Hair Peruvian (17.34t/ha) followed by hunter river (15.30 t/ha) and the lowest recorded from Magna#801 (14.02 t/ha). The combined mean plant height ranged from 68.6 to 82.65 cm with a mean of 78.95 cm. The highest combined leaf-to-stem ratio was recorded from Magna#801 (60.73) followed by Magna#788 (54.06) and the lowest was recorded from Hunter river (49.53). The mean disease occurrence varied from 1.18 to 1.88. The most susceptible varieties were Magna#788 (1.88) and Magna#801(1.81) while the tolerance varieties were werer (1.18) and Hair Peruvian (1.25). From this study, it is concluded that Hair Peruvian followed by Hunter River were found more promising in terms of agronomic traits, DM yield, and fresh biomass yield than others during the main rainy season and popularized as an alternative feed resource under smallholder conditions in the study areas and other places of similar climatic and edaphic conditions.

Kew words: Alfalfa varieties, Dry matter yield, fresh biomass and west Hararghe

INTRODUCTION

Ethiopia has the largest livestock population in Africa, with 65 million cattle, 40 million sheep, 51 million goats, 8 million camels and 49 million chickens (CSA, 2020a). The national herd supports, at least in part, the livelihoods of more than 11.3 million rural households, including 27– 35% of the highland livestock keepers, and a large proportion of the lowland herders, who live below the Government of Ethiopia established poverty line (Shapiro *et al.*, 2017). The sector contributed up to 40% of agricultural Gross Domestic Product (GDP), nearly 20% of total GDP, and 20% of national foreign exchange earnings (World Bank, 2017). The productivity of this sector is constrained by several factors, including poor quality and varying seasonal availability of feed, poor genetics, low reproductive performance, high disease incidence and parasite challenges, and low accessibility to services and inputs (Zeleke and Harris, 2021). Green pasture (55.2%) and crop residues (30.8%) are the main feed types available in the country (CSA, 2020a). The available feed resources in the mixed crop-livestock production areas are natural pastures, crop residues, and to a lesser extent, improved forage, concentrates, and nonconventional feeds (CSA, 2020a). Animals are fed on crop stubble during harvesting seasons. In some places, improved forage is cultivated and fed to dairy cows to increase milk production, but this practice is not widespread (Abate, 2012).

Among the improved forage alfalfa is the most influential in animal production industry. It is the most widely cultivated forage legume worldwide (Neima and Mustafa, (2016) and is widely known as the "queen of the forages" due to its ability to consistently produce high-yielding, high-quality, persistent, profitable potential if given adequate management and adaptability to different climatic conditions (Turan *et al.*, 2009; Lacefield and Lacefield (2004) and the most important forage legume in the world, grown in more than 30 million hectares (Annicchiarico, 2015). It is a valuable crop because of numerous agronomic and environmental advantages in terms of preserving soil fertility and biodiversity, soil erosion protection, mitigation of climate change impacts, reduction of groundwater nitrate pollution, fossil fuel consumption, greenhouse gas emissions (Vasileva *et al.*, 2015; Shi *et al.*, 2017). Alfalfa is one of the most palatable forages, providing high energy and protein for dairy and beef cows as well as other types of livestock. It is an "engine of human food production," eventually transformed into milk, cheese, and meat, wool and honeys (Neima and Mustafa, 2016).

Livestock production is one of the major components of agriculture in Ethiopia, and it is highly dependent on the quantitative and qualitative adequacy of feed resources (Mengistu *et al.,* 2017). Feed shortage has been a chronic problem for animal production in pastoral area of Ethiopia (Denbela, 2015). To reduce the nutritional constraints on livestock productivity, the use of adaptive, high yielding, and drought-tolerant improved forages of high quality is important (Mengistu *et al.,* 2017). The major livestock feed resources in Ethiopia are crop residues, natural pasture and crop aftermath. West Hararghe feed shortage is accounts 75.7%, Animal health (4.8%) and feed cost (3%) (Abdi *et al.,* 2013). Previous studies in various parts of West Hararghe Zone Fekede *et al.* (2016) and Fikadu and Asfaw (2017) reported that the major constraints of cattle keepers showed that feed shortage is ranked the first.

Hence, introducing different improved forage through adaptation is the quick and inclusive mechanisms in the study area. Among the improved forage crops alfalfa (Medicago sativa L.) could play an important role in providing a significant amount of quality forage, both for the smallholder farmer as well as intensive livestock production systems with appropriate management practices. So, this activity was initiated with the objective of to evaluate, identify and recommend the best adaptable, high yielder and drought tolerance alfalfa varieties for the study area

MATERIALS AND METHODS

Description of the study area

The study was conducted in West Hararghe zone mid to high land parts which include Chiro, Gemechis from high land and Daro Lebu from mid land districts as alfalfa has wide range of agro ecologies adaptation (Turan *et al.,* 2017). These districts are describes as follow:-

Chiro district is located at 9°05′N and 40°52′E. with an average altitude 1826 above sea level. Chat is an important cash crop of this district. Coffee is another important cash crop, with over 5,000 hectares is planted with this crop Fikadu and Asfaw Zewdu (2017). The district is mainly characterized by steep slope and mountains with rugged topography, which is highly vulnerable to erosion problems (Fekede *et al.,* 2018). It has maximum and minimum mean rainfall of 1800 and 900 mm respectively (Gosa, 2016).

The rainfall type is bimodal and erratic. Main rainy season is from June to September for the high land areas and from March to April for midland and that of lowland around July. The amount of rainfall is relatively adequate the highland and midland than the lowland (Fekede *et al.*, 2018).

Daro Labu district is located at latitude of 40°30′ E and 8°10′ N and Mecahara Agriculture Research Center found at 08° 35' E longitude and 40° 19' latitude with an altitude of 1,700 m above sea level. The district is located at 434 km and 111km to East of capital city of the country, Addis Ababa and Chiro, capital city of the zone respectively. The major soil texture of the center is sandy loam with reddish color. The ambient temperature of the district ranges from 14 to 26°C with the average of 20°C with average annual rainfall of 1094 mm/year

Gemachis district is also found in West Hararghe Zone, Oromia National Regional State, and eastern part of Ethiopia. The district is located about 343 km southeast of Addis Ababa and 17 km from Chiro town, the capital of West Hararghe Zone. It is located at 8°10′N latitude and 40° 45′E longitude longitudes in the East. The district covers an area of 77,785 ha and it has 35 rural kebeles and 3 urban administrative towns (GDoANRO, 2016).

Experimental design and layout

The experiment was conducted under rain fed conditions during the main cropping season for two consecutive (2020 – 2022) years in selected districts of West Hararghe zone. Accordingly, three districts, which includes Gemechis, Chiro and Daro Lebu were selected and used to conduct this experiment. From Gemechis: Kuni segeria FTC, from Chiro: Arba Rakate FTC and from Daro Lebu: Mechara Agricultural Research Center, on station was used as experimental sites. The planting material used for this was five alfalfa varieties which include Werer, Magna#788, Magna#801, Hair Peruvian and Hunter river varieties collected from Werer and Adami Tulu Agricultural Research Center. After the sites had been selected, land preparation was started from April to June through tractor for first time and oxen at second and third times. Both years, sowing date was at the first week of July with plot size of 2*2m using a randomized complete block design (RCBD) with three replications. The space between block, plot and row was 1m, 1m and 0.25m respectively. 8kg/ha seed rate was used through hand drilling with

fertilizer rate of 100 kg/ha NPS and 50 kg/ha UREA at the time of sowing. All other crop management practices were done uniformly to all plots as required.

Data collection

The collected data for the trial was included 50% flowering, plot cover, stand vigor, leaf to stem ratio, herbage yield, dry matter yield, disease occurrence, pest infestation and plant height. Drying the samples for evaluate dry matter yield were measured in an oven at 105°C overnight

Model and Statistical analysis

Agronomic data was analyzed using ANOVA by the general linear model procedure of SAS, 2002 version 9.0. Means were separated using Least Significant Difference (LSD) at 5% significant level.

The model: $Yijk = \mu + Gi + Ej + Bk(j) + (GE)ij + eijk$

Where Gi = Variety effect, Ej = Environmental effect, Bk(j) = Block effect, GEij = Variety and Environment interaction, μ = the overall mean and eijk = random error

RESULTS AND DISCUSSIONS

The combined analysis of variance over years and locations showed significant differences among the varieties, locations and years for all parameters except plot cover (Table 1). Mean squares of varieties, locations and years were significantly ($p<0.05$) affected by interaction of varieties over years. The yielding ability of varieties is the result of its interaction with the environment. Environmental factors such as soil characteristics, moisture and temperature over years and locations have an impact on yield performance. Some varieties exhibit highly specific response to a particular environment and others are uniform in performance over a range of environments.

Table1: Combined Analysis MSS of ANOVA for agronomic parameters

Source Variation	DF	FD	DI	PI	PC	SV	PH	LSR	BMtha	DMtha
Varieties	4	7.39^{NS}	1.58^{***}	0.82^{***}	1762.61^{***}	8.29^{***}	989.75^{***}	313.17^{**}	50.85^{*}	2.81^{*}
Replication	3	4.97^{NS}	0.35^{NS}	0.21^{NS}	128.81^{NS}	0.15^{NS}	136.95^{NS}	143.91^{NS}	25.27^{NS}	0.52^{NS}

year	1	884.5***	24.2***	21***	610.51NS	7.81**	1230.09**	17282.2***	21.82NS	76.4***
Location	2	4774***	31.25***	30.01***	918.01NS	7.81**	8366.09***	1169.15***	1895.6***	0.79NS
trt*year*loc	14	132.16***	1.36***	1.03***	249.98NS	1.26*	600.67***	427.42***	54.09*	3***

NS = Non-significant, * = significant, ** = very significant, *** = highly significant, DF = degree freedom, 50%F = 50% flowering date, DI= disease Incidence, PI = pest incidence, PC= plot cove, SV= stand vigor, PH= plant height in cm, GBMYtha = Green biomass yield tone/ha, LR = Leaf stem ratio, DMtha = dry matter yield tone/ha and PH = plant height in cm

Dry matter and Fresh biomass Yield

Forage dry matter yield and fresh biomass yield did not showed significant (P>0.05) variation among the tested alfalfa varieties across the locations except the Kuni Segeria FTC (Table 2). The result indicated that the highest mean dry matter yield recorded from on station was (3.42 t/ha), Arba Rakate FTC (5.51 t/ha) and Kuni Segeria (3.62 t/ha). Combined analysis indicated that dry matter yield varied significantly (P<0.05) among the tested varieties. The significant varieties differences observed for dry matter yield of alfalfa in this study is in line with reports of (Gezahagn *et al.,* 2015 3; Tessem *et al.,* 2021; Denbela, 2015). From the present findings, dry matter yield ranged from 3.9 to 4.82 t/ha with a mean of 4.18 t/ha. This finding is lower than the mean yield of 6.46 t/ha reported by Gezahagn *et al.* (2015), 6.5 t/ha reported by Denbela, (2015), 7.01 t/ha reported by Tessem *et al.* (20214) and Alemu *et al.,* (2022) 20.46. The reverse, dry matter yield ranged from 1.78-3.23 t/ha Afsharmanesh, (2009) and from 0.67-2.16 t/ha were reported Awad and Bakeri, (2009) which were indicate lower than the present findings. Generally, Hair Peruvian gave the highest dry matter yield and fresh biomass yield. The wide range of dry matter yield observed in different research findings could be attributed to varietal and environmental differences, their interactions, harvesting stage, soil types, management practice and other biotic and abiotic factors.

The highest mean fresh biomass yield recorded for Kuni Segeria FTC (18.78t/ha), Arba Rakate FTC (17.67 t/ha) and Mechara Agricultural Research Center, on station (9.04 t/ha). Combined analysis indicated that fresh biomass yield varied significantly (P<0.05) among the tested varieties. From the current findings, fresh biomass yield varied from 14.02 to 17.34 t/ha with the average of 15.16 t/ha. Generally, Hair Peruvian gave the highest fresh biomass yield. The present finding is lower than the mean yield 37.95t/ha reported by Turan, (2017); 29.83 t/ha reported by Denbela, (2015); 66.18 t/ha reported by Tucak *et al*. (2020); and 78.16t/ha reported by Alemu et

al. (2022). This high forage production difference from other findings indicated that other potential varieties are must be evaluated for the study area.

Table 2: Mean Dry matter and Fresh biomass yield of Alfalfa varieties tested across locations

Varieties	Dry matter yield (t/ha)				Fresh biomass yield (t/ha)			
	On station	A/Rakate FTC	K/Segeria FTC	Combined mean	On station	A/Rakate FTC	K/Segeria FTC	Combined mean
Werer	3.38	5.25	3.57^{b}	4.07^{b}	8.98	16.7	17.8^{bc}	14.49^{ab}
Magna#788	3.36	6.32	2.81^{b}	4.16^{b}	9.15	20.6	14.2^{c}	14.65^{b}
Magna#801	3.53	4.85	3.33^{b}	3.9^{b}	9.48	15.4	17.19^{bc}	14.02^{b}
Hair Peruvian	3.54	6.03	4.9^{a}	4.82^{a}	9.13	19.1	23.8^{a}	17.34^{a}
Hunter river	3.31	5.09	3.51_{b}	3.97^{b}	8.48	16.55	20.88^{ab}	15.30^{ab}
Mean	3.42	5.51	3.62	4.18	9.04	17.67	18.78	15.16
CV	23.65	25.48	23.83	24.32	24	23.9	29.24	31.38
LSD	0.83	2.16	0.89	0.86	2.23	6.51	5.63	3.79
P level	NS	NS	***	***	NS	NS	*	***

FTC = farmer training Center, NS = Non-significant, * = significant, ** = very significant, *** = highly significant, CV= CV= Coefficient variation, LSD = Least Significant difference

Plant height and Leaf stem ratio

Mean plant height of alfalfa varieties were significantly (P<0.05) different across all testing locations (Table 3). The result showed that the tallest mean plant height recorded for on station (56.32 cm), Arba Rakate FTC (78.95 cm) and Kuni Segeria FTC (76.77 cm). Hair Peruvian variety produced the tallest plant height (66.48 cm) at on station while Werer produced the tallest plant height at Arba Rakate FTC (82.65 cm) and Kuni Segeria FTC (85.65cm). On the other hand, Magna#801 produced the shortest plant height at on station (47.7 cm) and Arba Rakate FTC (68.6 cm) while Hunter river produced the shortest at Kuni Segeria (73.61 cm). Combined analysis for plant height also differed significantly (P<0.05) which ranged from 68.6 to 82.65 cm with a mean of 78.95 cm. The mean plant height of the present result is lower than the report of Teshale and Ketema (2021) 89.7 cm, Turan, (2017) 80.4 cm but higher than the mean report of Tucak *et al.* (2020) 63.94 cm, and Alemu *et al.* (2022) 52.61 cm This variation could be due to the differences in moisture content and soil fertility condition of the testing locations. Generally, variety Magna#788 gave the highest mean plant height followed by Werer while Hunter river gave the lowest plant height..

The mean leaf stem ratio were no showed significantly (P>0.05) variation at two locations (on station and Arba Rakate FTC) but significance (P<0.05) variation were recorded from Kuni

Segeria FTC. But the combined mean of leaf stem ratio of alfalfa varieties were showed significantly (P<0.05) different (Table 3). The highest combined leaf to stem ratio was recorded from Magna#801 (60.73) followed by Magna#788 (54.06) and the lowest was recorded from Hunter river (49.53).

Table 3: Mean plant height (cm) and Leaf stem ratio of Alfalfa varieties tested across locations

Varieties	Plant height (cm)				Leaf stem ratio			
	On station	A/Rakate FTC	K/Segeria FTC	Combined mean	On station	A/Rakate FTC	K/Segeria FTC	Combined mean
Werer	59.5^{ab}	82.65^{a}	85.65^{a}	82.65^{a}	55.63	48.75	45.63^{bc}	50.63^{b}
Magna#788	50.28^{cd}	81.55^{a}	75.1^{ab}	81.55^{a}	56.25	46.25	51.88^{b}	54.06^{b}
Magna#801	47.7^{d}	68.6^{b}	64.4^{a}	68.6^{b}	62.5	48.75	58.96^{a}	60.73^{a}
Hair Peruvian	66.48^{a}	81.05^{a}	85.08^{a}	81.05^{a}	55.63	47.5	48.75^{bc}	52.19^{b}
Hunter river	57.63^{bc}	80.9^{a}	73.61^{b}	80.9^{a}	56.25	46.25	42.81^{c}	49.53^{b}
Mean	56.32	78.95	76.77	78.95	57.25	47.5	49.6	53.43
CV	13.13	9.49	14.28	9.49	16.98	11.29	13.12	16.09
LSD	7.59	11.54	11.25	11.54	9.97	8.26	6.68	6.09
P level	***	*	**	*	NS	NS	***	***

FTC = farmer training Center, NS = Non-significant, * = significant, ** = very significant, *** = highly significant, CV= CV= Coefficient variation, LSD = Least Significant difference

Diseases and Pest Infestation

Mean diseases occurrence and pest infestation of alfalfa varieties were showed significantly (P<0.05) different at all experimental sites except at Arba Rakate FTC but the combined mean disease occurrence for both diseases occurrence and pest infestation showed significantly (P<0.05) variation for all research sites (Table 4). The diseases recorded were Lepto leaf spot and Stemphylium leaf spot. The mean diseases occurrence varied from 1.18 to 1.88. The most susceptible varieties were Magna#788 (1.88) and Magna#801(1.81) while the tolerance varieties were werer (1.18) and Hair Peruvian (1.25). Teshale and Ketema, (2021) reported that Magna-801-FG and Peruvien DZF- 406 were resistant to diseases that showed Peruvien are most tolerant that similar with the present findings. The findings of Teshale and Ketema, (2021) also indicated that disease occurrence of alfalfa varieties ranged from 0.7 to 2.17.

Lepto leaf spot

Stemphylium leaf spot

Pest infestation is the most factors that reduce both forage quality and quantity. The mean pest infestation varied from 1.06 to 1.56. The most varieties attacked by pest were Magna#801 and Magna#788 (1.56) followed by Hunter river (1.44) while the lowest pest infestation were recorded from Hair Peruvian (1.06) variety. Almost all alfalfa varieties were less affected by pests as alfalfa has tremendous genetic resistance to many pests (Putnam *et al.*, 2001).

Table 4: Mean disease occurrence and Pest Infestation of Alfalfa varieties tested across three locations/environments

Varieties	**Diseases Occurrences**				**Pest Infestation**			
	On station	A/Rakate FTC	K/Segeria FTC	Combined mean	On station	A/Rakate FTC	K/Segeria FTC	Combined mean
Werer	1.88^{c}	1.25	0.5^{b}	1.18^{c}	1.88^{c}	1	0.5^{c}	1.19^{bc}
Magna#788	2.75^{a}	1.25	1^{ab}	1.88^{a}	2.63^{a}	1	0.5^{c}	1.56^{a}
Magna#801	2.5^{ab}	1.5	1.13^{a}	1.81^{ab}	2.13^{b}	1	1^{ab}	1.56^{a}
Hair Peruvian	1.63^{c}	1.5	0.88^{ab}	1.25^{c}	1.5^{c}	1	0.63^{bc}	1.06^{c}
Hunter river	$2b^{c}$	1.5	1^{ab}	1.5^{bc}	1.75^{c}	1	1.15^{a}	1.44^{ab}
Mean	2.15	1.4	0.9	1.53	1.98	1	0.75	1.36
CV	24.18	23.51	56	34.14	21.29	0	55	33.14
LSD	0.53	0.51	0.52	0.37	0.43	0	0.42	0.33
P level	***	NS	*	***	***	NS	*	***

FTC = farmer training Center, NS = Non-significant, * = significant, ** = very significant, *** = highly significant, CV= Coefficient variation, LSD = Least Significant difference

Seed Yield at Different Harvesting year

There were a significance ($p<0.05$) variation in terms of seed yield for two year harvesting. The mean maximum seed yield (737.9 Kg/ha) was recorded from Werer alfalfa variety followed by (702.6 Kg/ha) Hair Peruvian variety whereas the mean lowest seed yield (65.8 Kg/ha) was recorded form Magna#801 variety (Table 5). This result is higher than the reports of Saprykin *et la*. (2021) at first and second (83 -122 Kg/ha) and (180 -250 Kg/ha) harvesting year respectively. Alfalfa seed yield setting is the major problems in the country as a general.

Table 5: Mean seed yield (Kg/ha) of Alfalfa varieties tested across three environments

Varieties	Harvesting Time		
	First year harvesting (kg/ha)	Second year harvesting (kg/ha)	Combined mean yield (kg/ha)
Werer	98.31^{a}	1377.5^{a}	737.9^{a}
Magna#788	50.75^{ab}	188.1^{c}	119.4^{c}
Magna#801	32.75^{b}	98.8^{c}	65.8^{c}
Hair Peruvian	77.63^{ab}	1327.5^{ab}	702.6^{ab}
Hunter river	80.50^{ab}	597.5^{bc}	339.0^{bc}
Mean	67.98750	717.88	392.93
CV	60.96416	66.12	61.49
LSD	63.857	731.27	372.28
P level	*	**	**

Seed production is increasing from first year harvesting to second year harvesting (fig. 1).

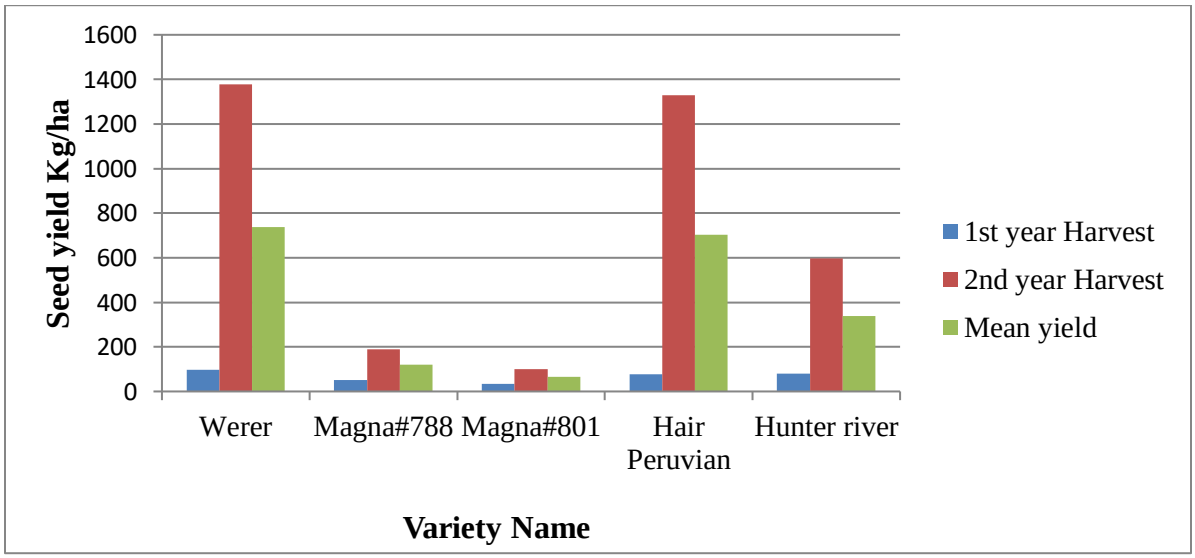

Figure 1: - Seed yield (Kg/ha) of Alfalfa Varieties for two harvesting year

Conclusions and Recommendations

Livestock production is challenged by animal feed both in terms of quality and quantity in West Hararghe. To solve these challenges, it is important to introduce different improved forage to the study area. Five alfalfa varieties were introduced to evaluate the arability. The highest mean dry matter was recorded from Hair Peruvian (4.82 t/ha) followed by Magna#788 (4.16 t/ha) and the lowest dry matter was recorded from Magna#801 (3.9 t/ha). The fresh biomass yield varied from 14.02 to 17.34 t/ha with the average of 15.16 t/ha that the highest mean fresh biomass recorded from Hair Peruvian (17.34t/ha). The mean plant height ranged from 68.6 to 82.65 cm with a mean of 78.95 cm and the highest stem ratio recorded from Magna#801 (60.73) followed by Magna#788 (54.06) and the lowest was recorded from Hunter river (49.53). The mean plant height ranged from 68.6 to 82.65 cm with a mean of 78.95 cm and the highest stem ratio recorded from Magna#801 (60.73) followed by Magna#788 (54.06) and the lowest was recorded from Hunter river (49.53).The mean diseases occurrence varied from 1.18 to 1.88 that the most susceptible varieties were Magna#788 (1.88) and Magna#801(1.81) while the tolerance varieties were werer (1.18) and Hair Peruvian (1.25). From this study, it is concluded that Hair Peruvian followed by Hunter River were found more promising in terms of agronomic traits, DM yield, and fresh biomass yield than others during the main rainy season and popularized as an alternative feed resource under smallholder conditions in the study areas and other places of similar climatic and edaphic

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