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Screening of various Alfalfa (*Medicago sativa* L.) genotypes in relation to environmental temperature

Ali, N.[1], Gondal, M. R.[1,2*], Rizvi, S. A.[3], Naseem, W.[3], Ijaz, S.[1], Ashraf, M. S.[1], Khan, M. N.[1] and Zafar, M.[1]

[1]Agronomic Research Institute, Ayub Agricultural Research Institute, Faisalabad, Pakistan; [2]Fodder Research Institute, Sargodha, Ayub Agricultural Research Institute, Faisalabad, Pakistan; [3]Soil and Water Conservation Research Institute, Chakwal, Pakistan.

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Abstract The five promising genotypes of alfalfa (*Medicago sativa L.*) were investigated in Sargodha Pakistan to examine their adoptive variability to improve the forage production and quality. The results of the study revealed notable variations in yield and quality attributes of these genotypes. It was observed that the genotype SGD-Lucern 2002 produced highest green fodder yield (101.28 t ha^{-1}), dry matter (20.02 t ha^{-1}), crude protein (3.89 t ha^{-1}), average plant height (81.5 cm), digestible dry matter (73.29%), dry matter intake (4.28%), relative feed values (243.96) and number of tillers (490 m^{-2}) in winter when the temperature remained between 2℃ and 17℃. Whereas, in December-January, Alpharite showed better plant height (73.33 cm), having maximum values of neutral detergent fiber (34.7%) and acid detergent fiber (33.1). The maximum crude protein contents (21.95%) were found in Surdii 10 genotype. Based on the results of this study, the cultivation of genotype SGD-Lucern 2002 in similar ecological conditions is highly recommended.

Keywords: Alfalfa, Climatic variability, Crude protein, Genotypes, Yield

Introduction

Alike Pakistan, several countries of the world possess an agricultural economy, which is threated due to the ever-increasing population, degradation of land and water resources, urbanization and industrialization. Livestock has become an integral part of the agriculture industry, which demands for enhancement of fodder production. Alfalfa (*Medicago sativa* L.) is one of the highest viable fodder crops on the earth, which has exceedingly inclusive adaptability to dissimilar climates (Moreira and Fageria, 2010). It is a versatile, highly palatable and nutritious crop used as green fodder, silage and pasture having natural source of nitrogen. Because of its better fodder qualities and excessive production, Alfalfa is called the "Queen of fodder crops" in several regions of the world (Yüksel *et al*.,

* **Corresponding Author:** Gondal, M. R.; **Email:** riazgondal1962@gmail.com

2016; Kavut and Avcioglu, 2015). Feed plays an important role in livestock nutrition, which supplies fibers, protein, energy and minerals (Kamalak and Canbolat, 2010; Kiraz, 2011). Alfalfa possesses excessive contents of protein, nutrients, minerals and numerous vitamins (Geren *et al*., 2009). Its dry matter contains considerable excessive digestibility co-adjacent with organic materials, crude fiber, protein and fats contrasted to other grass species (Sommer *et al*., 2005). Alfalfa is an imported species in Pakistan and its production is much below the world. Although various genotypes of alfalfa are being cultivated on an area of 0.13 million hectares, still there is a great potential in enhancing its production and quality. Less area under alfalfa cultivation, deficient cultivation of high yielding varieties, maximum assertion to geographical adaptability are the big issues in the country. Scientific investigation is required for the evaluation and selection of excessive yield and quality genotypes with maximum adaptability. Selection and evaluation of good quality suitable genotypes can help the farmers and producers in getting higher production with a better quality of production (Cacan *et al*., 2018). Neutral detergent fiber (NDF), acid detergent fiber (ADF), crude fat (CF) and crude protein (CP) classify the quality of Alfalfa fodder. ADF and NDF represent the compounds' cell walls, or structural carbohydrate components i.e., measure of feed. Neutral detergent fiber is the insoluble carbohydrate fraction that remains after a sample of feed has been refluxed in a neutral detergent solution. Low NDF and ADF ratios in digestible dry matter (DDM) provide relative feed value (RFV) and dry matter intake (DMI). Values of these attributes have direct effect on the roughage standard (Kaplan *et al*., 2016). Alfalfa genotypes possess varied nutrient compositions, thus the nutritional value of each genotype was found out (Ülger and Kaplan, 2016). Crude ash, NDF, ADF and CP content must be investigated to evaluate the quality of the feed stuff (Uke *et al*., 2017). Climate change and ambient temperature are amongst the main climatic factors that affect crop production (Anjum *et al*., 2011). To discover these attributes, some studies have continued in the dissimilar region of various countries of the world (Avci *et al*., 2010; Saruhan and Kuşvuran 2011; Yüksel *et al.*, 2016). This research was carried out to evaluate five alfalfa genotypes being cultivated in Punjab, Pakistan. Specifically, their production and quality attributes, correlation of these attributes and recognize the best suitable genotype.

Materials and methods

Site description

Field investigation was performed at the research farm of Fodder Research Institute Sargodha during winter seasons of 2016-17, 2017-18 and 2018-19. The soil of experimental field was loam, having pH 7.85 $\pm$ 0.11, Nitrogen (N) 0.06 % ± 0.01, Organic matter 0.61 %, available phosphorus 5.6 ± 0.42 mg kg^{-1} and available potassium 174 ± 6.34 mg kg^{-1} (Niazi *et al*., 2020). The soil properties were determined by adopting the standard procedure.

Experiment treatments and layout

Alfalfa samples were acquired from two sources i.e., the Fodder Research Institute Sargodha and a local private seed company. Five alfalfa genotypes namely: Sargodha Lucerne 2002 (SGD-Lucern 2002), Alpharite, Salt King, Surdii 10 and composite were selected for investigation. SGD-Lucern 2002 and composite are domestic whereas Alpharite, Salt King, and Surdii 10 are foreign genotypes. All genotypes are tall with vertical growth attributes but resistant to lodging. The experiment was planned in randomized complete block design (RCBD) with four replicates. The size of each plot was kept as 2.7 m × 6 m having 6 lines at 45 cm apart. A uniform seed bed was prepared for sowing at appropriate moisture condition. All selected genotypes were sown by using15 kg seed per hectare with the help of a hand drill during third week of October 2016 and after that ratoon crop was maintained for two years. At the time of seed bed preparation phosphorus (P_2O_5) fertilizer @57 kg ha^{-1} (DAP) was applied and nitrogen (N) @57 kg ha^{-1} (Urea) was applied after 30 days of sowing with 2^{nd} irrigation. The field remained fallow during previous season.

Climate data

Climate data of various parameters including minimum and maximum temperature, relative humidity and rainfall were recorded from Meteorological Observatory installed at Agriculture College, Sargodha University, Punjab, Pakistan for the period 2017 to 2019 (Table 1).

The data showed that average monthly temperature and relative humidity for the years 2017, 2018, and 2019 were almost at par as (24.83, 24.4, 23.6 ℃) and (59, 61.91, 61.75 %) respectively and rain fall slightly varied as (445 mm in 2017, 417 mm in 2018 & 422 mm in 2019). During the months of insufficient rainfall, canal irrigation was applied according to the requirement of crop.

Crop harvesting and data recording

After 74 days of sowing, the crop was harvested at 10% flowering, followed by subsequent cuts when the crop attained 10 % flowering as proposed by Manga *et al*. (2003). Ten (10) random plants were selected from each treatment at harvesting and data on plant height was recorded. Three samples of one meter square ($1m^2$) from each treatment were randomly selected for counting tillers per meter square. Plant height was also recorded at both minimum (during December and January) and maximum (during May and June) temperatures to check the effect of climate on the growth of genotypes. Green fodder yield was determined after harvesting all treatments for the entire plot by weighing in the field. Dry matter was determined by weighing fresh and dried samples. The fresh samples were dried at 70 ℃ for 48 hours. The dry matter ratio was also calculated from these samples. The experiment was continued for three years and ten cuts were obtained during each year.

Table 1. Mean monthly values of climatic parameters recorded at Sargodha

Month/ parameters	**Climatic parameters for Years 2017**					**Climatic parameters for Years 2018**					**Climatic parameters for Years 2019**				
	Min Temp °C	Max Temp °C	Av Temp °C	RH %	Rain mm	Min Temp °C	Max Temp °C	Av Temp °C	R. H%	Rain Mm	Min Temp °C	Max Temp °C	Av Temp °C	R. H%	Rain mm
January	2	23	13	72	28.1	4	24	13	68	1	2	22	12	70	24.6
February	5	29	17	60	20.1	7	29	17	57	18.5	5	23	14	71	21.4
March	8	37	21	54	11.5	12	38	23	52	19.3	9	33	19	61	40.3
April	15	45	29	40	44.3	16	41	29	46	32.8	16	41	28	48	80.8
May	21	45	33	37	52.1	21	44	33	40	56.4	20	46	31	39	32.5
June	21	46	32	54	50.7	23	44	33	57	65.8	22	46	34	41	7.5
July	23	40	31	68	113.9	23	39	30	77	121.4	22	43	30	68	77.3
August	22	40	31	69	64.1	22	38	30	76	25.7	23	38	30	71	59.1
September	20	38	30	63	25.3	18	36	28	74	28.6	21	39	30	68	38.7
October	16	39	28	56	1.2	14	34	24	66	19.5	17	34	25	62	14
November	8	28	18	72	16.4	10	29	19	61	0	11	30	20	64	19
December	8	26	15	63	17.5	3	26	14	69	28.4	0	24	11	78	7.6
Average	14.08	36.33	24.83	59	37.1	14.33	36.0	24.4	61.91	34.75	14	34.91	23.6	61.75	35.17

Crude protein was calculated with the help of the recommended method (AOAC, 1990). CP contents were obtained by multiplying the standard factor 6.25 with Nitrogen (%) achieved by Kjeldahl procedure. As suggested by Sharpe (2018), NDF was prepared from one gram sample taken in a conical flask, mixed with 100 ml NDF reagent solution and 0.50 g of sodium sulphite. The flask was then fixed in the cooling condenser and heated slowly for 60 minutes followed by washing of residues four times with hot distilled water and once with acetone, then dried. Residues were then shifted to an already weighed crucible and kept at 105 ℃ in the oven for four hours followed by keeping the dried residues in a desiccator for ten minutes. NDF ratios were calculated using the following expression:

NDF (%) = weight of residues / sample weight x 100

These residues were then shifted in 500 ml flask and placed on the condenser after applying 100 ml acid detergent solution. This substance was heated for approximately 2-3 minutes and refluxed by decreasing temperature for one hour and filtered the contents using suction pump. The residues were then transferred in crucible already weighed and put at 105 ℃ in oven for one day. After drying, the crucible was kept in a desiccator for cooling and thus ADF was obtained. Similarly, ADF ratio was determined by the formula:

$$\text{ADF ratio} = \text{weight of ADF residue} / \text{weight of sample} \times 100$$

Afterwards DDM, DMI and RFV were calculated by using NDF &ADF according to Morrison, (2003) as given below:

$$DDM = 88.9 - (0.779 \times \%\ ADF$$

$$DMI = 120 / \%\ NDF$$

$$RFV = (DDM \times DMI) / 1.29$$

Statistical analysis

Various data recorded from field experiment were analyzed statistically according to the procedure of Steel *et al.* (1997). Means were compared with LSD test at 5 percent probability level (Gomez and Gomez, 1984). Relationship among investigated traits was find out by calculating the correlation coefficient.

Results

The results showed significant differences among yields of alfalfa genotypes for both green forage and dry matter (Table 2).

Table 2. Fresh fodder and yield of dry matter of various genotypes of alfalfa

Genotypes	Fresh forage yield (tons /ha)				Yield of dry matter (tons /ha)			
	2017	**2018**	**2019**	**Means**	**2017**	**2018**	**2019**	**Means**
SGD-Lucern 2002	84.60a	104.8 a	114.60 a	101.33 a	16.72a	20.71 a	22.64 a	20. 02a
Alpharite	73.60b	93.52 b	98.52 b	88.52 b	13.58 b	17.27 b	18.22 bc	16.36b
Salt King	69.44 c	89.44 c	94.44 c	84.44 c	13.66 b	17.59 b	18.57 b	16.61 b
Surdii 10	55. 0e	75.48 e	80.25 e	70.23 e	11.76 c	16.13 c	17.15 d	15.01 c
Composite	60.82 d	80.25 d	85.50 d	75.52 d	12 29 c	16.21 c	17.27 cd	15.25 c
LSD	2.108	2.196.		2.2004	0.8248	0.9403		0. 9272
	2.294.				1.0206			

Maximum green forage tonnage (101.33 t ha^{-1}) and dry matter yield (20.02 t ha^{-1}) were obtained in genotype SGD-Lucern 2002 while the minimum yield of green fodder (70.23 t ha^{-1}) and dry matter (15.01 t ha^{-1}) was observed in genotype Surdii 10. Ratoon crop, produced highest significant green fodder (94.66 t ha^{-1}) and yield of dry matter (18.77 t ha^{-1}) during the third year of the study (i.e., 2019) while the lowest values of green fodder (68.67 t ha^{-1}) and dry (13.59 t ha^{-1} respectively) was observed in the first year (i.e., 2107). The maximum plant height (81.58 cm) was recorded in genotype SGD-Lucern 2002 and the lowest (68.58 cm) value was recorded in genotype Surdii 10 (Table 3).

Table 3. Comparison of plant height, Average of 10 cuts versus height of 18 January to 18 February (31 days)

Year/genotypes	Av. Plant height of 10 cuts (cm)				Plant height during 18 January to 18 February (cm)			
	2017	**2018**	**2019**	**Means**	**2017**	**2018**	**2019**	**Means**
SGD-Lucern 2002	76.75 a	82.25 a	85.50 a	81.58 a	46.25 c	52.00 d	54.75 d	51.00 d
Alpharite	67.50b	74.75 ab	76.75 b	73.00 b	70.75 a	73.00 a	76.25 a	73.33 a
Salt King	65.75b	71.50 b	74.25 b	70.50 bc	65.25 a	68.75 ab	70.75 ab	68.25 ab
Surdii 10	64.75 b	68.25 b	72.75 b	68.66 c	56.75 b	61.50 c	63.25 c	60.08 c
Composite	65.25b	69.50 b	73.25 b	69.33 c	65.50 a	66.25 bc	68.75 bc	66.83 b
LSD	7.048 4.677	7.538		3.608	7.476	6.038	7.421	5.21

In January and February when average temperature remained up to 17 °C, Alpharite showed maximum height (73.33 cm) but not significantly different from Salt King (68.25) and the lowest height (51.0 cm) was observed in SGD-Lucern 2002 (Table 3). Considering the ratoon crop, maximum plant height (76.50 cm) was observed in third year of experiment. Considering the temperature regime, genotype SGD-Lucern 2002 performed better with respect to plant height as compared to other genotypes when the average temperature remained around 34°C during May and June. SGD-Lucern 2002 showed maximum height (81.58 cm) and the lowest height (68.66 cm) was observed in Surdii 10 (Table 4).

Table 4. Plant height of alfalfa genotypes at a higher temperature during end May and end June (31 days)

Genotypes	Plant height during 31 May and 30 June(one cut)			
Year	**2017**	**2018**	**2019**	**Means**
SGD-Lucern 2002	76. 75 a	82.25 a	85.50 a	81.50 a
Alpharite	67.50 b	74.75 ab	76.75 b	73.00 b
Salt King	65.75 b	71.50 b	74.25 b	70.50bc
Surdii 10	64.75 b	68.25 b	72.75 b	68.58 c
Composite	65.25 b	69.50 b	73.25 b	69.33 c
LSD	7.048. 4.677	7.538		3.61

Crude protein contents (%) and yield (t ha^{-1})

The results showed significant differences in crude protein contents (%) and yields of five alfalfa genotypes (Table 5). Maximum crude protein contents were recorded in genotype Surdii 10 (21.97 %) while the lowest was observed in salt King (18.88 %). Crude protein yield was maximum (3.89 t ha^{-1}) in SGD-Lucern 2002 while the lowest was obtained by Salt King (3.13 t ha^{-1}).

Table 5. Crude protein ratio (%) and crude protein yield (t ha^{-1}) in alfalfa genotypes

Genotypes	Crude protein contents (%)				Crude protein yield (t ha^{-1})			
	2017	**2018**	**2019**	**Means**	**2017**	**2018**	**2019**	**Means**
SGD-Lucern 2002	19.49 c	19.44 c	19.45 c	19.46 c	3.335 a	4.025 a	4.403 a	3.891 a
Alpharite	20.87 b	20.87 b	20.90 b	20.87 b	2.835 b	3.605 b	3.810 b	3.417 b
Salt King	18.88 c	18.89 c	18.88 c	18.88 c	2.575 c	3.318 c	3.503 c	3.132 d
Surdii 10	21.95 a	21.95 a	21.96 a	21.97 a	2.580 c	3.540 bc	3.765 bc	3.357 bc
Composite	20.83 b	20.82 b	20.83 b	20.83 b	2.560 c	3.375 bc	3.598 bc	3.178 cd
LSD	0.9569 0.8518	0.8480.		0.8694	0.2318	0.2545.	0.2733	0.2671

ADF (%) and NDF (%) ratios

Significant differences were observed in acid detergent fiber (ADF) and neutral detergent fiber (NDF) ratios with respect to genotypes as well as the years (Table 6). Maximum ADF and NDF ratios were recorded in genotype Alpharite (23.73 % and 34.70 % respectively) while minimum ratios (19.98 and 28.17 % respectively) were observed in genotype SGD-Lucern 2002. Considering the ratios of years, the highest ratio of ADF and NDF (26.2% and 337.2% from Alpharite and Surdii10 respectively) were recorded in the third year (2019) and the lowest values (17.14% and 25.1% respectively) were observed from SGD lucern 2002 in first year 2017.

Table 6. ADF and NDF ratios of alfalfa genotypes

Genotypes / years	ADF ratios (%)				NDF ratios (%)			
	2017	**2018**	**2019**	**Means**	**2017**	**2018**	**2019**	**Means**
SGD-Lucern 2002	17.14 c	20.30 c	22.50 c	19.98 c	25.10 d	25.90 c	33.50 b	28.17 d
Alpharite	21.00 a	24.00 a	26.20 a	23.73 a	33.10 a	34.00 a	37.00 a	34.70 a
Salt King	19.03 b	22.03 b	24.23 bc	21.76 b	27.70 c	30.07 b	36.70 a	31.49 b
Surdii 10	19.20 b	22.20 b	24.40 ab	21.93 b	30.30 b	29.50 b	37.20 a	32.33 b
Composite	19.50 ab	22.50 b	24.70 ab	22.23 b	26.90 cd	29.80 b	34.80b	30.50 c
LSD	1.5689 1.8847	1.3978		1.4714	2.0898 1.4578	2.4007		0.9483

DDM (digestible dry matter) and DMI (dry matter intake) %

The differences among the ratios (%) of DDM and DMI were found significant for both the Genotypes and years (Table 7). The highest values of DDM and DMI (73.29 % and 4.28 % respectively) were recorded in genotype SGD-Lucern 2002 while the lowest values (70.29 % and 3.47 % respectively) were noted in genotype Alpharite. Considering the ratios of years, the highest ratios (73.87 % and 4.21 % respectively) were observed in the first year (i.e., 2017) and the lowest values (69.84 % and 3.36 % respectively) were recorded in the year 2019.

Table 7. DDM and DMI values of alfalfa genotypes

Genotypes/Years	DDM (%)				DMI (%)			
	2017	**2018**	**2019**	**Means**	**2017**	**2018**	**2019**	**Means**
SGD-Lucern 2002	75.42 a	73.08 a	71.38 a	73.29 a	4.620 a	4.640 a	3.592 a	4.284 a
Alpharite	72.43 c	70.20 c	68.24 c	70.29 c	3.638 d	3.533 c	3.248 b	3.473 e
Salt King	74.14 b	71.74 b	70.03 ab	71.97 b	4.348 b	4.013 b	3.275 b	3.878 c
Surdii 10	73.94 b	71.61 b	69.89 ab	71.81 b	3.968 c	4.070 b	3.230 b	3.756 d
Composite	73.46 b	71.37 b	69.65 bc	71.50 b	4.475 ab	4.037 b	3.455 a	3.989 b
LSD	1.003. 1.60	1.088		1.101	0.2024 0.1467	0.3456.		0.095

Relative feed values (RFV) and tillers m^{-2}

RFV and tillers m^{-2} of different genotypes showed significant differences for both genotypes and years (Table 8). Maximum RFV and the number of tillers m^{-2} (244 and 490.) were recorded in SGD-Lucern 2002 while minimum RFV and tillers m^{-2} (209.36 and 345 respectively) were found in genotype Surdii 10. With respect to years, maximum RFV and minimum tillers m^{-2} were calculated in the year 2017 while minimum RFV and maximum tillers m^{-2} were obtained in the third year 2019 in respect of all genotypes.

Table 8. RFV and tillers m^{-2} of different genotypes

Genotypes / years	RFV values				Tillers m^{-2}			
	2017	**2018**	**2019**	**Means**	**2017**	**2018**	**2019**	**Means**
SGD-Lucern 2002	270.14 a	262.87 a	198.88 a	243.96 a	482.5 a	492.5 a	496.3 a	490.4 a
Alpharite	204.25 d	192.26 c	171.71 c	189.41 d	382.5 b	392.5 b	400.0 b	403.33 b
Salt King	249.57 b	223.24 b	177.67 bc	216.82 b	366.3 b	375.0 b	377.3 bc	372.8 bc
Surdii 10	227.38 c	225.81 b	174.88 c	209.36 c	337.5 b	346.3 b	351.3 c	345.00 c
Composite	253.37 b	223 23 b	186.54 b	221.05 b	362.5 b	367.5 b	371.8 bc	367.3 bc
LSD	12.66. 10.200	18.204		6.5430	51.61 43.102	51.04		37.05

Correlation among traits

The correlation coefficient of the tested traits in five alfalfa genotypes showed significant differences from each other except a few, those remained insignificant (Table 9). Results on the correlation among different forage yield attributes of alfalfa genotypes obtained under the current investigation are presented in Table 9. These results indicate that different genotypes had a dominant effect on fodder yield, plant growth and yield parameters as well quality of alfalfa. Number of tillers plant^{-1} showed a significant positive correlation with plant height, green fodder yield, dry matter yield, and crude protein yield as well as quality traits. The present investigation correlation between PH and NDF was non-significantly positive. A non-significant negative correlation of PH was observed with DDM, DMI, and RFV.

Table 9. Correlation among various traits

Traits	Av. PH	FY	DM	CPR	CPY	ADF	NDF	DDM	DMI	RFV
Tillers	0.724**	0.621**	0.635**	-0.410**	0.538**	-0.114	-0.155	0.110	0.197	0.198
Av. PH		0.813**	0.790*f	-0.353**	0.729ff	0.260*	0.181	-0.258*	-0.140	-0.160
FY			0.961*f-	-0.331**	0.893*f	0.335*f	0.314*f	-0.351**	-0.280*	-0.300**
DM				-0.412**	0.952*f	0.315*f	0.297*f	-0.310*f	-0.266*	-0.282*
CPR					-0.054	0.210	0.176	-0.214	-0.216	-0.231
CPY						0.410**	0.377*f	-0.407**	-0.357**	-0.374**
ADF							0.686**	-0.796**	-0.698**	-0.787**
NDF								-0.679**	-0985**	-0.974**
DDM									0.689**	0.779**
DMI										0.992**

*significant at $P<0.05$; **significant at $P<0.01$;

Where PH denotes plant height; Av denotes Average; DM denotes dry matter; FY denotes fodder yield; CPY denotes crude protein yield; CPR denotes crude protein ratio; ADF denotes acid detergent fiber; NDF denotes neutral detergent fiber; DDM denotes digestible dry matter; DMI denotes dry matter intake; RFV denotes relative feed value

Discussion

Results of the study showed a significant effect of weather parameters on various attributes of genotypes especially the temperature. Similar findings were reported i.e., the climatic condition may show considerable differences in yield parameters of various genotypes of alfalfa (Luo *et al*., 2016). Rain fall, temperature, soil structure, genetics of plants, cultural practices and sowing time significantly affect the yields of green fodder and dry matter (Seydoşoğlu, 2014).

In various studies, yields of green fodder in alfalfa genotypes were recorded as 9.31 to 118.4 t ha^{-1} (Kir and Soya, 2006; Demiroğlu *et al*., 2008) and that of dry matter were observed as 20.25 to 32.87 t ha^{-1} (Sengul *et al*., 2003; Kir and Soya, 2006; Demiroğlu *et al*., 2008; Avci *et al*., 2010; Saruhan and Kuşvuran, 2011).Various scientists reported different values of yield in alfalfa for green fodder and dry matter due to differences of ecological conditions, number of cuts and genetic makeup (Cacan *et al*., 2018).

In another investigation, plant heights were recorded in the range of 49.7 to 86.8 cm (Kusvuran *et al*., 2005; Kir and Soya, 2006; Demiroğlu *et al*., 2008; Basbag, 2009; Yesil and Sengul, 2009; Saruhan and Kusvuran, 2011). Keneni, (2012) reported that tonnage and quality attributes of lucern genotypes varied due to the climatic condition. Harmanlioglu and Kaplan (2020) reported same findings that is yield and quality attributes varied with climate change. Various scientists i.e., (Musa *et al*., 1993) reported that significantly higher yields were obtained due to more number of tillers and greater plant height and similarly they also reported that stem diameter and number of tillers per plant were associated with fresh forage and dry matter yield.

CPR were recorded in the range of 15.95 to 28.09 % (Sengul *et al*., 2003; Kir and Soya, 2006; Başbağ, 2009; Avci *et al.*, 2010; Kiraz, 2011; Saruhan and Kuşvuran, 2011; Çaçan *et al*., 2015). In a research study, the variation in CPY was reported because of the variations in hay production of alfalfa genotypes with respect to crude protein ratio while quality of all genotypes was observed as good (Rohweder *et al*., 1978).

Acid detergent fiber and neutral detergent fiber ratios are considered quality indicators of fodder crops (Aydın *et al*., 2010) and they recommended these values minimum because these values have adverse effect on digestibility and intake of feed. The feed having ideal ratios of ADF and NDF would be preferred (Kiraz, 2011). ADF and NDF %age of some alfalfa genotypes were recorded between 16.8 to 41.0% and 20.3 to 49.0% respectively (Basbag *et al.*, 2009; Canbolat and Karaman, 2009; Avci *et al*., 2010; Kiraz, 2011; Ça ҫan *et al*., 2015) while DDM and DMI values in the range of 56.9 to 75.8%, and 2.46 to 5.9% respectively (Başbağ, 2009; Canbolat and Karaman, 2009; Avci *et al*., 2010; Kiraz, 2011; Ça ҫan *et al*., 2015) and RFV between 127.0 to 347.0 (Başbağ, 2009; Kiraz, 2011; Ça ҫan *et al*., 2015). Low NDF and ADF ratios in all genotypes were kept in better quality group (Rohweder *et al*., 1978). The results of this study showed that the values of NDF and ADF ratios were enhanced in the second year (2018) and third years (2019), however the values of DMI, RFV and DDM rates tended to decrease as years progress. With time as the plant age increases, the ratio of ADF and NDF compound, the formation of cell wall also enhances (Uke *et al*., 2017). The quality standard report of (Lacefield, 1988) referred to the values of CP equal to 19 %, NDF below 40%, ADF below 31%, DMI above 3%, RFV above 151%, and DDM above 65% in all genotypes falling under "prime" group. Mattera *et al*. (2013) found that increased plant density had positive effect on alfalfa production due to higher number of stem per unit area.

Fodder yield had a significant and positive correlation with yield and quality attributes, as observed by Yadav *et al*. (2003); Shinde *et al*. (2012); Tariq *et al*. (2012); Amare *et al*. (2015); Ça ğan *et al*. (2015). Iyanar *et al*. (2010) and Bibi *et al*. (2016) reported a significant positive correlation between plant height and GFY. Dry matter yield showed a significant positive correlation with PH, GFY, CPY, ADF, NDF (Cacan *et al*., 2018). Results revealed that an increase in fresh fodder yield would increase DMY as well as other contributing traits (Sukhchain and Singh, 2008; Warkad *et al*., 2010; Nabin and Pahuja, 2013). Mushtaq *et al*., 2013 also observed that green fodder had a significant positive correlation with the number of tillers, plant height and dry matter yield while the dry matter showed a significantly positive correlation with plant height and green fodder yield. Kumar *et al.,* 2016 reported that CPY, GFY, DMY had highly significant positive correlation with PH, tillers, RFV, and CPR.

It was concluded that the highest plant height, fresh forage, dry matter, crude protein yield and the lowest ratio of acid detergent fiber, (ADF) & neutral detergent fiber (NDF) was observed in SGD-Lucern 2002 with somewhat higher values of DDM and DMI. Therefore, keeping in view the above attributes, the authors recommend the cultivation of alfalfa genotype SGD-Lucerne 2002 for fodder in the areas having temperatures above 15℃ around the major part of the year.

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