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COMPARISON OF CULTIVATED AND WILD RELATIVES OF SEVERAL FORAGE SPECIES IN MIXED RANGELAND BASED ON SOME NUTRITIONAL CHARACTERISTICS

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Abstract: Cultivated forage species may have higher nutrients contents (NC) and forage quality indicators (FQI) than their wild relatives. Nine forage samples collected five times from a mixed rangeland and an experimental field during two consecutive years was analysed for ash, crude protein (CP), ether extract (EE) and neutral detergent (NDF) and acid detergent (ADF) fibres. Then, their FQI such as digestible dry matter (DDM), dry matter intake (DMI), metabolizable energy (ME) and relative forage quality (RFQ) were calculated. Data were performed in a linear model with fixed effects (forage plant type [PT] and species [PS]) to NC and FQI, and subjected to hierarchical two-way clustering analysis. Cultivated and wilds relatives varied in CP (12.0-18.9% and 8.8-23.3%), ADF (20.9-33.1% and 39.3-73.5%) and NDF (37.2-61.6% and 26.7-46.1%) contents and ME (8.7-9.7 MJ kg^{-1} DM and 7.0-9.6 MJ kg^{-1} DM) and RFQ (98.8-186.7 and 74.6-161.7) values. There were interactions between PT and PS for all NC and FQI, except for CP and EE contents. In general, the CP, EE, ADF, ME and RFQ of cultivars were higher, whereas NDF was lower than those of the wilds. The most notable differences (NDF, ADF and RFQ) between the PT represented the differences in nutritional traits based on the clustering analysis. The cultivated and wilds relatives are comprised of NC and FQI that respond differently under same circumstances.

Keywords: Forage quality, Grassland, Nutritive value, Nutrient content, Plant breeding

1. Introduction

Rangelands and pastures subjected to intensive management are consisted of simple mixtures of only grass (Gramineae) varieties and cultivars or grass and legume (Leguminosae) species (Hayes et al., 2013) but are not included other botanical families (OBF) or non-leguminous forbs (Elgersma et al., 2014). However, natural and semi-natural rangelands are characterized by a rich botanical composition (Dudek et al., 2020) due to a more excellent range of species belonging to grasses, legumes and OBF (Aydin et al., 2019). Grasses increase yield and stability of rangelands, whereas the legume and OBF species improve both their productivity and nutritional value or quality (Capstaff and Miller, 2018). Therefore, understanding nutritional value, as well as productivity of the range forages, is useful for determining the capacity and ability of rangelands to meet the needs of animals (Asaadi and Yazdi, 2011; Aydın et al., 2020). The botanical composition of grasslands helps to explain nutritional value and production levels (Michaud et al., 2012; Aydın et al., 2020), whereas plant functional traits enable to link

morphological, physiological and phenological plant properties to their functions (Schellberg and Pontes, 2012).

Forage crops utilized in both grazing and the cut-and-carry system meets the physical and physiological requirements of domesticated ruminants (Capstaff and Miller, 2018). Indeed, these crops not merely maintain these animals, but also sustain the delivery of meat, milk and other products (Hayes et al., 2013; Lee, 2018). However, one of the greatest challenges to the efficient production of ruminants is the shortage of forage resources available throughout critical periods of their production cycle (Uzun and Ocak, 2019). In such cases, to enhance ruminant productivity, the high-yield and nutritious native forages that cultivated (hereafter cultivars) are used in grazing or the cut-and-carry system (Aydin et al., 2019). Indeed, for re-vegetation and rehabilitation, the cultivars are introduced into the rangelands that composed of their wild relatives (Algan et al., 2019).

The yield and quality of herbage and persistence in forages, the primary production traits, are critical for

forage improvement in the various management systems and support feed conversion into unit quantities of an animal product as meat or milk (Hayes et al., 2013; Capstaff and Miller, 2018). The cultivation of forage plants has resulted in arguably the most desirable improvements such as dry matter (DM) yield and digestibility in forage species, such as *Medicago*, *Trifolium*, *Lolium*, and *Festuca* (Capstaff and Miller, 2018; Lee, 2018). Measuring the impacts of cultivars on high quality is very difficult since it needs laboratory analysis or animal feeding trials. Functional traits, such as digestible dry matter (DDM) and dry matter intake (DMI) that closely related to neutral detergent fibre (NDF) and acid detergent fibre (ADF) are easily measured predictor in quality of forage species (Bumb et al., 2016).

The information on whether cultivars may have higher nutrient content (NC) and forage quality indicators (FQI) than their wild relatives is scarce. Together with analysing distinct components of the wilds and the cultivars simultaneously may be useful to determine the impacts of species cultivation. Moreover, investigating the parallels and opposites between cultivars and wilds may help nutritional concepts and qualities of forages from biodiversity studies. Therefore, the objectives of this study were to determine similarities and differences between cultivars and wilds of several forage species that grown in field conditions and collected from rangeland, respectively and to provide to the farmers' useful recommendations on the best forage species to utilize.

2. Materials and Methods

2.1. Study Area and Species Selection

In this study, the third part of a research project (Aydın et al., 2018), the nine of forage species belong to cultivars and wild relatives (hereafter wilds) collected from an experimental field and the collected from the mountainous rangeland, respectively, (40°50′ to 41°51′ N and 37°08′ to 34°25′ E at nearly 1200 m above sea level) in Samsun province located in the middle Black Sea region of Turkey were used. The experimental field had a loam soil with sub-alkaline pH, normal saline, low-lime, organic matter, N and P, and high-K concentrations. The rangeland had a clay-loamy with sub-alkaline pH, low-saline, good organic matter, low-N and high-P and K contents (Tyler and Olsson, 2001). As was reported by Aydin et al. (2019), in the experimental area, winters are cool and damp, while summers are warm and damp for many years. The mean annual temperature and rainfall were 10.2°C (ranged from 3.1°C in winter to 16.7°C in summer) and 583.6 mm in the study period, respectively. Forage plant species in the study were perennial desirable such as *Lotus corniculatus* L. (*L. corniculatus*), *Medicago sativa* L. (*M. sativa*), *Trifolium pratense* L. (*T. pratense*), *Trifolium repens* L. (*T. repens*), *Dactylis glomerata* L. (*D. glomerata*), *Festuca ovina* L. (*F. ovina*), *Lolium perenne* L. (*L. perenne*) *Cichorium intybus* L. (*C. intybus*) and *Sanguisorba minor* Scop. (*S. minor*). The cultivars represent legume, grass and OBF species of

unknown genetic type but which reared in private or state farms and research centres (Kazak Tarım, Ankara, Turkey). The wilds were the most dominant and promising species for region rangelands (Uzun and Ocak, 2019; Aydın et al., 2020).

2.2. Collection and Laboratory Analyses of Forage Samples

Samples of the forage plant types, defined as cultivars and wilds were collected five times at the active growth stages (from before-flowering stage to after-flowering stage) of dominant species in the rangelands in two consecutive years (2016 and 2017). The herbage samples taken at each collection period were dried at 60°C for 48 h in an air-forced oven and then, stored at 4 °C until the proximate analysis. For proximate analysis, all samples were ground with a 1-mm screen and then, analysed for dry matter (DM, ID number: 2001.12), CP (978.04), ether extract (EE, 920.39) and ash (930.05) as reported by AOAC (2005) procedures. The NDF and ADF contents of the samples were also determined using the ANKOM A200/220 (ANKOM Technology Corp., Fairport, NY, USA) fibre analyser filter bag technique (Van Soest et al., 1991). Then, their FQI such as DDM (equation 1), DMI (equation 2), metabolizable energy (ME, equation 3), relative feed value (RFV, equation 4) and relative forage quality (RFQ, equation 5) were calculated as described by Rohweder et al. (1978).

$$DDM\ (\%) = 88.9 - 0.779 \times (ADF, \%\ of\ DM) \quad (1)$$

$$DMI\ (\%\ of\ body\ weight,\ BW) = 120/\ (NDF, \%\ of\ DM) \quad (2)$$

$$ME\ (MJ\ kg^{-1}\ DM) = 0.17\%\ DDM - 2.0 \quad (3)$$
(Belyea et al., 1993)

$$RFV = (DDM \times DMI)/1.29 \quad (4)$$

$$RFQ = (DMI_{legume\ or\ grass}, \%\ of\ BW) \times (TDN_{legume\ or\ grass}, \%\ of\ DM)/1.23 \quad (5)$$

The $DMI_{legume\ or\ grass}$ and total digestible nutrients (TDN) were calculated separately for legume and grass species as described by Undersander et al. (2010). Ten nutritional characteristics chosen for this study were among the most common agronomic metrics (Lee, 2018; Aydin et al., 2019).

2.3. Statistical Analysis

Data was performed by adjusting one linear model (equation 6) with fixed effects forage plant type (cultivars and wilds) and plant species (nine species) to the nutritional traits (NC and FQI). Analyses of variance were performed with GLM procedure of SPSS Statistics (Windows version of SPSS, release 21.0, SPSS Inc., Chicago, IL, USA).

$$Y_{ijk} = \mu + PT_i + PS_j + PTPS_{ij} + e_{ijk} \quad (6)$$

Where: Y_{ijk} is the nutritional traits of k species, of i PT

(plant type) and *j* PS (plant species); *µ* is the mean value; PT*i* is an effect of plant type; PS*j* is the effect of plant species; PTPS*ij* is the interaction of the plant type and plant species factors, and *eijk* is the error value and then means were compared by Tukey's range test. The experimental unit for the cultivars and the wilds were the parcel and collection repetitions, respectively. The total number of samples was 65: two plant types × nine plant species × three or five (collection repetitions) × three (analytical replicates). The replication values of each trait for each species belonging to the wilds and cultivars were subjected to hierarchical two-way clustering analysis using the JMP statistical program (SAS Institute Inc.USA).

Thus, both plant type (as defined cultivated or wild type) and nutritional traits (as defined NC or FQI) were clustered according to similarity measures to simultaneously identify the associations between species and nutritional traits (Amiri and Shariff, 2012).

3. Results
Legumes contained higher CP, ash, DDM, DMI, ME, RFV and RFQ, and lower ADF and NDF than grasses (Table 1). Compared to the OBF species, legumes had higher CP and lower DMI, RFV and RFQ values, whereas grasses had lower DDM, RFV and RFQ, and higher CP, ash, ADF and NDF.

Table 1. The mean, standard error and 95% confidence intervals of the studied variables of each forage family

Variable[1]	CP	EE	Ash	ADF	NDF	DDM	DMI	ME	RFV	RFQ
Legumes (n=30)										
Mean	18.7	2.4	9.5	39.6	36.2	64.3	2.79	8.9	140.5	141.8
Standard error	0.63	0.13	0.24	1.71	1.17	0.61	0.065	0.10	4.49	5.25
95% confidence interval										
Lower bound	17.4	2.1	9.0	36.1	33.8	63.0	2.66	8.7	131.3	131.0
Upper bound	19.9	2.6	10.0	43.1	38.6	65.5	2.93	9.1	149.7	152.5
Grasses (n=22)										
Mean	11.7	2.5	8.2	53.2	44.2	62.2	1.87	8.6	91.4	100.0
Standard error	0.61	0.20	0.36	4.80	2.48	0.91	0.055	0.16	3.99	3.08
95% confidence interval										
Lower bound	10.5	2.1	7.4	43.2	39.1	60.3	1.76	8.3	83.1	93.6
Upper bound	13.0	2.9	8.9	63.2	49.4	64.1	1.99	8.9	99.7	106.4
Other botanical families (n=13)										
Mean	11.1	2.5	10.1	39.7	37.9	64.1	2.84	8.9	148.4	147.6
Standard error	0.71	0.22	0.54	4.14	2.63	2.08	0.179	0.35	13.34	13.76
95% confidence interval										
Lower bound	9.5	2.0	8.9	30.7	32.2	59.6	2.49	8.1	119.4	117.6
Upper bound	12.6	2.9	11.3	48.7	43.6	68.6	3.27	9.7	177.9	177.5

CP= crude protein, EE= ether extract, ADF= acid detergent fibre, NDF= neutral detergent fibre, DDM= digestible dry matter, DMI – dry mater intake, ME= metabolizable energy, RFV= relative feed value, RFQ= relative forage quality.

[1]Unit of CP, EE, Ash, ADF, NDF and DDM is % of dry matter, while DMI and ME is % of body weight and MJ/kg DM, respectively.

There were significant differences between the wilds and cultivars in terms of the NC (Table 1) and FQI (Table 2) variables. The content of CP was affected by the plant type and plant species factors, while EE content was only affected by plant type (P < 0.001, Table 2). The wilds had lower CP (14.9% vs 14.3%) and EE (2.8% vs 2.2%) levels compared to the cultivars. The CP content of *M. sativa* was higher than those of other species (P < 0.05), except for *T. repens*. The CP contents of *L. corniculatus* and *T. pratense* were higher (P < 0.05) than those of the grasses (*D. glomerata*, *F. ovina*, and *L. perenne*) and the OBF species (*C. intybus* and *S. minor*). The grass and OBF species had similar values in CP content.
There were interactions between two factors for all NC (Table 2) and FQI (Table 3), except for CP and EE contents. Except for the cultivar *T. repens*, cultivar *C. intybus* had the highest ash content among the cultivars

(P < 0.05), but did not differ from all wilds. The ADF content of the wild *D. glomerata*, *F. ovina*, and *L. perenne* and *C. intybus* had higher than those of the wild *L. corniculatus*, *T. pratense* and *S. minor*, and all cultivars (P < 0.05). The cultivar *L. perenne* had a lower ADL content compared to all wilds (P < 0.05). In terms of the NDF content, the wild *C. intybus* had higher (P < 0.05) value than the wild *S. minor*. The NDF contents of cultivar *F. ovina* and *D. glomerata* were higher than those of the other species, except for the cultivar *T. pratense* and the wild *C. intybus* (P < 0.05).
The wild *S. minor* had a higher DDM value compared to the DMM values of the wild *D. glomerata*, *F. ovina* and *C. intybus* (P < 0.05). These three wild types had lower DDM values compared to the cultivar *T. repens*, *L. perenne* and *S. minor* (P < 0.05). Except for the cultivar *T. repens,* the DMI of the cultivar grasses was lower than those of the

cultivar legume and OBF species (P < 0.05). The DMI of the wild *D. glomerata* and *F. ovina* were lower than all wild legumes and the wild *S. minor* (P < 0.05). The cultivar legumes had a higher DMI level compared to the wild *T. pratense*, *C. intybus* and all wild grasses (P < 0.05). The ME of the cultivar *T. repens*, *L. perenne*, *S. minor* and the wild *S. minor* were higher than those of the wild *D.*

glomerata, *F. ovina* and *C. intybus* (P < 0.05). The RFV of the cultivar *T. repens* was similar with cultivar *L. perenne*, wild *M. sativa* and wild *T. repens*, whereas the RFQ of the cultivar *T. repens* were higher than those of the wild *M. sativa*, *T. pratense*, *T. repens* and *C. intybus* as well as all grasses (P < 0.05).

Table 2. Nutrients contents (% of dry matter) of cultivated and wild types of some forage species belonging to grass, legume and other botanical families

Plant type	Plant species	CP	EE	Ash	ADF	NDF
Cultivars						
	L. corniculatus	17.4	2.7	8.2b	28.8dfe	40.2cde
	M. sativa	18.9	2.1	8.7b	32.4c-f	43.4bcd
	T. pratense	15.7	2.4	8.3b	33.1c-f	46.6abc
	T. repens	18.0	2.5	9.6ab	26.6ef	37.4cde
	D. glomerata	13.4	3.9	9.3b	31.0dfe	57.9ab
	F. ovina	12.0	3.1	7.3b	30.6dfe	61.6a
	L. perenne	14.6	2.6	8.9b	20.9f	41.6cde
	C. intybus	12.3	2.7	10.3a	30.0dfe	40.1cde
	S. minor	11.9	3.0	9.3b	26.3ef	42.4cd
Wilds						
	L. corniculatus	17.7	2.9	9.5ab	41.4bcd	29.9de
	M. sativa	23.3	2.5	9.7ab	45.1ab	32.1cde
	T. pratense	16.4	2.2	10.1ab	49.5b	34.5cde
	T. repens	19.6	2.0	10.8ab	45.5ab	32.6cde
	D. glomerata	11.3	1.9	8.8b	71.1a	38.6cde
	F. ovina	9.7	2.1	7.1b	73.5a	39.0cde
	L. perenne	10.7	1.9	7.8b	68.2a	35.1cde
	C. intybus	8.8	2.3	9.9ab	63.3a	46.1abc
	S. minor	11.2	2.0	8.6b	39.3b-e	26.e
Plant type						
Cultivars		14.9a	2.8a	9.2	45.7	28.9
Wilds		14.3b	2.2b	9.1	25.0	55.2
Plant species						
L. corniculatus		17.6b	2.8	8.9	35.0	35.1
M. sativa		21.6a	2.3	9.3	36.2	40.4
T. pratense		16.2b	2.3	9.4	39.0	43.3
T. repens		19.0a	2.2	10.3	34.3	38.4
D. glomerata		12.1c	2.6	9.0	45.9	56.0
F. ovina		10.7c	2.5	7.2	48.7	55.1
L. perenne		12.4c	2.2	8.3	37.9	48.0
C. intybus		10.6c	2.5	11.5	43.2	46.7
S. minor		11.5c	2.4	8.9	33.4	33.8
SEM		0.59	0.01	0.22	2.11	1.20
Main effect of						
Plant type		<0.001	<0.001	<0.001	<0.001	<0.001
Plant type		<0.001	0.888	<0.001	<0.001	<0.001
Plant type × Plant type		0.111	0.062	0.040	<0.001	0.001

[a,c,d] Means of the same column followed by different letters differ significantly (P < 0.05).

CP= crude protein, EE= ether extract, ADF= acid detergent fibre, NDF= neutral detergent fibre, SEM= standard error of mean.

Table 3. Forage quality indicators of cultivated and wild-types of some forage species belonging to grass, legumes and other botanical families

Plant type	Plant species	DDM[1]	DMI	ME	RFV	RFQ
Cultivars						
	L. corniculatus	66.5ab	3.11ab	9.3ab	162.3ab	175.5abc
	M. sativa	63.7ab	2.83abc	8.8ab	140.4abc	151.2a-e
	T. pratense	63.1ab	2.66a-e	8.7ab	131.7a-e	141.3a-f
	T. repens	68.2a	3.31a	9.6a	176.3a	186.7a
	D. glomerata	64.8ab	2.09d-g	9.0ab	105.4c-f	106.6e-h
	F. ovina	64.4ab	1.96efg	9.0ab	98.9c-f	98.5e-h
	L. perenne	69.0a	2.34c-g	9.7a	125.2a-f	125.5c-h
	C. intybus	65.5ab	3.19ab	9.1ab	165.7ab	166.9a-d
	S. minor	68.4a	3.20ab	9.6a	175.3ab	182.4ab
Wilds						
	L. corniculatus	65.7ab	2.93abc	9.2ab	149.1abc	143.4a-f
	M. sativa	63.9ab	2.70a-d	8.9ab	134.7a-d	129.4b-g
	T. pratense	62.1abc	2.48b-f	8.5abc	120.6b-f	115.8d-h
	T. repens	63.5ab	2.66a-e	8.8ab	131.8a-e	126.5c-h
	D. glomerata	58.8bc	1.70g	8.0bc	77.9ef	84.7gh
	F. ovina	58.5bc	1.63g	7.9bc	74.1f	93.4fgh
	L. perenne	61.5abc	1.76fg	8.5abc	83.9def	102.9e-h
	C. intybus	53.0c	1.90fg	7.0c	78.1ef	74.6 h
	S. minor	68.1a	3.13ab	9.6a	168.0ab	161.7a-d
Plant type						
Cultivars		66.0	2.74	9.2	142.4	148.3
Wilds		61.7	2.32	8.5	113.1	114.7
Plant species						
L. corniculatus		66.1	3.02	9.2	155.7	159.4
M. sativa		63.8	2.75	8.9	136.9	137.6
T. pratense		62.5	2.55	8.6	124.8	125.4
T. repens		65.2	2.91	9.1	148.4	149.1
D. glomerata		61.1	1.85	8.4	88.3	92.9
F. ovina		61.0	1.77	8.4	84.7	95.5
L. perenne		64.8	2.01	9.0	101.6	112.6
C. intybus		59.3	2.55	8.1	121.9	120.8
S. minor		68.2	3.16	9.6	171.1	170.6
SEM		0.59	0.075	0.10	4.70	4.54
Main effect of						
Plant type		<0.001	<0.001	<0.001	<0.001	<0.001
Plant species		<0.001	<0.001	<0.001	<0.001	<0.001
Plant type × Plant species		0.013	0.004	0.013	0.014	0.009

[a,c,d] Means of the same column followed by different letters differ significantly (P < 0.05). DDM= digestible dry matter, DMI= dry matter intake, ME= Metabolizable energy, RFV= relative feed value, RFQ= Relative forage quality.

[1] Unit of DDM, DMI, and ME is % of dry matter, % of body weight, and MJ/kg DM, respectively.

Both cultivars and wilds separated into two main clusters (named as I and II) according to the similarity of the nutritional traits (Figure 1). In terms of the families and the number of subset and species, there was no similarity among the species within the clusters (I and II) of both cultivars and the wilds. The Cluster I of the cultivars had

two species (*F. ovina* and *D. glomerata*), whereas that of the wilds had two sub-groups that had one (*C. intybus*) and three (*L. perenne*, *F. ovina*, and *D. glomerata*) species, respectively. Cluster II of both cultivars and wilds showed two subsets (II₁ and II₂). The II₁ and II₂ subsets of the cultivars included two (*T. pratense* and *M. sativa*) and five (*L. perenne*, *C. intybus*, *S. minor*, *L. corniculatus* and *T. repens*) species, respectively. Despite that, the II₁ and II₂ subsets of the wilds included one (*S. minor*) and four (*T. pratense*, *L. corniculatus*, *T. repens* and *M. sativa*) species,

respectively. Based on the dendrogram, the most similar species pairs were *T. repens – L. corniculatus*, *S. minor – C. intybus*, *M. sativa – T. pratense* and *D. glomerata – F. ovina* in the cultivars, whereas *M. sativa – T. repens* and *D. glomerata – F. ovina* in the wilds. The plant type clustered into two sets that included similar NC and FQI. However, the most similar pairs were RFV - RFQ and ADF - NDF in the cultivars, while RFV - RFQ and ADF - DDM in the wilds.
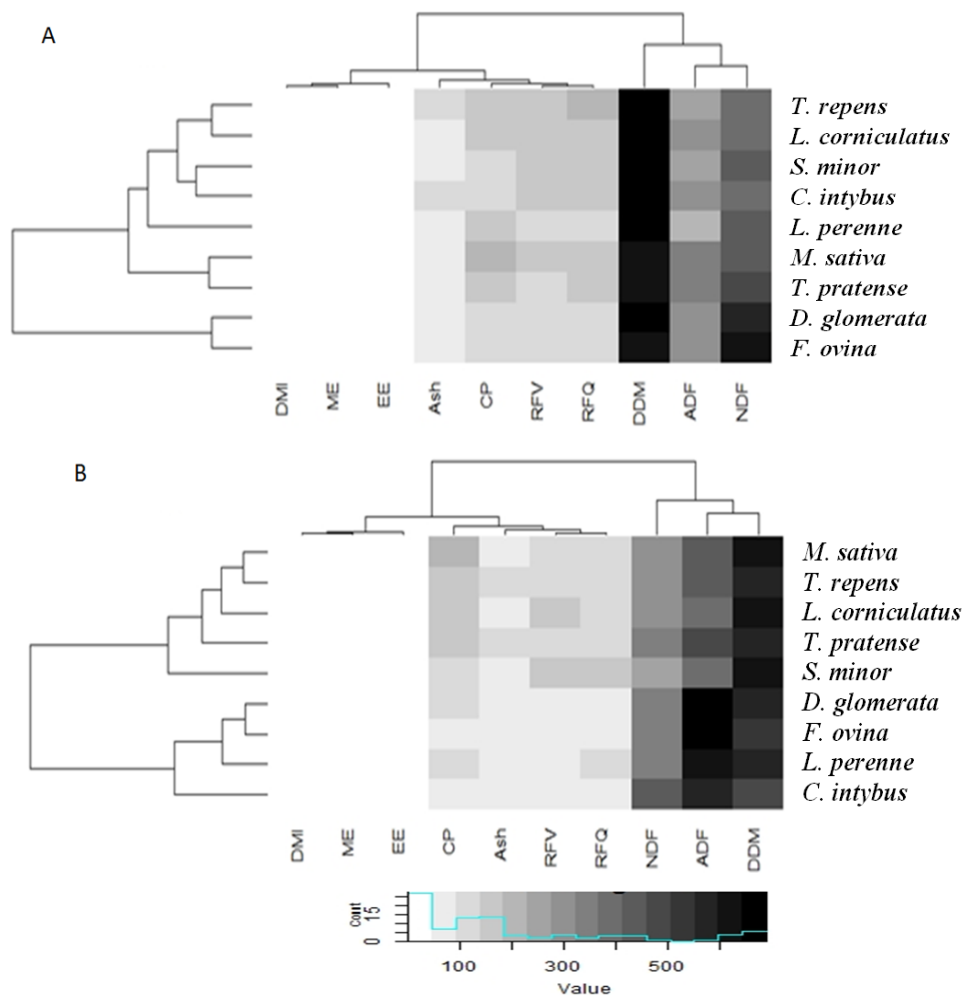

Figure 1. Dendrograms that derived from a two-way clustering analysis of the nine cultivated forage species (A) and their wild relatives (B) together with their nutritional traits. The horizontal and vertical dendrogram is the clusters of plant species and nutritional traits, respectively, according to similarities in the studied parameters. The intensity of colour histogram indicates the lowest (light white) and the highest (dark black) strength of similarity. CP= crude protein, EE= ether extract, ADF= acid detergent fibre, NDF= neutral detergent fibre, DDM= digestible dry matter, DMI= dry matter intake, ME= metabolizable energy, RFV= relative feed value, RFQ= relative forage quality.

4. Discussion

The results of the present study indicated that the cultivars and the wilds comprised of components that respond differently to ecological processes under the same circumstances. Indeed, the cultivars resulted in a remarkable higher nutritive value relative to the wilds. These results confirmed that the quality, one of the primary production traits (Hayes et al., 2013) for forage species, is improved by cultivation of forage species (Lee,

2018). All nutritional traits of both cultivars and wilds were within the range reported in the literature (Asaadi and Yazdi, 2011; Bidgoli et al., 2013; Lee, 2018; Aydin et al., 2019). In agreement with Asaadi and Yazdi (2011), therefore, adequate nutrients were available in rangelands that included the studied wilds. The most notable was that the ADF content, the RFV, and RFQ values of cultivars were a mean of 30% higher and the NDF content was 48% lower than those of the wilds.

These findings might be related to the fact that the legume and OBF cultivars generally had lower ADF and NDF, and higher ash concentrations than their wilds and all grasses (Elgersma et al., 2014; Aydin et al., 2019). These changes in nutritional traits that represented the quality of the forages are very critical in terms of digestible nutrients and energy provision to the ruminants (Hayes et al., 2013). Available study results (Dudek et al., 2020) indicate that differences in the nutrient content of the forage species depend on the difference between years in terms of season (Fan et al., 2020), and, in particular, the amount of precipitation (Gulwa et al., 2017). Unfortunately, we did not estimate the year × species or type interaction in the present study because the samples collected in each year were mixed at the end or were not analysed separately.

Because the cultivars such as *M. sativa*, *L. corniculatus*, *D. glomerata*, *S. minor*, and CI are highly valuable and palatable species for ruminants (Aydın et al., 2020), these cultivars are introduced within the degraded rangeland for re-vegetation and restoration purposes (Schröder and Prasse, 2013; Uzun et al., 2015; Aşcı, 2016; Algan et al., 2019). Based on our results, the use of mixtures of the legume and OBF cultivars (*L. corniculatus*, *M. sativa*, *T. pratense*, *S. minor* and *C. intybus*) for that aim may cause the combined beneficial impacts for the rangelands (Kemp et al., 2010; Hutton et al., 2011) due to the higher CP and lower ADF and NDF contents in these cultivars than companion grasses (Elgersma et al., 2014). Grazing such rangelands may help to boost the productivity of animals and to diminish costs (Algan et al., 2018). However, it should remember that the potential of rangeland improvement by the cultivars depends upon whether they are good competitors to the present vegetation in stressful environmental factors (Schröder and Prasse, 2013).

The productivity of the OBF species and their use for livestock is much lower than the grass and legume species (Elgersma et al., 2014). As reported previously (Elgersma et al., 2014; Aydin et al., 2019), the wild *S. minor* and *C. intybus* generally showed lower FQI values due to CP, ADF, and NDF contents. The results of the present study indicated that the OBF species cultivated relatively new compared to the grass and legume forage caused significant improvements in the FQI of the OBF cultivars. The differences between the cultivars and the wilds may be due to leaf form, structure and leaf to stem ratio (Onoda et al., 2017; Lee, 2018; Aydin et al., 2019). The increased NC and FQI in the cultivars may, also, be due to the impacts of fertilizer applied in the field conditions (Onoda et al., 2017; Lee, 2018; Algan et al., 2019). Indeed, the ME and RFQ values of the OBF cultivars were higher than the grass cultivars, but not the legumes. The results of two-way clustering analysis confirmed the significant differences among nutritional traits of the cultivars and the wilds. These findings supported the idea that the *C. intybus* and *S. minor* provide a suitable balance between CP and energy, as

well as minerals and thus, these species may cause high-animal productivities in harsh environments (Asaadi and Yazdi, 2011). Indeed, plant type containing high-CP and ash as well as low-ADF and NDF representing high-digestibility are more nutritious (Arzani et al., 2010; Lee, 2018).

Due to the interaction effect between plant type and plant species factors, there was substantial variation between the cultivars and the wilds. This interaction suggested that the cultivars may differ in their rates of response to cultivation pressures and also, the responses of species in terms of nutritional traits may not always be equally strong, as described previously (Capstaff and Miller, 2018; Pfeiffer et al., 2018). Indeed, variation in CP and EE values within and between the studied species was less compared with ADF and NDF values. In the present study, grass species had a lower feeding value due to insufficient CP content and unsatisfactory fibre digest for ruminants compared to the legumes and the OFB species (Amiri and Shariff, 2012; Algan et al., 2019; Aydin et al., 2019). The fact that grass species had a lower ME and RFQ compared to the species from legume and the other families could be associated with their cell wall and contents (Aydin et al., 2019). Therefore, both types of grass species may limit animal productivity. However, the NC and FQI results of the studied wilds indicated that these species were sufficient in guaranteeing the roughages required by grazing ruminants (Amiri and Shariff, 2012; Elgersma et al., 2014).

The results of the hierarchical two-way clustering analysis showed that the wilds and the cultivars were comprised of nutritional traits that respond differently under the same circumstances. The colour histogram of the dendrogram showed that low-NC and FQI were rare in the cultivars or common in the wilds. These clustering groups agree with the results of previous studies (Amiri and Shariff, 2012; Aydin et al., 2019) related to the rangeland forages. The clusters of families in both the cultivars and wilds were probably related to the NC and FQI of the species belonging to each family (Arzani et al., 2010; Amiri and Shariff, 2012; Aydin et al., 2019). Although the significant variations within and between the forage plant species, the results of clustering analysis confirmed that ADF and NDF contents of forages were the best quality indicator (Ruckle et al., 2017; Lee, 2018; Aydin et al., 2019).

5. Conclusion

The results of the present study indicate that, under normal circumstances, the cultivars resulted in a remarkable higher nutritive value relative to the wilds. Also, the results divulge that legume (*L. corniculatus*, *M. sativa*, *T. pratense* and *T. repens*) and probably the OBF species (*C. intybus* and *S. minor*) are highly acceptable to enhance the productivity of ruminants compared to grasses (*D. glomerata*, *F. ovina* and *L. perenne*). The information reported herein may help to improve the

animal diet based on the wilds and to farmers for increasing productivity of the small ruminants.

Author Contributions

IA; supervision project administration and resources. IA and NO; funding acquisition, conceptualization, methodology and writing-original draft preparation. BP and NO; investigation, data curation and formal analysis. NO; writing-review and editing, All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The author declared that there is no conflict of interest.

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