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Evaluating environmental adaptive variability of various Alfalfa (*Medicago sativa* L.) fodder cultivars

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Abstract Five cultivars of alfalfa (*Medicago sativa* L.) were studied in Sargodha Pakistan to examine their adoptive variability to improve the forage quality and production. Results of the study revealed notable variations in yield and quality of these cultivars. It was observed that the cultivar SGD-Lucerne 2002 produced highest green fodder yield (101.33 t ha^{-1}), dry matter yield (20.0 t ha^{-1}), crude protein yield (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}) when the temperature remained between 2 ℃ and 17 ℃. Whereas, in December-January, Alpharite showed better plant height (73.33 cm) as compared to SGD-Lucerne 2002 (51.00 cm), having maximum values of acid detergent fiber (33.1%) and neutral detergent fiber (34.7%) while the highest crude protein contents (21.95 %) was found in Surdii 10 cultivar. Based on the results of this study, the authors recommend the cultivation of cultivar SGD-Lucerne 2002 in similar ecologies and environment.

Keywords: Alfalfa (*Medicago sativa* L.) cultivars, Climatic variability, Crude protein, Yield attributes of Alfalfa

Introduction

Alike Pakistan, several countries of the world possess an agricultural economy, which is threated by the ever-increasing population, degradation of land & water resources, urbanization and industrialization. Therefore, livestock has become an integral part of the agriculture industry, which demands for the enhanced fodder production. Alfalfa (*Medicago sativa* L.) is considered to be one of the highest viable fodder crops on the earth, which has exceedingly

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inclusive adaptability to dissimilar climates (Moreira and Fageria, 2010). Alfalfa is a versatile, highly palatable and the 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.*, 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 coadjacent with organic materials, crude fiber, protein and fats contrasted to other grass species (Sommer *et al*., 2005). Alfalfa is an imported species in Pakistan but its production is much below as compared to rest of the world. Although various cultivars of alfalfa are being cultivated on an area of 0.13 million hectares but 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 of this crop in the country. Therefore, scientific investigation is required for the evaluation and selection of excessive yield and quality cultivars with maximum environmental adaptability. Selection and evaluation of good quality suitable cultivars can help the farmers and producers in getting higher production with a better quality of production (Cacan *et al*., 2018). Acid detergent fiber (ADF), neutral detergent fiber (NDF), 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 cultivars possess varied nutrient compositions, therefore the nutrition value of cultivars must be find out (Ülger and Kaplan, 2016). Mainly crude ash, NDF, ADF and CP 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 (Başbağ 2009), (Saruhan and Kuşvuran 2011; Yüksel *et al*., 2016). The current research was carried out to evaluate five alfalfa cultivars against their production and quality attributes being cultivated in Punjab, Pakistan and to

find out the correlation in these attributes of cultivars and to recognize the best suitable cultivar.

Materials and methods

Site description

Current field investigation study was performed at the research farm of Fodder Research Institute Sargodha during winter seasons of 2016-17, 2017-18, 2018-19. The soil of experimental field was loam, having pH 7.85 ± 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.

Experimental Treatments and layout

Cultivars of alfalfa were acquired from two sources i.e., the Fodder Research Institute Sargodha and a local private seed company. Five alfalfa cultivars namely Sargodha Lucerne 2002 (SGD-Lucerne 2002), Alpharite, Salt King, Surdii 10 and composite were selected for investigation. SGD-Lucerne 2002 and composite are domestic whereas Alpharite, Salt King, and Surdii 10 were foreign cultivars. All cultivars are tall with vertical growth attributes but resistant to lodging. The experiment was planned in randomized complete block design (RCBD) with four replications. 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 suitable moisture condition. All selected cultivars were sown at a rate 15 kg per hectare with the help of a hand drill during third week of October each year. 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 2nd irrigation. These fertilizers were procured from Fauji fertilizer company (FFC). 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).

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

Month/ parameters	Climatic parameters for Year 2017					Climatic parameters for Year 2018					Climatic parameters for Year 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

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 records

After 74 days of sowing, the crop was harvested at 10% flowering, followed by subsequent cutting when the crop attained 10 % flowering as proposed by Manga *et al*., 2003. Ten random plants were selected from each treatment at harvesting and data on plant height was recorded. Three samples of one meter square (1 m^2) from each treatment were randomly selected for counting tillers per meter square. Plant height was also recorded at both minimum and maximum temperatures during December-January, and May-June respectively. The effect of climate on the growth of cultivars were thus observed. Green fodder yield was determined after harvesting all treatments for

the entire plots 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.

Crude protein was calculated using 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:

$$\text{NDF (\%)} = \text{weight of residues} / \text{sample weight} \times 100$$

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 following 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 Morris, 2005 as given below:

$$\text{DDM} = 88.9 - (0.779 \times \% \text{ ADF}$$

$$\text{DMI} = 120 / \% \text{ NDF}$$

$$\text{RFV} = (\text{DDM} \times \text{DMI}) / 1.29$$

Statistical analysis

Various data recorded from field experiment were analysed statistically and calculated ANOVA by JMP Statistics software. Means were compared with HSD test and the relationship among investigated traits was found out by calculating the correlation coefficient (Kalayci, 2005).

Results

The results showed significant differences among yields of alfalfa cultivars for both green fodder and dry matter (Table 2). Maximum green fodder yield (101.33 t ha^{-1}) and dry matter yield (20.0 t ha^{-1}) were obtained in cultivar SGD-Lucerne 2002 while the minimum yield of green fodder (70.23 t ha^{-1}) and dry matter (15.01 t ha^{-1}) was observed in cultivar Surdii 10. Considering the years, the highest significant green fodder (94.66 t ha^{-1}) and dry matter yield (18.77 t ha^{-1}) was observed in 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).

Table 2. Green and dry matter yield of various cultivars of alfalfa

Cultivars	**Green fodder yield (tons /ha)**				**Dry matter yield (tons /ha)**			
	2017	2018	2019	Means	2017	2018	2019	Means
SGD-Lucerne 2002	84.60f	104.8 b	114.60 a	101.33 a	16.65 fg	20.71 b	22.64 a	20. 00 a
Alpharite	73.52 i	93.52 d	98.52 c	88.52 b	13.58 h	17.27 ef	18.22 cd	16.36 b
Salt King	69.44 i	89.44 e	94.44 d	84.44 c	13.66 h	17.59 de	18.57 c	16.61 b
Surdii 10	54.97 l	75.48 h	80.25 g	70.23 e	11.76 i	16.13 g	17.15 ef	15.01 c
Composite	60.82 k	80.25 g	85.50 f	75.52 d	12 29 i	16.21 g	17.27 ef	15.25 c
Means	68.67 c	88.70 b	94.66 a		13.59 c	17.58 b	18.77 a	
LSD		0.2282		1.183		0.1305		0.489
LSD interactive effect			1.85				0.847	

The maximum plant height (81.5 cm) was recorded in cultivar SGD-Lucerne 2002 and the lowest (68.58 cm) value was recorded in cultivar Surdii 10 (Table 3). Considering the plant height among years, the highest average value (76.50 cm) was recorded in the third year of study and the minimum value of (68.00 cm) was observed in the first year of the study (i.e., 2017). Considering the temperature regime, cultivar SGD-Lucerne 2002 performed better with respect to plant height as compared to other cultivars when the average temperature remained around 34 ℃ during May and June. SGD-Lucerne 2002 showed maximum height (77.5 cm) and the lowest height (48.08 cm) was observed in Surdii 10 (Table 4). During January and February when average temperature remained up to 17 ℃, Alpharite showed maximum height (73.33cm) and the lowest height (51.0 cm) was observed in SGD-Lucerne 2002

(Table 3). Considering years, the maximum average height was recorded in the third year, i.e., 2019.

Table 3. Comparison of plant height, Average of 10 cuts versus height of December to February

Year/cultivars	Av. Plant height of 10 cuts (cm)				Plant height during December-January (cm)			
	2017	2018	2019	Means	2017	2018	2019	Means
SGD-Lucerne 2002	76.75 b	82.25 a	85.50 a	81.50 a	46.25 h	52.00 gh	57.75 g	51.00 d
Alpharite	67.50fgh	74.75 bc	76.75 b	73.00 b	70.75 abc	73.00 ab	76.25 a	73.33 a
Salt King	65.75gh	71.50 de	74.25bcd	70.50 c	65.25 cde	68.75 bcd	70.75 abc	68.25 b
Surdii 10	64.75 h	68.25 fg	72.75 cde	68.58 d	56.75 fg	61.50 ef	63.25 de	60.50 c
Composite	65.25gh	69.50 ef	73.25 cd	69.33 cd	65.50 cde	66.25 cde	68.75 bcd	66.83 b
Means	68.00 c	73.25 b	76.50 a		60.90 c	64.30 b	66.75 a	
LSD		1.795		1.875		1.354		3.767
LSD interactive effect		3.248				6.525		

Table 4. Plant height of alfalfa cultivars at a higher temperature during May and June

Cultivars	Plant height during May and June			
Year	2017	2018	2019	Means
SGD-Lucerne 2002	72.75	78.25	81.50	77.50a
Alpharite	54.50	58.75	60.50	57.91b
Salt King	51.75	53.70	54.90	53.45c
Surdii 10	46.75	47.5	50.00	48.08e
Composite	49.75	51.80	54.25	51.93d
Means	55.1c	58b	60.23a	
LSD		0.5		0.51

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

The results showed significant differences in crude protein contents (%) and yields of five alfalfa cultivars (Table 5). Maximum crude protein contents were recorded in cultivar Surdii 10 (21.95 %) while the lowest was observed in salt King (18.86 %). Years and interactive effect was found non-significant. Crude protein yield was maximum (3.89 t ha^{-1}) in SGD-Lucerne 2002 while the lowest was obtained by Salt King (3.13 t ha^{-1}). Considering the CP yield of years, a significantly higher yield (3.81 t ha^{-1}) was achieved in the third year (i.e., 2019) and the lowest value- (2.76 t ha^{-1}) was observed in the year 2017.

ADF(%) and NDF(%) ratios

Alike other yield parameters as discussed above, significant differences were also observed in acid detergent fiber (ADF) and neutral detergent fiber (NDF) ratios with respect to cultivars as well as the years (table 6). Maximum

ADF and NDF ratios were recorded in cultivar Alpharite (23.73 % and 34.70 % respectively) while minimum ratios (26.0 and 28.47 % respectively) were observed in cultivar SGD-Lucerne 2002. Considering the ratios of years, the highest ratio of ADF and NDF(24.41 % and 35.64 % respectively) were recorded in the year 2019 and the lowest values (19.21 and 28.8 % respectively) were observed in 2017.

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

Cultivars	Crude protein contents (%)				Crude protein yield (t ha^{-1})			
	2017	2018	2019	Means	2017	2018	2019	Means
SGD-Lucerne 2002	19.49	19.44	19.44	19.46 c	3.245 f	4.025 b	4.403 a	3.891 a
Alpharite	20.87	20.87	20.91	20.88 b	2.835 g	3.605 cd	3.810 c	3.417 b
Salt King	18.85	18.86	18.86	18.86 d	2.575 h	3.318 ef	3.503 de	3.132 d
Surdii 10	21.94	21.95	21.96	21.95 a	2.580 h	3.540 de	3.765 c	3.295 bc
Composite	20.83	20.82	20.83	20.83 b	2.560 h	3.375 def	3.598 cd	3.178 cd
Means	20.39	20.38	20.40		2.76 c	3.57 b	3.815 a	
LSD	Ns			0.394	0.032			0.135
LSD interactive effect	NS				0.2338			

Table 6. ADF and NDF ratios of alfalfa cultivars

Cultivars / years	ADF ratios (%)				NDF ratios (%)			
	2017	2018	2019	Means	2017	2018	2019	Means
SGD-Lucerne 2002	17.30 g	20.30 ef	22.50 c	20.03 c	26.00 f	25.90 f	33.50 c	28.47 d
Alpharite	21.00 de	24.00 b	26.20 a	23.73 a	33.10 c	34.00 bc	37.00 a	34.70 a
Salt King	19.03 f	22.03 cd	24.23 b	21.76 b	27.70 ef	30.00 de	36.70 a	31.47 bv
Surdii 10	19.20 f	22.20 cd	24.40 b	21.93 b	30.30 d	29.50 de	36.20 ab	32.00 b
Composite	19.50 f	22.50 c	24.70 b	22.23 b	26.90 f	29.80 de	34.80 bc	30.50 c
Means	19.21 c	22.21 b	24.42 a		28.80 b	29.84 b	35.65 a	
LSD	0.2825			0.8492	2.054			1.032
LSD interactive effect	1.472				1.788			

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

The differences among the ratios (%) of DDM and DMI were found significant for both the Cultivars and years (Table 7). The highest values of DDM and DMI (73.29 %and 4.28 % respectively) were recorded in cultivar SGD-Lucerne 2002 while the lowest values (70.29 % and 3.47 % respectively) were noted in cultivar 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 cultivars

Cultivars /	DDM (%)				DMI (%)			
years	2017	2018	2019	Means	2017	2018	2019	Means
SGD-Lucerne 2002	75.42 a	73.08 bc	71.38 e	73.29 a	4.620 a	4.640 a	3.592 d	4.284 a
Alpharite	72.45 cd	70.20 fg	68.24 h	70.30 c	3.638 d	3.533 de	3.248 e	3.473 d
Salt King	74.08 a	71.74 de	70.03 g	71.95 b	4.348 ab	4.013 c	3.275 e	3.878 bc
Surdii 10	73.94 b	71.61 de	69.89 h	71.82 b	3.968 c	4.070 bc	3.230 e	3.756 c
Composite	73.46 bc	71.37 ef	69.65 g	71.50 b	4.475 a	4.038 bc	3.455 de	3.989 b
Means	73.87 a	71.60 b	69.84 c		4.210 a	4.059 a	3.360 b	
LSD		0.2028		0.6781		0.2509		0.1324
LSD interactive effect		1.1744				0.2292		

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

RFV and tillers m^{-2} of different cultivars showed significant differences for both cultivars and years (Table 8) maximum RFV and the number of tillers m^{-2} (244 and 490.) were recorded in SGD-Lucerne 2002 while minimum RFV and tillers m^{-2} (209and 345 respectively) were found in cultivar 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.

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

Cultivars /	RFV values				Tillers m^{-2}			
years	2017	2018	2019	Means	2017	2018	2019	Means
SGD-Lucerne 2002	270.14 a	262.87 ab	198.88 d	243.96 a	482.5 a	492.5 a	496.3 a	490.4 a
Alpharite	204.25 d	192.26 de	171.71 f	189.41 d	382.5 bc	392.5 b	400.0 b	391.7 b
Salt King	249.57 b	223.24 c	177.67 ef	216.82 bc	366.3 bc	375.0 bc	377.3 bc	372.8 b
Surdii 10	227.38 c	225.81 c	174.88 ef	209.36 c	337.5 c	346.3 c	351.3 c	345.00 c
Composite	253.37 b	223 23 c	186.54 de	221.05 b	362.5 bc	367.5 bc	371.8 bc	367.3 bc
Means	240.94 a	225.48 b	181.93 c		386.3 c	349.8 b	399.3 a	
LSD		14.566		7.5729		3.2549		26.031
LSD interactive effect		13.117				45.087		

Correlation among traits

The correlation coefficient of tested traits in five alfalfa cultivars showed significant differences from each other except a few, those remained insignificant (Table 9). Tillers showed significant differences having a positive correlation with yields of green fodder & dry matter, plant height and CPY, while a non-significant negative correlation was found with ADF, NDF and CPR. Plant height showed a strong positive correlation with green fodder yield, DMY, tillers, CPY, ADF and positive non-significant correlation with NDF while negative significance with DDM, CPR and non-significant with DMI, RFV. Green fodder yield showed a strong positive correlation with ADF, CPY, DMY & NDF, while a strong negative correlation with CPR, DDM, DMI & RFV. The yield of the dry matter showed a strong positive correlation with ADF, CPY & NDF and a highly negative correlation with CPR, DDM, DMI & RFV. CPR showed highly significant negative correlation with forage yield, DMY, PH, tillers, and negative non-significant correlation with CPY DDM, DMI, and RFV. The yield of crude protein showed a strong positive correlation with ADF & NDF and highly negative correlation with parameters like CPR, DDM, DMI & RFV. Acid detergent fiber had strong positive correlation with NDF and a negative correlation strongly significant to DDM, RFV, and DMI. Neutral detergent fiber (NDF) had a negative correlation strongly significant to DDM RFV, and DMI. DDM showed a highly significant positive correlation with RFV and DMI and there had strongly positive correlation between 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 values.

Discussion

Results of the study showed a significant effect of weather parameters on various attributes of cultivars especially the temperature. Similar findings were reported i.e., the climatic condition may show considerable differences in yield parameters of various cultivars 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). Yields of green fodder in alfalfa cultivars were recorded as 9.31 to 118.4 t ha^{-1} (Kır and Soya, 2006; Demiroğlu *et al*., 2008) and that of dry matter were observed as 20.25 to 32.87 t ha^{-1} (Kuşvuran and Sağlamtimur, (2005); Sengul *et al*., 2003; Kır and Soya, 2006; Demiroğlu *et al*., 2008; 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). Protein and dry matter ratio mostly depend on genetic properties of the seed. These properties commonly vary by shoot and leaf ratio, the period of ripening, fertilization and temperatures (Ball *et al*., 2001). In various studies, CPR were recorded in the range of 15.95 to 28.09 % (Sengul *et al*., 2003; Kır and Soya, 2006; Başbağ, 2009; 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 cultivars with respect to crude protein ratio while quality of all cultivars 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 cultivars were recorded between 16.8 to 41.0 % and 20.3 to 49.0 % respectively (Basbag *et al*., 2009; Canbolat and Karaman, 2009; Kiraz, 2011; Çaçan *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; Kiraz, 2011; Çaçan *et al,*. 2015) and RFV between 127.0 to 347.0 (Başbağ, 2009; Kiraz, 2011; Çaçan *et al*., 2015). Low NDF and ADF ratios in all cultivars were kept in better quality group (Rohweder *et al*., 1978). 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 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. 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 cultivars falling under "prime" group. 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 *et al.,* 2009; Yesil and sengul, 2009; Saruhan and Kusvuran, 2011). 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. (Mattera *et al*., 2013) found that increased plant density had positive effect on alfalfa production due to higher number of stem per unit area. Results on the correlation among different forage yield attributes of alfalfa cultivars obtained under the current investigation are presented in table 9. These results indicate that different cultivars had a dominant effect on fodder yield, plant growth and yield parameters as well as 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 i.e., CP, RFV & RFQ (Ali *et al*., 2011a; Ali *et al*., 2011b; Tariq *et al*., 2012; Bibi *et al*., 2016; Kumar *et al*., 2016). Plant height also showed a positive correlation with dry matter yield, fresh fodder yield, CPY, NDF & ADF, while the negative correlation with CPR, DDM, DMI and RFV (Cacan *et al*., 2018) but under 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. 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; Çaçan *et al*., 2015. Iyanar *et al*., 2010; 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, 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) and neutral detergent fiber (NDF) was observed in SGD-Lucerne 2002 with

somewhat higher values of DDM and DMI. Therefore, It is recommended the cultivation of alfalfa cultivar SGD-Lucerne 2002 for fodder in the areas having temperatures above 15 ℃ round the major part of the year.

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